SIEMENS

SIMATIC

FM 350-2 Counter Function Module Installation and Parameter Assignment

Manual

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Safety Guidelines

This manual contains notices intended to ensure personal safety, as well as to protect the products and connected equipment against damage. These notices are highlighted by the symbols shown below and graded according to severity by the following texts:

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

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

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

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Notice
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Only **qualified personnel** should be allowed to install and work on this equipment. Qualified persons are defined as persons who are authorized to commission, to ground and to tag circuits, equipment, and systems in accordance with established safety practices and standards.

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Note the following:

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

Preface

Purpose

This manual describes all the steps required for using the FM 350-2 function module. It introduces you quickly and effectively to the functions of the FM 350-2.

Contents of This Manual

This manual describes the hardware and software of the FM 350-2. It consists of an introductory section and a reference section (with Appendix).

The manual contains sections on the following topics:

- Basic information on counting
- Installation and expansion of the FM 350-2
- Wiring the FM 350-2
- Assigning parameters to the FM 350-2
- Programming the FM 350-2
- Appendix

Audience

The manual is aimed at the following readers:

- Installation engineers
- Programmers
- Startup engineers
- Service and maintenance personnel

Scope of This Manual

This manual contains the description of the FM 350-2 function module valid at the time the manual was printed. We reserve the right to describe any subsequent changes to the functions of the FM 350-2 in a Product Information.

Other References

You will find a list of other references on the topic of the S7-300 and programmable controllers in the appendix.

Structure of This Manual

To make it easier for you to locate specific information, the manual has been structured as follows:

- At the beginning of the manual, you will find a complete table of contents for the manual.
- In the individual chapters, the information in the left margin gives an overview of the contents of each section.
- Following the appendices, there is a glossary containing definitions of the important technical terms used in the manual.
- At the end of the manual, you will find a detailed index giving you fast access to the information you seek.

Standards

The S7-300 programmable controller conforms to the IEC 1131 standard.

Recycling and Disposal

The SIMATIC S7-300 is an environmentally friendly product. It is characterized by the following points:

- The plastic for the casing is coated with a halogen-free flame retardant despite its high resistance to fire.
- Labeling is done by laser (meaning no labels)
- The plastics are coded according to DIN 54840
- Fewer materials are used in this compact design, fewer components are required as the result of integration in ASICs

The SIMATIC S7-300 can be recycled as a result of its minimal use of harmful substances.

For environmentally compatible recycling and disposal of your old SIMATIC device in accordance with the current state of the art, please contact:

Siemens AG
Anlagenbau und Technische Dienstleistungen
ATD TD 3 Kreislaufwirtschaft

Postfach 32 40

D–91050 Erlangen

Phone: (+49) 9131 / 7-33698
Fax: (+49) 9131 / 7-26643

This Siemens department provides a comprehensive and flexible disposal service at a fixed cost with individual consultancy. You will be provided with papers documenting the breaking down of your system giving details on the fractional parts and the relevant verification papers for the materials.

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- A forum, where users and experts from all over the world exchange their experiences.
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- Information on field service, repairs, spare parts and more under "Services".

Contents

1 Product Overview

1.1 What Can the FM 350-2 Do?

What Can the FM 350-2 Do?

The FM 350-2 function module is an 8-channel counter module with proportioning functions for use in the S7-300 programmable controller. The function module can operate within the following maximum count range:

- - 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 10 kHz per count channel depending on the encoder signal.

You can use the FM 350-2 for the following tasks:

- Continuous counting up/down
- Single counting up/down
- Periodic counting up/down
- Frequency measurement
- Rotational speed measurement
- Period duration measurement
- Proportioning

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

Count, gate, and direction signals can be connected directly to the module.

Comparison Values

You can store a comparison value for each count channel on the module (four comparison values in the “proportioning” mode). If the counter reading reaches this comparison value, the relevant output can be set/reset to initiate control actions direct in the process and/or a hardware interrupt can be triggered.

Count Limits

In the operating modes “single counting”, “periodic counting”, and “proportioning“ you can set count limits within the maximum count range. The following applies here:

- When counting up, the count starts at 0 (start value) and you specify an end value between 2 and 2,147,483,647.
- When counting down, you specify a start value between 2 and 2,147,483,647, the end value is set at 0.

Hardware Interrupts

Four hardware interrupts are possible per count channel. Two hardware interrupts can be generated by each edge change at the hardware gate. Two additional specific hardware interrupts (five specific hardware interrupts in the “proportioning” mode) can be generated depending on the operating mode set.

Count Process

Count processes can be started or stopped via the software gate or via the hardware gate and the software gate.

Diagnostic Interrupts

The FM 350-2 can trigger a diagnostic interrupt if any of the following occur:

- Faulty NAMUR encoder supply
- Module not assigned parameters or errors in parameter assignment
- Watchdog tripped
- Hardware interrupt lost
- Wire break or short circuit at a NAMUR input

Which Signals Can the FM 350-2 Count?

The FM 350-2 can count signals generated by the following encoders: only bounce-free encoders are permitted.

- 24-V incremental encoder, push-pull switch, or current-sourcing switch
- 24-V pulse encoder with direction level
- 24-V initiator without direction level

  for example, light barrier or BERO (type 2)
- NAMUR encoder in accordance with DIN 19234

Inputs

24-V signals or NAMUR-conforming signals can be connected in groups of four at the count input. Encoder signals of more than 8.2 V must not be connected to an input module with parameters set for a NAMUR encoder.

Only 24-V signals can be connected to the gate and direction inputs.

Input Filter

For the purpose of suppressing interference, an input filter (RC element) with a uniform filter time for all inputs of 50 ms is set for the inputs.

Outputs

High-speed responses to specific count events are possible per count channel via a digital output (or four digital outputs in the “proportioning” mode). The outputs can be controlled dependent on the count or via programmable control bits.

Reaction to S7-300 Failure

The reaction of the FM 350-2 to CPU STOP can be set. The current operating mode can continue to run or be interrupted. The digital outputs can retain the last values set, be set to substitute values, or be deactivated.

Danger

Danger of property damage.

If you set the reaction of the FM 350-2 so that the digital outputs are set to substitute values on CPU STOP, these values are also set at digital outputs which are not enabled.

Ensure that substitute values at disabled digital outputs cannot cause dangerous states in the plant.

Reaction to Module Supply Failure

The reaction of the FM 350-2 to a failure of the module voltage supply depends on whether the FM 350-2 is being operated with a standard backplane bus or an active backplane bus.

- Standard backplane bus

  When the module supply fails in the FM 350-2, the CPU recognizes an I/O access error. The FM 350-2 does **not** start up again when power returns.

- Active backplane bus

  When the module supply fails in the FM 350-2, a “module-removed” alarm is sent to the CPU. When power returns, a “module-inserted” alarm is sent to the CPU.

1.2 Application Areas of the FM 350-2

Where Can You Use the FM 350-2?

The main application area of the FM 350-2 is where signals are counted and high-speed responses to predefined counter readings are triggered, and where frequencies or rotational speeds are measured.

Examples include:

- Packaging plants
- Sorting plants
- Dosing or proportioning plants
- Rotational speed controls and gas turbine monitoring

Example for the Use of an FM 350-2

A box must be filled with a specific number of parts from a container. The count channel 0 counts the parts and controls the valve to fill the box. The motor to transport the boxes is controlled and the number of boxes is counted with count channel 1.

When the box is in the correct position, the valve is opened and the box is filled with parts. When the specified number of parts is reached, the valve is closed and the transport of the boxes is started. Any following parts continue to be counted until a new box appears.

A new number of parts can be specified during the transport of the box. The number of parts placed in a box and the number of boxes can be monitored.

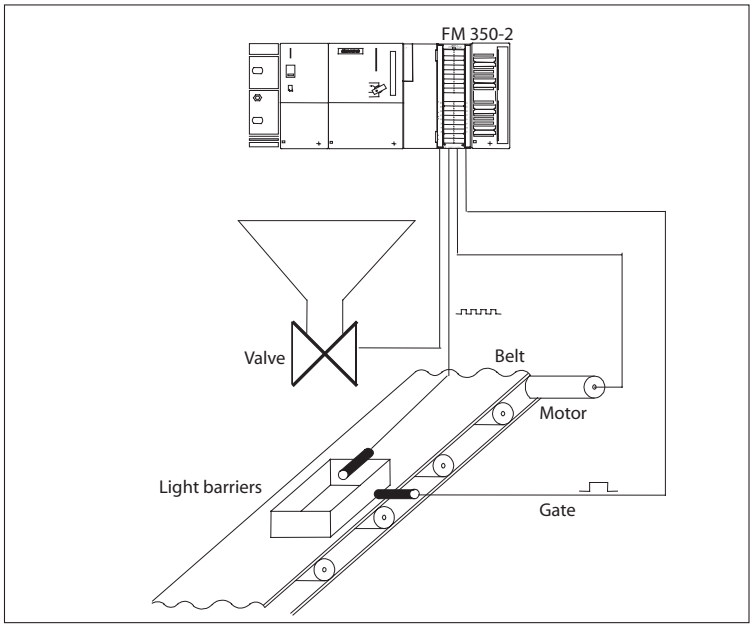


Figure 1-1 Example for Using an FM 350-2 in the S7-300

1.3 FM 350-2 Hardware

View of Module

Figure 1-2 shows the FM 350-2 module with a front connector and the expansion bus with the front panels closed.

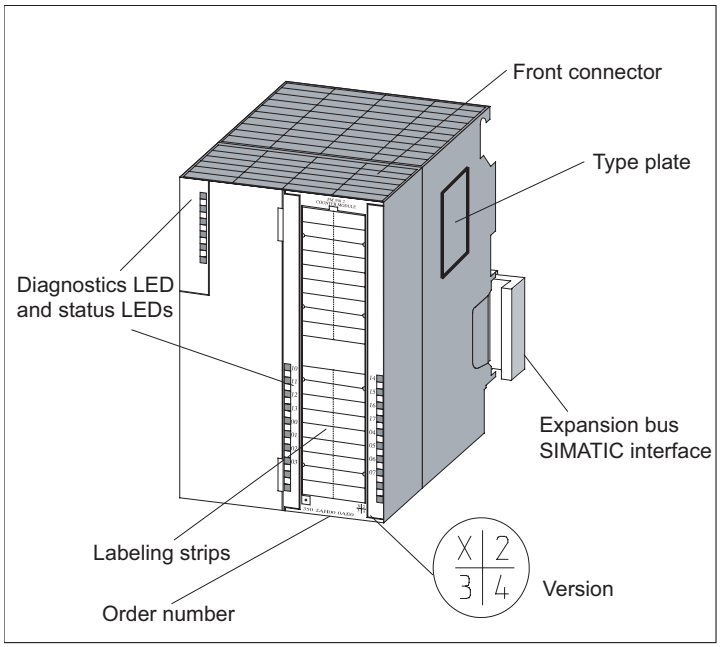


Figure 1-2 FM 350-2 Module View

Front Connector

The FM 350-2 offers the following connection possibilities via the front connector:

- Count signals
- Direction signals
- Module voltage supply
- Input signals for hardware gate
- Output signals
- NAMUR encoder 8.2 V supply

The front connector must be ordered separately.

Labeling Strips

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

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

Order Number and Release

The order number and the release of the FM 350-2 are shown at the bottom of the front panel.

Expansion Bus

Communication within one tier of the S7-300 takes place via the expansion bus. The expansion bus is supplied with the FM 350-2.

Status and Diagnostics LEDs

The FM 350-2 has one LED for diagnostics, eight LEDs to indicate the status of the digital inputs, and eight LEDs to indicate the status of the digital outputs.

The following Table lists the LEDs with their labeling, color and function.

Label	Color	Function
SF	Red	Group error
I0	Green	Status of hardware gate channel 0
I1	Green	Status of hardware gate channel 1
I2	Green	Status of hardware gate channel 2
I3	Green	Status of hardware gate channel 3
I4	Green	Status of hardware gate channel 4
I5	Green	Status of hardware gate channel 5
I6	Green	Status of hardware gate channel 6
I7	Green	Status of hardware gate channel 7
Q0	Green	Status of output Q0
Q1	Green	Status of output Q1
Q2	Green	Status of output Q2
Q3	Green	Status of output Q3
Q4	Green	Status of output Q4
Q5	Green	Status of output Q5
Q6	Green	Status of output Q6
Q7	Green	Status of output Q7

1.4 FM 350-2 Software

FM 350-2 Configuration Package

To integrate the FM 350-2 into the S7-300, you require the configuration package with:

- Parameter assignment dialogs and
- Functions for linking the FM 350-2 into the user program

Parameter Assignment Dialogs

The FM 350-2 is adapted to the task in hand via parameters. These parameters are stored in the CPU and transferred to the module from the CPU.

You can specify the parameters via parameter assignment dialog boxes. These parameter assignment dialogs are installed on your programming device and opened in STEP 7.

Functions for Linking in the FM 350-2

The functions for linking the FM 350-2 into the user program consist of the FCs CNT2_CTR, CNT2_WR, and CNT2_RD which are called in the CPU user program. These FCs enable communication between the CPU and the FM 350-2. In addition, there is also the FC DIAG_RD for the FM 350-2 with which you can transfer diagnostic data into the DB of the FC CNT_CTRL.

Figure 1-3 shows an S7-300 configuration with an FM 350-2 and several signal modules.

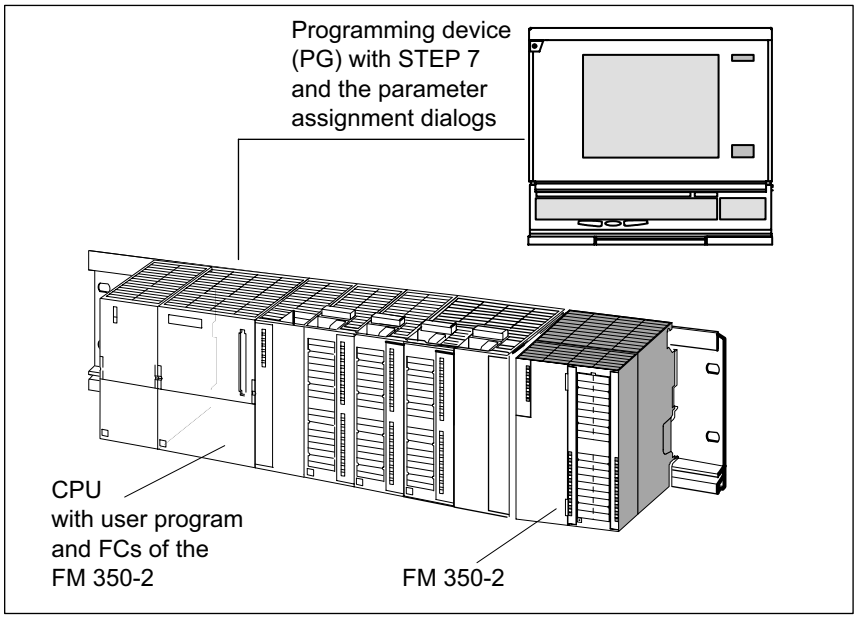


Figure 1-3 SIMATIC S7-300 Configuration with an FM 350-2

2 How the FM 350-2 Counts

2.1 Definitions

What is Counting?

Counting refers to the process of recording and totaling events. In the case of the FM 350-2, encoder signals are recorded and evaluated accordingly.

Count Range

The FM 350-2 can count up and down. The maximum count range within which the FM 350-2 can count is ” 31 bits (“continuous counting” mode).

Count Range	Lower Count Limit	Upper Count Limit
Count range:” 31 bits	- 2,147,483,648	+ 2,147,483,647

Count Limits

In the operating modes “single counting,” “periodic counting,” and “proportioning” you can select a count limit in the range 2 to 2147483647. The other count limit is fixed at 0.

Main Count Direction

You can set the main count direction for the FM 350-2 as “up” or “down.” This means you specify which count limit is to act as the start value and which is the end value for the operating modes “single counting,” “periodic counting,” and “proportioning.”

Even if you set the main count direction “down,” to count down you must either apply a corresponding direction signal or set “inverted count direction” when you set the FM 350-2 parameters.

Load Value

You can specify a load value for each of the eight counters of the FM 350-2. You can specify this load value directly, then it is immediately used by the counter as the new count value.

You can also specify the load value in preparation, then it is used by the counter as the new count value if the following events occur:

- Reaching the end value when counting up
- Reaching 0 when counting down
- Interruption of the count process by a software gate or a hardware gate (when the count process is interrupted the load value is not used).

Comparison Values

In order to trigger responses in the process independently of the CPU when a specific count is reached, you can use the eight digital outputs on the module. For this purpose you can assign one comparison value for each count channel on the FM 350-2 (four comparison values for a proportioning channel). You can specify each value between the count limits as a comparison value. If the count reaches the comparison value, the corresponding digital output is set/reset and/or a hardware interrupt is generated.

Example

In the example in Section 1.2, the valve is to be closed as soon as the box contains the programmed number of parts. For this purpose, you can specify this number as the comparison value for the FM 350-2 and use the corresponding digital output to close the valve.

Operating Modes

With the FM 350-2, you can count rectangular pulses in three ways:

- Continuous counting
- Single counting
- Periodic counting

The differences between the modes become obvious in the behavior of the FM 350-2 when a counter reaches a count limit.

There are also four other operating modes based on count processes:

- Frequency measurement
- Rotational speed measurement
- Period duration measurement
- Proportioning

With the exception of “proportioning,” all operating modes can be assigned to each channel independently of each other. For example: channel 1 = frequency measurement; channel 2 = single counting, etc.. The operating mode “proportioning” requires four channels (channels 0 to 3 and/or 4 to 7).

Continuous Counting

If the counter reaches the upper count limit when counting up and a further count pulse is received, the counter jumps to the lower count limit and starts to add the count pulses again, meaning it counts continuously.

If the counter reaches the lower count limit when counting down and a further count pulse is received, the counter jumps to the upper count limit and continues to count down from there.

The count range in this mode is always ”31 bits (-2,147,483,648 to +2,147,483,647); it cannot be changed. The counter starts to count at 0 when a complete restart is executed on the module.

If a comparison value was assigned, when the current counter reading = the comparison value a hardware interrupt can be triggered and/or the output can be switched.

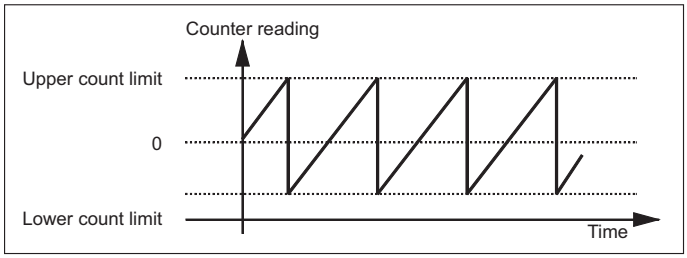


Figure 2-1 Continuous Counting in the Up Direction

Single Counting

In single counting, the start value and end value (max. count range: 0 to +2147483647) and the main count direction are set via a parameter assignment dialog box.

When counting up, the counter counts from 0 once in the direction of the end value. If the counter reaches the end value -1 and a further count pulse is received, the counter jumps back to 0 and remains there even if further count pulses are received.

When counting down, the counter counts from the start value once in the direction of 0. If the counter reaches the count 1 and a further count pulse is received, the counter jumps back to the start value and remains there even if further count pulses are received.

If the counter counts against the selected main count direction and overshoots or undershoots the start value, the module returns the current counter reading with the correct sign. An overflow or underflow does not occur in this case. The behavior of the output remains unchanged.

If a comparison value was assigned, when the current counter reading = the comparison value a hardware interrupt can be triggered and/or the output can be switched.

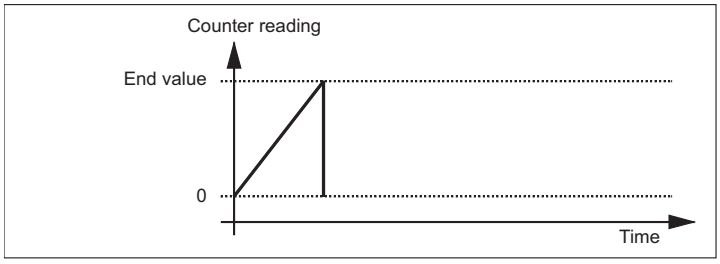


Figure 2-2 Single Counting in the Up Direction

Periodic Counting

In periodic counting, the start value and end value (max. count range: 0 to +2147483647) and the main count direction are set via a parameter assignment dialog box.

When counting up, the counter starts at the start value 0. When the counter reaches the “end value -1” and a further count pulse is received, the counter jumps back to 0 and continues to add the count pulses.

When counting down, the counter starts at the set start value. When the counter reaches the value 1 and a further count pulse is received, the counter jumps back to the start value and continues to count down from there.

If the counter counts against the selected main count direction and overshoots or undershoots the start value, the module returns the current counter reading with the correct sign. An overflow or underflow does not occur in this case. The behavior of the output remains unchanged.

If a comparison value was assigned, when the current counter reading = the comparison value a hardware interrupt can be triggered and/or the output can be switched.

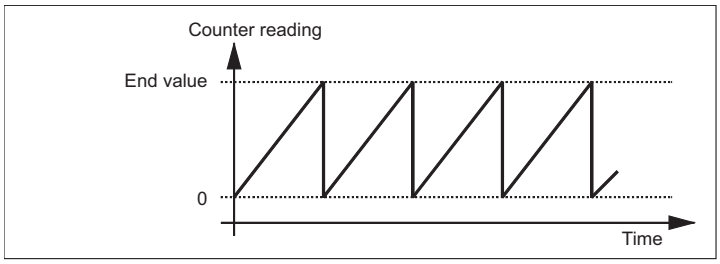


Figure 2-3 Periodic Counting in the Up Direction

Frequency Measurement

In frequency measurement the FM 350-2 counts the pulses which are received in a time window set via the parameter assignment dialog box. Integration times between 10 ms and 10 seconds can be set.

At the end of each time window the frequency value is updated. The calculated frequency is displayed in the unit Hz*10^{-3} (range: 0 to 2^{31} Hz*10^{-3}).

If no valid value was calculated, -1 is returned. If no pulses are counted in a time interval, the module returns 0 Hz*10^{-3}.

You can start and end frequency measurement via the gate functions.

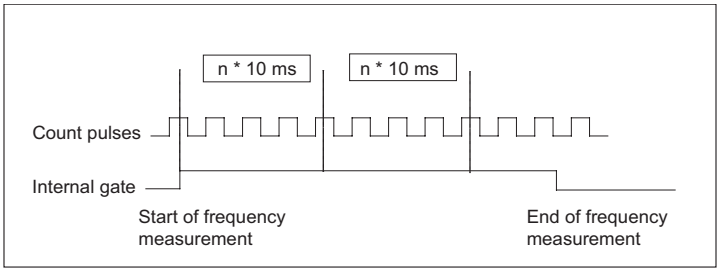


Figure 2-4 Frequency Measurement with Gate Function

You can set two frequency comparison values (value range for the upper limit value: 0 to 9999999 Hz*10^{-3}; value range for the lower limit value: 1 to 10000000 Hz*10^{-3}).

You can choose from the following hardware interrupts:

- Start of frequency measurement with a hardware gate (positive edge)
- End of frequency measurement with a hardware gate (negative edge)
- End of measurement value recording (integration time expired)
- Frequency limits exceeded or not reached

After each time interval has expired, the frequency determined is compared with the set frequency limits (fu / fo). If the current frequency lies below the set lower limit or above the set upper limit a hardware interrupt is triggered if this has been assigned accordingly.

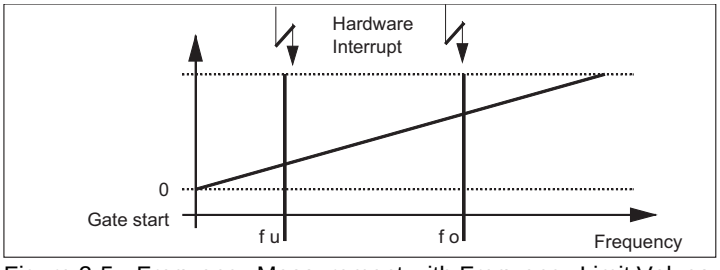


Figure 2-5 Frequency Measurement with Frequency Limit Values

Rotational Speed Measurement

The operating mode “rotational speed measurement” is almost identical to frequency measurement.

In addition to the length of the time window you must also specify the number of pulses per motor or encoder revolution for this mode in the parameter assignment dialog box.

The value for the number of revolutions is updated at the end of each time window. The calculated frequency is displayed in the unit 1 x 10^{-3} rpm.

If no valid value was calculated, -1 is returned. If no pulses are counted in a time interval, the module returns 0 x 10^{-3} rpm.

Using two rotational speed comparison values (value range for the lower limit value: 0 to 24999999 x 10^{-3} rpm, DWORD; value range for the upper limit value: 1 to 25000000 x 10^{-3} rpm, DWORD) you can monitor whether the measured rotational speed lies within the specified range. If this range is exceeded, a hardware interrupt can be triggered. The FM 350-2 checks whether the upper limit is greater than the lower limit and reports a parameter assignment error if this is not the case.

You can start and end rotational speed measurement via the gate functions.

You can choose from the following hardware interrupts:

- Start of rotational speed measurement with a hardware gate (positive edge)
- End of rotational speed measurement with a hardware gate (negative edge)
- End of measurement value recording (integration time expired)
- Rotational speed limits exceeded or not reached

Period Duration Measurement

With very small frequencies, often the period duration has to be measured instead of the frequency. In the operating mode “period duration measurement” the exact time between two rising edges is measured.

Period duration measurement is started and ended using the gate signals (hardware or software gate).

The period duration can only be recorded in the set main count direction. The permissible measurement range lies between 100 ms and 120 seconds (10,000 Hz to 0.00833 Hz). If no valid value was calculated, -1 is returned.

You can set two period duration comparison values on the module via the parameter assignment dialog box (value range for the lower limit value: 0 ms to 119999999 ms; value range for the upper limit value: 100 ms to 120000000 ms).

You can choose from the following hardware interrupts:

- Start of period duration measurement with a hardware gate (+ edge)
- End of period duration measurement with a hardware gate (- edge)
- End of measurement value recording (integration time expired)
- Period duration limits exceeded or not reached

Proportioning

In the “proportioning” operating mode four count channels on the module are combined together in one proportioning channel.

You can specify four comparison values which can be changed individually or in groups of four. The counter reading is continuously compared with the comparison values; if the current counter reading = the comparison value a hardware interrupt can be triggered and/or the corresponding digital output can be switched. You can therefore control up to four proportioning units with one proportioning counter.

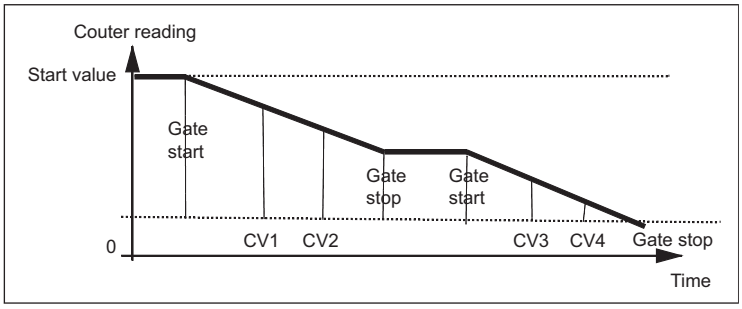


Figure 2-6 Proportioning in the Down Direction

You can choose from the following hardware interrupts:

- Start of proportioning with a hardware gate (positive edge)
- Cancel/interrupt proportioning with a hardware gate (negative edge)
- One hardware interrupt each for the four comparison values
- Reaching the count range limits (end value/start value)

2.2 Gate Functions

Counting with Gate Functions

Many applications require that the count be started or stopped at a defined time depending on other events. This starting and stopping of the count process is done in the FM 350-2 via a gate function. If the gate is opened, count pulses can reach a counter and the count is started. If the gate is closed, count pulses can no longer reach the counter and the count is stopped.

Software Gate and Hardware Gate

The module has two gate functions:

- A software gate controlled via the control bit “SW_GATE7...0”.

  The software gate can only be switched through by an edge change from 0 to 1 of the control bit “SW_GATE7...0”. It is closed by resetting this bit.

- A hardware gate controlled via digital inputs I0 to I7 on the module.

  A hardware gate is opened by an edge change from 0 to 1 at the respective digital input and closed by an edge change 1 to 0.

Internal Gate

The internal gate is the logic AND operation combining a hardware gate and a software gate. If no hardware gate was assigned, only the setting of the software gate is relevant. The count process is activated, interrupted, resumed, and canceled via the internal gate. The internal gate can also be closed by events dependent on the counter reading in the operating modes “single counting” and “proportioning.”

Hardware Gate	Software Gate	Internal Gate	Count Process
Open	Open	Open	Active
Open	Closed	Closed	Inactive
Closed	Open	Closed	Inactive
Closed	Closed	Closed	Inactive

When assigning the hardware and software gates you can specify whether the internal gate can cancel or interrupt the count process. When canceled, the count process starts from the beginning again following a gate stop and gate start. When interrupted, the count process resumes at the last current count value following a gate stop and gate start.

Example

The gate is opened and the count pulses are counted by setting the gate signal. If the gate signal is removed, the gate is closed and the count pulses are no longer recorded by the counter. The counter reading remains constant.

Figure 2-7 shows the opening and closing of a gate and the counting of the pulses.

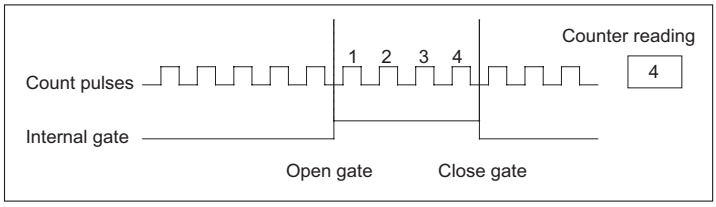


Figure 2-7 Opening and Closing a Gate

3 Installing and Removing the FM 350-2

3.1 Preparing for Installation

Defining the Slots

The FM 350-2 function module can be inserted in any slot just as any signal module.

Mechanical Configuration

Manual: *S7-300 Programmable Controller, Hardware and Installation* describes the possibilities open to you for mechanical installation and how to proceed when configuring. The following paragraphs give only a few supplementary tips.

1. A maximum of eight signal modules (SM) or function modules (FM) are permitted per rack.
2. The maximum number is restricted by the width of the modules or the length of your DIN rail. The FM 350-2 requires an installation width of 80 mm.
3. The maximum number is restricted by the total current consumptions of all modules to the right of the CPU from the 5-V backplane bus supply. The current consumption of the FM 350-2 is 100 mA.
4. The maximum number is restricted by the memory required by the CPU software for communication with the FM 350-2.

Vertical or Horizontal Arrangement

Horizontal arrangement is preferable. For vertical arrangement, you must observe the restricted ambient temperatures (max. 40° C).

Determining the Start Address

The start address of the FM 350-2 is required for communications between the CPU and the FM 350-2. The start address is entered in the counter DB (see Chapters 6 and 10). The entry is made either with the help of the Program Editor or in the parameter assignment dialog boxes.

You can determine the start address of the FM 350-2 in accordance with the same rules used to determine the start address of an analog module.

Fixed Addressing

In the case of fixed addressing, the start address depends on the slot. Refer to the tables in manual: *S7-300 Programmable Controller, Hardware and Installation* for the start address of an analog module in the various slots.

You can also calculate this fixed start address using the following formula:

Address = 256 + (mounting rack no. * 128) + (slot no. - 4) * 16

Free Addressing

With free addressing, you specify the start address of the module using STEP 7.

Important Safety Regulations

There are important regulations you must observe for integrating an S7-300 with an FM 350-2 into a plant or a system. These rules and regulations are explained in Manual: *S7-300 Programmable Controller, Hardware and Installation*.

3.2 How to Install and Remove the FM 350-2

Rules

No special protection measures (ESD guidelines) are required for installing an FM 350-2.

Tools Required

You require a 4.5 mm screwdriver for installing and removing the FM 350-2.

Installation Procedure

Below is a description of how to proceed when installing the FM 350-2 on the DIN rail. You will find further information on installing modules in manual: *S7-300 Programmable Controller, Hardware and Installation*.

1. Switch the CPU to STOP.
2. The FM 350-2 is supplied with an expansion bus. Plug this into the bus connector of the module to the left of the FM 350-2. (The bus connector is located on the back and you may have to loosen the neighboring module.)
3. Hook the FM 350-2 onto the rail and swing it down.
4. If further modules are to be installed to the right of the FM 350-2, first connect the expansion bus of the next module to the right-hand backplane bus connector of the FM 350-2.

   If the FM 350-2 is the last module in the rack, do **not** connect an expansion bus.

   Tighten the screw on the FM 350-2 (tightening torque approximately 0.8 to 1.1 Nm).

5. Label the FM 350-2 with its slot number. Use the number wheel supplied with the CPU for this purpose.

   Manual: *S7-300 Programmable Controller, Hardware and Installation* describes the numbering scheme you must use and how to connect the slot numbers.

6. Install the shield attachment.

   You can order the shield attachment under the order number 6ES7390-5AA00-0AA0.

Procedure for Removing or Exchanging Modules

Below is a description of how to remove the FM 350-2. You will find further information on removing modules in Manual: *S7-300 Programmable Controller, Hardware and Installation*.

1. Switch off the auxiliary voltage and the load voltage at the front connector.
2. Switch the CPU to STOP.

   If you are running the FM 350-2 in an active backplane bus you can also exchange the module while the CPU is in RUN.

3. Open the front panel. If necessary, remove the labeling strip.
4. Unscrew the fixing screw for the front connector and remove the front connector.
5. Unscrew the fixing screw on the module.
6. Swing the module out of the DIN rail and unhook it.
7. Install the new module if applicable.

Further Information

Manual: *S7-300 Programmable Controller, Hardware and Installation* contains further information on installing and removing modules.

4 Wiring the FM 350-2

4.1 Terminal Assignments of the Front Connector

Front Connector

You connect the count signals, the digital inputs and outputs, the encoder supply, and the module voltage via the 40-pin front connector.

Figure 4-1 shows the front of the module, the front connector, and the inside of the front panel with the terminal assignments.

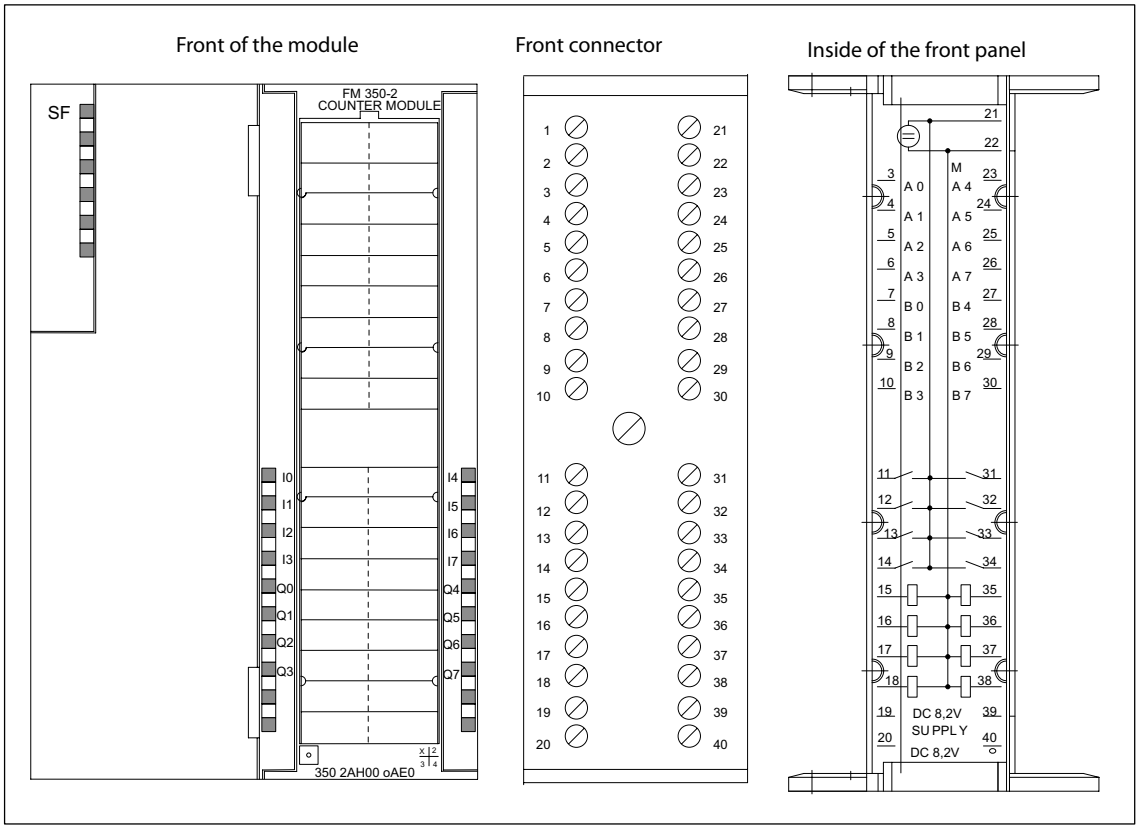


Figure 4-1 Front Connector of the FM 350-2

Front Connector Assignments

The following Table shows the front connector assignments.

Terminal	Name	Input / Output	Function
1	-	-	Not connected
2	-	-	Not connected
3	A0	INP	Channel 0 count input NAMUR / BERO
4	A1	INP	Channel 1 count input NAMUR / BERO
5	A2	INP	Channel 2 count input NAMUR / BERO
6	A3	INP	Channel 3 count input NAMUR / BERO
7	B0	INP	Channel 0 direction input BERO
8	B1	INP	Channel 1 direction input BERO
9	B2	INP	Channel 2 direction input BERO
10	B3	INP	Channel 3 direction input BERO
11	I0	INP	Channel 0 hardware gate input BERO
12	I1	INP	Channel 1 hardware gate input BERO
13	I2	INP	Channel 2 hardware gate input BERO
14	I3	INP	Channel 3 hardware gate input BERO
15	Q0	OUTP	Channel 0 digital output 0.5 A
16	Q1	OUTP	Channel 1 digital output 0.5 A
17	Q2	OUTP	Channel 2 digital output 0.5 A
18	Q3	OUTP	Channel 3 digital output 0.5 A
19	P8V2	OUTP	NAMUR encoder supply 8.2 V
20	P8V2	OUTP	NAMUR encoder supply 8.2 V
21	L+	INP	24-V module supply
22	M	INP	Ground module supply
23	A4	INP	Channel 4 count input NAMUR / BERO
24	A5	INP	Channel 5 count input NAMUR / BERO
25	A6	INP	Channel 6 count input NAMUR / BERO
26	A7	INP	Channel 7 count input NAMUR / BERO
27	B4	INP	Channel 4 direction input BERO
28	B5	INP	Channel 5 direction input BERO
29	B6	INP	Channel 6 direction input BERO
30	B7	INP	Channel 7 direction input BERO
31	I4	INP	Channel 4 hardware gate input BERO
32	I5	INP	Channel 5 hardware gate input BERO
33	I6	INP	Channel 6 hardware gate input BERO
34	I7	INP	Channel 7 hardware gate input BERO
35	Q4	OUTP	Channel 4 digital output 0.5 A
36	Q5	OUTP	Channel 5 digital output 0.5 A
37	Q6	OUTP	Channel 6 digital output 0.5 A
38	Q7	OUTP	Channel 7 digital output 0.5 A
39	P8V2	OUTP	NAMUR encoder supply 8.2 V
40	P8V2	OUTP	NAMUR encoder supply 8.2 V

Note

The circuits for the counter inputs (encoder supply, encoder signals) are isolated from the ground of the CPU.

All inputs are not isolated from each other but are isolated from the S7-300 bus.

24 V Voltage Supply

Connect a direct voltage of 24 V to the L+ and M terminals for the voltage supply of the FM 350-2.

8.2 VDC Encoder Supply

From the 24-V voltage supply the module generates a voltage of 8.2 V (max. 200 mA). This voltage is available at the terminals P8V2 (pins 19, 20, 39, and 40) for the voltage supply to the NAMUR encoders and is resistant to short circuits.

The encoder supply is monitored for 8.2 V.

Encoder Signals A0 to A7, B0 to B7

You can connect four different types of encoder:

- NAMUR encoders in accordance with DIN 19234 (with diagnostics).

  The signals are connected at the terminals A0 to A7.

- 24-V incremental encoders.

  The signals A0/B0 to A7/B7 are connected via the terminals so labeled.

- 24-V pulse encoder with direction level.

  The count signals are connected to the terminals A0 to A7. The direction levels are connected to the terminals B0 to B7.

- 24 V pulse encoders.

  The signals are connected to the terminals A0 to A7.

Note

You must connect the encoder supply for the 24-V encoders via an external 24 VDC voltage supply.

Digital Inputs I0 to I7 (Hardware Gates)

You can use the digital inputs I0 to I7 for the gate control of the counter.

One digital input is available for each count channel with which you can start and stop the corresponding counter.

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

Digital Outputs Q0 to Q7

The FM 350 has the digital outputs Q0 to Q7 for direct triggering of control actions.

One digital output is available per counter.

The digital outputs are fed via the 24-V voltage supply of the FM 350-2.

The digital outputs are current-sourcing switches 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.

4.2 Wiring the Front Connector

Cables

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

- The cables for the inputs 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, for example, via the shield attachment.
- Use flexible cables with cross-sections of 0.25 to 1.5 mm^2.

Note

If the NAMUR encoder is fed 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.

- A wire-end ferrule is not required. If you use wire-end ferrules then use only those without insulation collars in accordance with DIN 46228 Form A, short version.

Tool Required

You will require a screwdriver or power screwdriver with a 3.5 mm blade.

Wiring Steps

Proceed as follows when wiring the front connector:

Warning

Danger of personal injury.

If you wire the front connector of the FM 350-2 when the power is switched on, you are in danger of injury from electric shock.

Wire the FM 350-2 only when the power is switched off.

1. Open the front panel.
2. Strip the conductors (length 6 mm).
3. Are you using wire-end ferrules?

   If so: Press-fit the wire-end ferrules onto the conductors.
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 tighten unused terminals (tightening torque 0.6 to 0.8 Nm).
6. Tighten the strain relief clamp for the cable strand.
7. Plug in the front connector and screw it tight.
8. Apply the cable shields to the shield attachment or to the shield bar.

   You can order the shield attachment under the order number 6ES7390-5AA00-0AA0.
9. Label the terminals on the labeling strip.

Figure 4-2 shows the FM 350-2 with shielded cables and shield attachment.

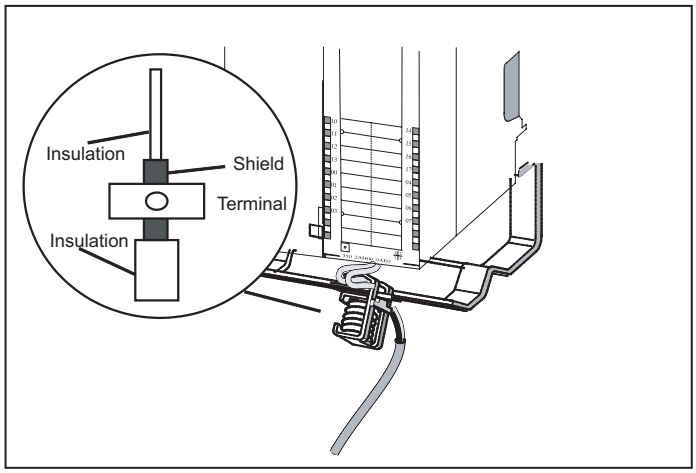


Figure 4-2 Connecting the Shielded Cables to the FM 350-2

Note

You will find a detailed description of wiring the front connector in manual: *S7-300 Programmable Controller, Hardware and Installation*.

Example: Connecting a NAMUR Encoder

Before you connect and operate a NAMUR encoder on a channel of the FM 350-2, you must assign parameters to a NAMUR encoder for the corresponding channel. The following figure shows the connection of a NAMUR encoder to channel 0.

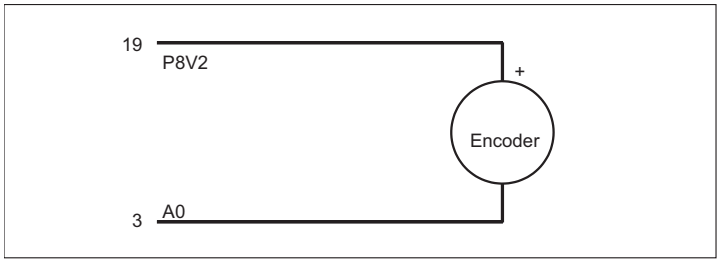


Figure 4-3 Connecting a NAMUR Encoder to Channel 0

Caution

Danger of property damage.

If you use another encoder on a channel of the FM 350-2 which was assigned parameters for the connection of a NAMUR encoder, the module may be damaged.

Connect only a NAMUR encoder to a channel of the FM 350-2 which was assigned parameters for the connection of a NAMUR encoder.

5 Assigning Parameters to the FM 350-2

5.1 Installing and Opening Parameter Assignment Dialog Boxes

Requirements

The following requirements apply for downloading parameter assignment data to the CPU:

- STEP 7 (≥V4.0.2.1) must be correctly installed on your programming device
- The programming device must be correctly connected to the CPU
- The CPU must be in STOP

Note

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

Installing the Parameter Assignment Dialog Boxes

The entire configuration package is on the CD supplied. Install the configuration package as follows:

1. Uninstall any already existing project packages.
2. Insert the CD in the CD drive of your PGs/PCs.
3. In Windows start the dialog for installing software by double-clicking the "Add and Remove Programs" icon in the "Control Panel".
4. In the dialog, select the CD drive, and in the **Setup** directory, select the **Setup.exe** file and start the installation procedure.
5. Follow the instructions displayed on the installation program step by step.

   Result: The components of the configuration package are installed to the following directories:

   - **SIEMENS\STEP7\S7LIBS\fm_cntli**: FCs, UDTs
   - **SIEMENS\STEP7\S7FCOUNT**: Configuration software, Readme, Online Help
   - **SIEMENS\STEP7\EXAMPLES**: ZXX34_01_FM350-2
   - **SIEMENS\STEP7\S7MANUAL\S7FCOUNT**: Getting Started, Manuals

Note

If you have selected another directory other than SIEMENS\STEP7 when installing STEP 7, this directory will be specified.

Calling the Parameter Assignment Dialog Boxes

Proceed as follows to call the FM 350-2 parameter assignment dialog boxes:

1. Position the order number on a free slot.

   Up to STEP 7 V5.3 : Double-click on the order number and then on the Parameter button

   As of STEP 7 V5.3 : Double-click on the order number.

2. Acknowledge the dialog which prompts you to save the configuration with “OK”.

Reading the README File

The README file may contain important up-to-date information concerning the software supplied. You can read this file with the WordPad Editor under Windows.

Integrated Help Function

There is an integrated online help function for the parameter assignment dialog boxes that you can call in any phase of parameter assignment either with the F1 key or with the Help button.

5.2 Default Parameter Assignment

Default State

When you switch on the module without assigning any parameters yourself, all eight count channels are assigned as follows:

- Count signal inputs: 24 V
- Signal evaluation: pulse and direction
- Counter reading: 0
- Digital outputs Q0 to Q7 deactivated
- Hysteresis: 1
- Hardware interrupts: none
- Diagnostic interrupts: none
- Mode: continuous counting
- Hardware gate: inactive
- Software gate: closed
- Status messages and counter states: updated

With these settings you can execute simple count tasks without assigning any additional parameters.

Note

Even if you do not use all eight count channels of the FM 350-2, all the unused channels must still be assigned valid parameters. In this case it is advisable to leave the unused channels in their default state.

6 Programming the FM 350-2

6.1 Programming the FM 350-2

Introduction

For linking the FM 350-2 into a user program, you are provided with STEP 7 blocks that make handling functions easier for you.

This chapter describes these blocks.

Block Number	Block Name	Meaning	Can/Must
FC2	CNT2_CTR	Controls the FM 350-2 in simple counting applications	Must
FC3	CNT2_WR	Loads counter readings, limit values, and comparison values of the FM 350-2	Can
FC4	CNT2_RD	Reads current count and measurement values of the FM 350-2 for four channels each	Can
FC5	DIAG_RD	Reads diagnostic information in the case of a diagnostic interrupt on the FM 350-2	Can
-	Data block “counter DB”	Contains all relevant data for operating the FM 350-2, is generated from the UDT1 supplied	Must

You must use the blocks marked with “Must;” the blocks marked with “Can” are additional options.

Requirements

If you want to control the FM 350-2 via the user program, the following requirements must be fulfilled:

- Your S7-300 system must be configured.
- STEP 7 version V4.0.2.1 or upwards must be installed on your computer.
- Your programming device or PC must be connected to the CPU in the S7-300.
- You must have installed the software on your programming device/PC as specified in Chapter 5.

  The blocks are then installed in the library FM_CNTLI, the sample program is installed in the project ZXX34_01_FM350-2.
- The counter data block must be created from UDT1 and initialized (a counter DB, DB2, is already created in the example).
- The FM 350-2 module must be assigned parameters.

CPUs

The FM 350-2 can be used with the following CPUs:

- CPU 313 6ES7313-1AD01-0AB0
- CPU 314 6ES7314-1AE02-0AB0
- CPU 314 IFM 6ES7314-5AE01-0AB0
- CPU 315 6ES7315-1AF01-0AB0
- CPU 315-2DP 6ES7315-2AF01-0AB0
- CPU 614 6ES7614-1AH01-0AB3

The FM 350-2 can also be used in a distributed configuration in an ET 200M via the following interface modules.

- IM 153-1 6ES7153-1AA02-0XB0
- IM 153-2 6ES7153-2AA00-0XB0

Programming Rules

You should note the following rules when programming the FM 350-2:

- Only link the functions you actually require for your task into the program code. Any elements which are not required only place an unnecessary load on program processing and increase the memory required.
- FC2 CNT2_CTR must be called cyclically once for each FM 350-2 used.
- The data in the counter DB only become valid when the CHECKBACK_SIGNALS.PARA bit in the counter DB is set. Then the startup is also coordinated.

Direct Access

To access count and measurement values in the set user area (USER STAT) quickly from every program level, you can also use direct access with L PIW and L PID. For L PIW use the module address plus offset 8 to offset 14 as the address; for L PID use the module address plus offset 8 to offset 12 as the address.

You structure the area from module address + offset 8 in the parameter assignment dialog boxes for the FM 350-2 using the menu command **Edit > Specify Channels**.

Here you specify which value (count or measurement value) for which channel (0 to 7) should be stored at which module address. Either the low word or the high word of a value or both can be used.

The values are updated every 2 ms.

Consistency between the values when using direct access is only guaranteed if you access the values as follows in accordance with the structure of this area:

Low word or high word of the value

L PIW
possible addresses = module address +8, +10, +12, +14

Both

L PID
possible addresses = module address +8, +12

6.2 Counter Data Block

Task

All the data you require and some data required for the FCs are in a data block, the counter data block. You require a counter data block for each FM 350-2. The block contains entries for addressing the FM 350-2 and the data for the individual functions of the FM 350-2.

Creating the Counter DB

You create the counter DB in STEP 7 as a data block with associated user-defined data type. Select UDT1 as the source. UDT1 was copied into the block library for the counter (FM_CNTLI) during installation of the FCs. You must not modify UDT1. Copy UDT1 together with the FCs into your project.

To create a counter DB, proceed as follows:

1. Open the library FM_CNTLI in the SIMATIC Manager using the menu command **File > Open**.
2. Copy the data structure UDT1 from the “Blocks” container of the library FM_CNTLI to the “Blocks” container of your project.
3. Use the menu command **Insert > S7 Block > Data Block** to insert a data block, for example, DB1, in the “Blocks” container.
4. Open the data block and create the counter DB with associated user-defined data type UDT1.

Entering Addresses Automatically

In the parameter assignment dialog boxes you can make the following address entries automatically with the choice of corresponding counter DB.

If you assign the counter DB in question to another FM 350-2 or change the module address of the FM 350-2, you must adjust these address entries.

12	MOD_ADR	WORD	W#16#0	**Module address**: this must match the set input address of the FM 350-2 (“Configuring Hardware**”,** FM 350-2 Properties)
14	CH_ADR	DWORD	DW#16#0	**Channel address:** this is the same as the module address in pointer format, so module address*8.

Example

Below you will find an example of a possible method of entering addresses automatically.

1. Open your project in the SIMATIC Manager.
2. Open the hardware configuration table in your project.
3. From the hardware catalog select the FM 350-2 with the correct order number and drag it to the required slot.
4. Open the “FM 350-2 Counter” window by double-clicking this FM 350-2.
5. Change to the “Addresses” tab but retain all the settings on this page.
6. Change to the “Basic Parameters” tab.

   A dialog box is opened in which you can select a data block.

6.3 Processing Interrupts

Types of Interrupts

The FM 350-2 can trigger two types of interrupts in the CPU:

- Diagnostic interrupts
- Hardware interrupts

Requirements

For interrupt processing you must have programmed the appropriate interrupt OBs. These are:

- OB82 (I/O_FLT1) for a diagnostic interrupt
- OB40 (HW_INT1) for a hardware interrupt

Note

If you have not programmed the diagnostic interrupt OB or the hardware interrupt OB, the CPU goes into STOP when an interrupt occurs.

Interrupt Information

With both interrupt types the operating system provides you with four bytes of interrupt data which you can evaluate. These four bytes are:

- Complete for a hardware interrupt. No other data are available here.
- Group information for a diagnostic interrupt. In this case you can read other data from the FM 350-2. To do this, call the FC DIAG_RD in OB82 which then reads 16 bytes of diagnostic data from the FM 350-2 and enters them in the user DB from address 212.

Diagnostic Data

You evaluate the diagnostic data using OB82 or the counter DB. You will find the parameters you can evaluate in the table below.

Error	**Evaluate via OB82, Temporary Variables OB82-**	**Counter DB via FC DIAG_RD**		
		Byte	**Bit**	**Entries**
Module diagnostics				
Module failed	MDL_DEFECT	212	0	Bit 0 of DIAGNOSTIC_INT_INFO.BYTE0
Internal error	INT_FAULT	212	1	Bit 1 of DIAGNOSTIC_INT_INFO.BYTE0
External error	EXT_FAULT	212	2	Bit 2 of DIAGNOSTIC_INT_INFO.BYTE0
Channel error	PNT_INFO	212	3	Bit 3 of DIAGNOSTIC_INT_INFO.BYTE0
Module without parameters		212	6	Bit 6 of DIAGNOSTIC_INT_INFO.BYTE0
Incorrect parameters in module		212	7	Bit 7 of DIAGNOSTIC_INT_INFO.BYTE0
Watchdog responded	WTCH_DOG_FLT	214	3	Bit 3 of DIAGNOSTIC_INT_INFO.BYTE2
Hardware interrupt lost	HWL_INTR_FLT	215	6	Bit 6 of DIAGNOSTIC_INT_INFO.BYTE3
Channel diagnostics				
Channel error (channel 0)		219	0	Bit 0 of DIAGNOSTIC_INT_INFO.BYTE7
Channel error (channel 1)		219	1	Bit 1 of DIAGNOSTIC_INT_INFO.BYTE7
Channel error (channel 2)		219	2	Bit 2 of DIAGNOSTIC_INT_INFO.BYTE7
Channel error (channel 3)		219	3	Bit 3 of DIAGNOSTIC_INT_INFO.BYTE7
Channel error (channel 4)		219	4	Bit 4 of DIAGNOSTIC_INT_INFO.BYTE7
Channel error (channel 5)		219	5	Bit 5 of DIAGNOSTIC_INT_INFO.BYTE7
Channel error (channel 6)		219	6	Bit 6 of DIAGNOSTIC_INT_INFO.BYTE7
Channel error (channel 7)		219	7	Bit 7 of DIAGNOSTIC_INT_INFO.BYTE7
Individual error (channel 0)		220	4/6	Bit 4/6 of DIAGNOSTIC_INT_INFO.BYTE8
Individual error (channel 1)		221	4/6	Bit 4/6 of DIAGNOSTIC_INT_INFO.BYTE9
Individual error (channel 2)		222	4/6	Bit 4/6 of DIAGNOSTIC_INT_INFO.BYTE10
Individual error (channel 3)		223	4/6	Bit 4/6 of DIAGNOSTIC_INT_INFO.BYTE11
Individual error (channel 4)		224	4/6	Bit 4/6 of DIAGNOSTIC_INT_INFO.BYTE12
Individual error (channel 5)		225	4/6	Bit 4/6 of DIAGNOSTIC_INT_INFO.BYTE13
Individual error (channel 6)		226	4/6	Bit 4/6 of DIAGNOSTIC_INT_INFO.BYTE14
Individual error (channel 7)		227	4/6	Bit 4/6 of DIAGNOSTIC_INT_INFO.BYTE15

You will find the complete assignments for the data sets 0 and 1 in Chapter 11 from page 11-6.

Hardware Interrupt Data

In the case of a hardware interrupt the FM 350-2 provides four bytes of hardware interrupt data which are stored in the status information of OB40 in the temporary variable OB40_POINT_ADDR (bytes 8 to 11). You load the temporary variable with the command L # OB40_POINT_ADDR.

Mode: Single counting, Continuous counting, Periodic counting									
Channel	Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	8					Com-parator tripped	Overflow/ Underflow	Close hardware gate	Open hardware gate
1		Com-parator tripped	Overflow/ Underflow	Close hardware gate	Open hardware gate				
2 to 7	9 to 11	See Byte 8							
Mode: Frequency measurement									
Channel	Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	8					Upper/ lower frequency limit exceeded	Frequency measure-ment ended	Close hardware gate	Open hardware gate
1		Upper/ lower frequency limit exceeded	Frequency measure-ment ended	Close hardware gate	Open hardware gate				
2 to 7	9 to 11	See Byte 8							
Mode: Rotational speed measurement									
Channel	Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	8					Upper/ lower rot. speed limit exceeded	Rot. speed measure-ment ended	Close hardware gate	Open hardware gate
1		Upper/ lower rot. speed limit exceeded	Rot. speed measure-ment ended	Close hardware gate	Open hardware gate				
2 to 7	9 to 11	See Byte 8							
Mode: Period duration measurement									
Channel	Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	8					Upper/ lower time limit exceeded	Period duration measure-ment ended	Close hardware gate	Open hardware gate
1		Upper/ lower time limit exceeded	Period duration measure-ment ended	Close hardware gate	Open hardware gate				
2 to 7	9 to 11	See Byte 8							
Mode: Proportioning									
Channel	Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	8	-	Overflow/ Under-flow	Com-parator 4 tripped	Com-parator 3 tripped	Com-parator 2 tripped	Com-parator 1 tripped	Close hardware gate	Open hardware gate
1	10	See Byte 8							

6.4 The CNT2_CTR Function (FC2), Control the Module

Task

With the CNT2_CTR function you control the digital outputs (enable and disable them) and the software gates of the FM 350-2. You also receive checkback signals from the FM 350-2.

Actions

The CNT2_CTR function executes the following actions:

1. Initializes the counter DB.
2. Reads the checkback signals. The read values are stored by the FC in the counter DB in the structure CHECKBACK_SIGNALS.
3. Transfers the control signals from the counter DB (CONTROL_SIGNALS structure) to the FM 350-2.

Call

You must call the FC CNT2_CTR cyclically (in OB1 or in the cyclic interrupts - only OB35 in S7-300) for each module. Calling the FC CNT2_CTR in an interrupt program is not permitted.

Before the FC CNT2_CTR call, enter the current control signals in the CONTROL_SIGNALS structure in the counter DB. After the FC CNT2_CTR call the checkback signals are updated in the CHECKBACK_SIGNALS structure in the counter DB and you can continue processing them from there.

The number of the counter DB is specified in the FC call at the parameter DB_NO.

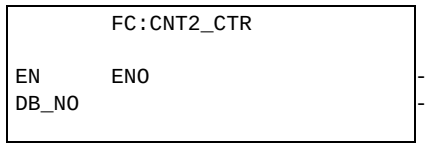
Representation

The FC CNT2_CTR call in the STL and LAD methods of representation is given below.

STL method of representation

```
CALL           CNT2_CTR       (
               DB_NO                  :=
       );
```

LAD method of representation



FC CNT2_CTR Parameters

The following Table lists the FC CNT2_CTR parameters:

Parameter	Declaration Type	Data Type	Meaning	The User...	The Block...
DB_NO	INPUT	WORD	Number of counter DB	enters it	queries it

Counter DB

The FC CNT2_CTR works together with the counter DB. You will require a counter DB for each FM 350-2 which contains the entries for addressing the FM 350-2 and the data for the individual functions of the FM 350-2. The number of the counter DB is specified in the FC call at the parameter DB_NO.

Address	Name	Data Type	Initial Value	Comment
21.0 - 7	CTRL_DQ0 - 7	BOOL	FALSE	Enables the digital outputs 0 to 7
22.0 - 7	SET_DQ0 - 7	BOOL	FALSE	Sets the digital outputs 0 to 7
23.0 - 7	SW_GATE0 - 7	BOOL	FALSE	Software gate counters 0 to 7

Address	Name	Data Type	Initial Value	Comment
36.1	STS_TFB	BOOL	FALSE	TRUE: PG operation is active, controlling not possible from CPU FALSE: PG operation deactivated
36.4	DATA_ERR	BOOL	FALSE	TRUE: Data error occurred FALSE: No data error
36.7	PARA	BOOL	FALSE	TRUE: FM 350-2 has parameters assigned, all other CHECKBACK_SIGNALS are valid FALSE: FM 350-2 has no parameters assigned
37.0 - 7	STS_CMP0 - 7	BOOL	FALSE	Status of comparators 0 to 7 or status of SET_DQ0 - 7 after digital outputs were set You must evaluate the status after the FC CNT2_CTR call because it is then reset
38.0 - 7	STS_UFLW0 - 7	BOOL	FALSE	Status of underflow counters 0 to 7 in main count direction “down” You must evaluate the status after the FC CNT2_CTR call because it is then reset
39.0 - 7	STS_OFLW0 - 7	BOOL	FALSE	Status of overflow counters 0 to 7 in main count direction “up” You must evaluate the status after the FC CNT2_CTR call because it is then reset
40.0 - 7	STS_DIR0 - 7	BOOL	FALSE	Status of count direction counters 0 to 7, applies to the last recorded count pulse TRUE: Counter counts down FALSE: Counter counts up

Address	Name	Data Type	Initial Value	Comment
41.0 - 7	STS_DI0 - 7	BOOL	FALSE	Status of hardware gates 0 to 7, i.e. the status of the corresponding digital input
42.0 - 7	STS_DQ0 - 7	BOOL	FALSE	Status of digital outputs 0 to 7
43.0 - 7	STS_GATE0 - 7	BOOL	FALSE	Status of internal gate counters 0 to 7
44	USER_STAT_ WORD0	WORD	W#16#0	Depends on parameters set for count/measured value
46	USER_STAT_ WORD1	WORD	W#16#0	Depends on parameters set for count/measured value
48	USER_STAT_ WORD2	WORD	W#16#0	Depends on parameters set for count/measured value
50	USER_STAT_ WORD3	WORD	W#16#0	Depends on parameters set for count/measured value

Initializing the Counter DB

Operating the FM 350-2 is only permitted if the CHECKBACK_SIGNALS.PARA bit is set. When the FM 350-2 starts up, the FC deletes the structures CONTROL_SIGNALS, JOB_WR status, JOB_RD status, RESERVE_0, and RESERVE_1 in the counter DB.

6.5 The CNT2_WR Function (FC3), Load Counter Readings, Limit Values, and Comparison Values

Task

With the CNT2_WR function you load the counters and comparators for the FM 350-2 using write jobs. For this you must call the function CNT2_WR as required for each module.

You link the function CNT2_WR into your program only if you have to reload the counters and comparators for the FM 350-2 during operation.

Actions

The FC CNT2_WR executes the following actions:

- Executes the write job (JOB_WR) from the counter DB.
- Transfers the relevant data from the counter DB.
- Displays the status of the write job.

Call

The FC CNT2_WR can be called either cyclically or in a time-driven program. Calling the FC CNT2_WR in an interrupt program is not permitted.

Before processing write jobs you must supply the data area for the write job with the relevant values. The last write job must be completed, meaning JOB_WR.NO (data byte DBB0) is deleted in the counter DB.

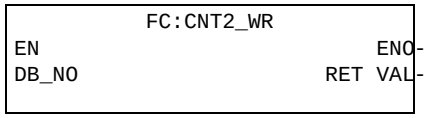
Representation

The FC CNT2_WR call in the STL and LAD methods of representation is given below.

STL method of representation

```
CALL              CNT2_WR (
                  DB_NO          :=          ,
                  RET_VAL        :=         );
```

LAD method of representation



FC CNT2_WR Parameters

The following Table lists the FC CNT2_WR parameters:

Name	Declaration Type	Data Type	Meaning	The User...	The Block...
DB_NO	INPUT	WORD	Number of counter DB	enters it	queries it
RET_VAL	OUTPUT	INT	Return code for SFC58 WR_REC	queries it	enters it

Write Job

You trigger a new write job by entering a write job in JOB_WR.NO. The following write jobs are permitted:

JOB_ WR.NO (DBB0)	Entry in UDT1	Address in Counter DB	Meaning: Counting Mode	Meaning: Frequency Mode
0	None	None	No write job / last write job completed	
10	LOAD_VAL0	52	Load counter 0	Load lower limit 0
11	LOAD_VAL1	56	Load counter 1	Load lower limit 1
12	LOAD_VAL2	60	Load counter 2	Load lower limit 2
13	LOAD_VAL3	64	Load counter 3	Load lower limit 3
14	LOAD_VAL4	68	Load counter 4	Load lower limit 4
15	LOAD_VAL5	72	Load counter 5	Load lower limit 5
16	LOAD_VAL6	76	Load counter 6	Load lower limit 6
17	LOAD_VAL7	80	Load counter 7	Load lower limit 7
20	LOAD_PREPARE_VAL0	84	Load counter 0 in preparation	Load upper limit 0
21	LOAD_PREPARE_VAL1	88	Load counter 1 in preparation	Load upper limit 1
22	LOAD_PREPARE_VAL2	92	Load counter 2 in preparation	Load upper limit 2
23	LOAD_PREPARE_VAL3	96	Load counter 3 in preparation	Load upper limit 3
24	LOAD_PREPARE_VAL4	100	Load counter 4 in preparation	Load upper limit 4
25	LOAD_PREPARE_VAL5	104	Load counter 5 in preparation	Load upper limit 5
26	LOAD_PREPARE_VAL6	108	Load counter 6 in preparation	Load upper limit 6
27	LOAD_PREPARE_VAL7	112	Load counter 7 in preparation	Load upper limit 7
30	CMP_VAL0	116	Load comparator 0	
31	CMP_VAL1	120	Load comparator 1	
32	CMP_VAL2	124	Load comparator 2	
33	CMP_VAL3	128	Load comparator 3	
34	CMP_VAL4	132	Load comparator 4	
35	CMP_VAL5	136	Load comparator 5	
36	CMP_VAL6	140	Load comparator 6	
37	CMP_VAL7	144	Load comparator 7	
40	LOAD_VAL0 to LOAD_VAL3	52 - 67	Load counters 0 to 3	Load lower limit 0 to 3
41	LOAD_VAL4 to LOAD_VAL7	68 - 83	Load counters 4 to 7	Load lower limit 4 to 7
42	LOAD_VAL0 to LOAD_VAL7	52 - 83	Load counters 0 to 7	Load lower limit 0 to 7
50	LOAD_PREPARE_VAL0 to LOAD_PREPARE_VAL3	84 - 99	Load counters 0 to 3 in preparation	Load upper limit 0 to 3
51	LOAD_PREPARE_VAL4 to LOAD_PREPARE_VAL7	100 - 111	Load counters 4 to 7 in preparation	Load upper limit 4 to 7
52	LOAD_PREPARE_VAL0 to LOAD_PREPARE_VAL7	84 - 111	Load counters 0 to 7 in preparation	Load upper limit 0 to 7
60	CMP_VAL0 to CMP_VAL3	116 - 131	Load comparators 0 to 3	
61	CMP_VAL4 to CMP_VAL7	132 - 147	Load comparators 4 to 7	
62	CMP_VAL0 to CMP_VAL7	116 - 147	Load comparators 0 to 7	

Write Job Status

The status of a write job is displayed in the counter DB (data byte DBB1).

Bit in JOB_WR (DBX1.)	Meaning
.BUSY, 0	= 1: Write job running. The function CNT2_WR sets this bit as soon as it processes a write job (JOB_WR.NO > 0 and JOB_WR.IMPOSS = 0). The function CNT2_WR clears the bit as soon as the write job is completed (JOB_WR.NO = 0).
.DONE, 1	= 1: Write job completed. The function CNT2_WR sets this bit as soon as a write job (even a faulty one) is completed. The function CNT2_WR clears the bit when a new write job starts. You can also clear this bit via the user program.
.IMPOSS, 2	= 1: Write job cannot be processed (the FM 350-2 is not assigned parameters, startup or PG operation are active). You can leave the write job (JOB_WR) or delete it. The function CNT2_WR clears the bit when the above conditions are fulfilled.
.UNKNOWN, 3	= 1: Write job unknown. The write job (JOB_WR) you specified is not in the permitted range (see error message). The function CNT2_WR clears this bit as soon as a valid number is entered in JOB_WR. The unknown number is retained until this happens.

Error Messages

Any errors which occurred are displayed in the binary result bit (BR = 0). Possible errors are:

- Unknown write job (see JOB_WR.UNKNOWN).
- Data transfer error when transferring data with SFC58 “WR_REC”. The error is indicated at the output parameter RET_VAL (see *STEP 7 Standard and System Functions Reference Manual*).
- The transferred data are checked for data errors and interpreted by the module. If a data error occurs, the bit CHECKBACK_SIGNALS.DATA_ERR = “1” is set in the counter DB. You will find more information on data errors in the parameter assignment dialog boxes under the menu command **Debug > Diagnostics**.

6.6 The CNT2_RD Function (FC4), Read Count and Measurement Values from the Module

Task

With the function CNT2_RD you read the count and measurement values from the FM 350-2 using read jobs. For this you must call the function CNT2_RD cyclically once for each module.

You do not link the function CNT2_RD into your program if you are not processing any read jobs.

Caution

If data records are read continuously, the test operation with the Start up dialog of the configuration software will be affected negatively. The CPU will cancel the data records reading by the configuration package, for example, The CPU will cancel the parameter download if the user program requests a read job. Thus, read jobs should be executed quickly if there is no or hardly any read job request during the test period.

Actions

The FC CNT2_RD executes the following actions:

- Executes the read job (JOB_RD) from the counter DB.
- Transfers the relevant data to the counter DB.
- Displays the status of the read job.

Call

The FC CNT2_RD can be called either cyclically or in a time-driven program. Calling the FC CNT2_RD in an interrupt program is not permitted.

The last read job must be completed, meaning JOB_RD.NO (data byte DBB2) is deleted in the counter DB.

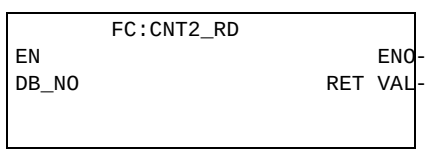
Representation

The FC CNT2_RD call in the STL and LAD methods of representation is given below.

STL method of representation

```
CALL              CNT2_RD          (
                  DB_NO            :=       ,
                  RET_VAL          :=      );
```

LAD method of representation



FC CNT2_RD Parameters

The following Table lists the FC CNT2_RD parameters:

Name	Declaration Type	Data Type	Meaning	The User...	The Block...
DB_NO	INPUT	WORD	Number of counter DB	enters it	queries it
RET_VAL	OUTPUT	INT	Return code for SFC59 RD_REC	queries it	enters it

Read Job

You trigger a new read job by entering a read job in JOB_RD.NO. The following read jobs are permitted:

JOB_RD.NO (DBB2)	Entry in UDT1	Address in Counter DB	Meaning
0	None	None	No read job / last read job completed
100	ACT_CNTV0 ACT_MSRV0 ACT_CNTV1 ACT_MSRV1 ACT_CNTV2 ACT_MSRV2 ACT_CNTV3 ACT_MSRV3	148 to 179	Current counter reading 0 to 3 and measurement result 0 to 3
101	ACT_CNTV4 ACT_MSRV4 ACT_CNTV5 ACT_MSRV5 ACT_CNTV6 ACT_MSRV6 ACT_CNTV7 ACT_MSRV7	180 to 211	Current counter reading 4 to 7 and measurement result 4 to 7

Read Job Status

The status of a read job is displayed in the counter DB (data byte DBB3).

Bit in JOB_RD (DBX3.)	Meaning
.BUSY, 0	= 1: Read job running. The function CNT2_RD sets this bit as soon as it processes a read job (JOB_RD.NO > 0 and JOB_RD.IMPOSS = 0). The function CNT2_RD clears the bit as soon as the read job is completed (JOB_RD.NO = 0).
.DONE, 1	= 1: Read job completed. The function CNT2_RD sets this bit as soon as a read job (even a faulty one) is completed. The function CNT2_RD clears the bit when a new read job starts. You can also clear this bit via the user program.
.IMPOSS, 2	= 1: Read job cannot be processed (the FM 350-2 is not assigned parameters, startup or PG operation are active). You can leave the read job (JOB_RD) or delete it. The function CNT2_RD clears the bit when the above conditions are fulfilled.
.UNKNOWN, 3	= 1: Read job unknown. The read job (JOB_RD) you specified is not in the permitted range (see error evaluation). The function CNT2_RD clears this bit as soon as a valid number is entered in JOB_RD.NO. The unknown number is retained until this happens.

Error Messages

Any errors which occurred are displayed in the binary result bit (BR = 0). Possible errors are:

- Unknown read job (see JOB_RD.UNKNOWN).
- Data transfer error when transferring data with SFC59 “RD_REC”. The error is indicated at the output parameter RET_VAL (see *Reference Manual: System Software for S7-300 and S7-400, System and Standard Functions*).

6.7 The DIAG_RD Function (FC5), Read Diagnostic Interrupt Data

Task

With the function DIAG_RD you can load the diagnostic interrupt data into the counter DB in the case of a diagnostic interrupt.

Actions

The FC DIAG_RD executes the following actions:

- Reads 16 bytes of diagnostic data from the FM 350-2
- Enters these data in the counter DB in the data area DIAGNOSTIC_IN_INFO

These data contain the diagnostic status of the whole module (covering all counters).

Call

The function DIAG_RD can only be called in the interrupt OB82.

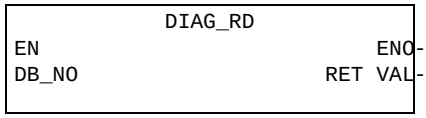
Representation

The FC DIAG_RD call in the STL and LAD methods of representation is given below.

STL method of representation

```
CALL           DIAG_RD(
                  DB_NO            :=       ,
                  RET_VAL          :=       , -
                                            -
```

LAD method of representation



FC DIAG_RD Parameters

The following Table lists the FC DIAG_RD parameters (see also Section 6.3).

Name	Declaration Type	Data Type	Meaning	The User...	The Block...
DB_NO	INPUT	WORD	Number of counter DB	enters it	queries it
RET_VAL	OUTPUT	INT	Return code for SFC51 RDSYSST	queries it	enters it

6.8 Application and Programming Example for FM 350-2

Overview

In this example, two different applications are fulfilled with the counter module FM 350-2. One application uses the count channels 0 and 1 as a filling unit. The second application works with count channel 4 to record frequencies with a limit value check.

Filling Unit

A box must be filled with a specific number of parts from a container. The count channel 0 counts the parts and controls the valve to fill the box. The motor to transport the boxes is controlled and the number of boxes is counted with count channel 1.

When the box is in the correct position, the valve is opened and the box is filled with parts. When the specified number of parts is reached, the valve is closed and the transport of the boxes is started. Any following parts continue to be counted until a new box appears.

A new number of parts can be specified during the transport of the box. The number of parts placed in a box and the number of boxes can be monitored.

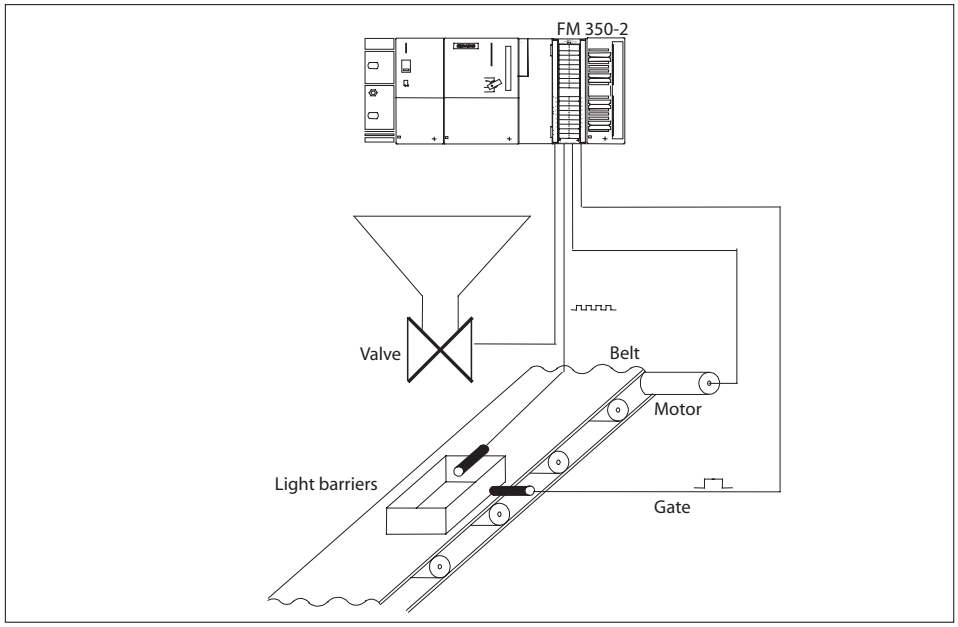


Figure 6-1 Example for Using an FM 350-2 in the S7-300 (Filling Unit)

Frequency Measurement

At count channel 4 frequencies of up to 10 kHz are measured. The measured frequency is subject to a limit value check for the lower limit 1 kHz and the upper limit 9 kHz. The status of the limit values and the measured frequency and the continuously counted pulses can be monitored.

Project ZXX34_01_FM350-2

The whole example is located in the STEP 7 project ZXX34_01_FM350-2. The project is part of the configuration package for FM 350-2.

The project comprises the following components:

- The hardware configuration of the SIMATIC S7-300 station with the parameter assignments for the FM 350-2
- The programming example with the blocks (system data, FC2, FC3, FC4, FC5, FC100, DB2, OB1, OB82, UDT1, VAT1, and SFC46)
- The source files for the programming example (CNT2_CYC and UDT1)
- The symbols

Requirements

The following requirements must be fulfilled:

- You must have a SIMATIC S7-300 station, comprising a power supply module, a CPU 314, a digital input/output module DI8/DO8x24V/0.5A, with the necessary accessories such as expansion bus and front connectors. You will find more information in the ZXX34_01_FM350-2 project under “HW Config - Configuring Hardware: SIMATIC 300 Station (1).”
- STEP 7 (≥ V 4.0.2.1) must be correctly installed on your programming device.
- The programming device must be connected to the CPU.
- You must have an FM 350-2 module, the corresponding software, and the necessary accessories such as expansion bus, front connectors, encoders or switches, and wiring material.

Installing the Software on the Programming Device

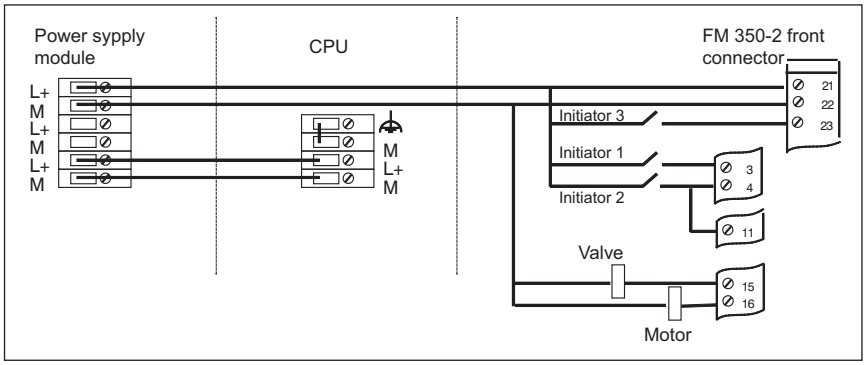
The parameter assignment package contains the dialog boxes for assigning the FM 350-2 parameters, the necessary functions (FCs), and the data structure (UDT) in the library FM_CNTLI, and the programming example ZXX34_01_FM350-2.

1. Install the software from this copy of the CD by launching the SETUP.EXE installation program on diskette 1 in the setup catalog.
2. Follow the instructions on the installation program.

Installing and Wiring the FM 350-2

To install and wire up the FM 350-2, proceed as follows:

1. Plug the expansion bus supplied with the FM 350-2 into the bus connector on the CPU.
2. Hook the FM 350-2 onto the DIN rail, swing it down, and screw it tight (you will find a more detailed description in Section 3.2 of this manual).
3. Wire up the front connector as follows (you will find the complete terminal assignments for the front connector in Chapter 4).



Terminal	Name	Meaning
21	L +	24-V module supply
22	M	Ground
23	A4	Frequency input from 24-V initiator 3
3	A0	Count pulses for parts from 24-V initiator 1
4	A1	Count pulses for boxes from 24-V initiator 2
11	I0	Box in position (hardware gate) from terminal 4
15	Q0	Valve control fill box with parts
16	Q1	Motor control for transporting boxes

4. Plug the front connector into the FM 350-2 and screw it tight.

Debugging

Switch on the voltage on the power supply module. The red LED SF on the FM 350-2 illuminates briefly and extinguishes again after a successful self-test of the FM 350-2.

When you switch on the power supply for the first time, the FM 350-2 has the default parameters assigned (the features of the default parameter assignment are described in Section 5.2).

Checking Parameters

To check the parameters, proceed as follows:

1. Open the ZXX34_01_FM350-2project in the SIMATIC Manager.
2. Open the SIMATIC 300 object.

   The station described above under Requirements is displayed under "HW Config - Configuring Hardware: SIMATIC 300." The parameter assignments for the applications described above are also stored there under "FM 350-2 Counter."

   You display the parameters by double-clicking the FM 350-2 to open the "FM 350-2 Counter" window, showing "General," "Addresses," and the "Basic Parameters" of the FM 350-2.
3. Click the "Parameters" button.

   The parameter assignment dialog boxes for the FM 350-2 are opened. Here the parameters for encoders, operating modes, interrupt enable, and outputs are stored for each channel.

   Using the menu command **Edit > Specify Channels** you will find the global settings for all channels of the FM 350-2.
4. Enter the parameter assignments for the FM 350-2 in the hardware configuration using the menu command **File > Save** and close the "FM 350-2 Counter" window by clicking the "OK" button.
5. Save the hardware configuration with the menu command **Station > Save**.
6. Exit the Hardware Configuration application with **Station > Exit**.

Downloading the Sample Program

To download the sample program, proceed as follows:

1. Open the block container in the project ZXX34_01_FM350-2 via **SIMATIC 300 > CPU 314 > S7 Program > Blocks** by clicking on Blocks.
2. Download the whole example (blocks) to the CPU using the menu command **PLC > Download**.

Executing the Sample Program

The sample program is executed in OB1. The FC100 called there contains both applications and the corresponding calls for the functions CNT2_CTR, CNT2_WR, and CNT2_RD.

1. Switch the CPU to RUN-P.
2. Modify and monitor the example via the digital input/output module and the variable table VAT1.

Input/Output Assignments

The inputs and outputs are assigned in OB1 memory bits.

Input	**Memory Bit**	**Symbol**	**Meaning**
I 0.0	M 0.0	stfill	TRUE: Starts the filling unit
I 0.1	M 0.1	stfrequ	TRUE: Starts recording frequencies
I 0.2	M 0.2	in_load	FALSE ->TRUE: Triggers a new quantity
I 0.3	M 0.3	in_act_val	TRUE: Selects read actual values
I 0.4	M 0.4	ch_act_val	Selects actual values FALSE: from count channels 0 to 3 TRUE: from count channels 4 to 7
Output	**Memory Bit**	**Symbol**	**Meaning**
Q 0.0	M 2.0	state_load	TRUE: Load new quantity executed
Q 0.1	M 2.1	err_wr	TRUE: Error loading quantity
Q 0.2	M 2.2	err_rd	TRUE: Error reading actual values
Q 0.3	M 2.3	oflw	TRUE: Upper frequency limit exceeded
Q 0.4	M 2.4	uflw	TRUE: Lower frequency limit not reached

Monitoring Using the Variable Table

To monitor using the variable table, proceed as follows:

1. Open the block VAT1 by double-clicking it.
2. Switch online with the menu command **PLC > Connect To > Configured CPU**.
3. Start monitoring with the menu command **Variable > Monitor.**

Filling Unit Application Procedure

Below is a description of the sequence of operations of the filling unit application:

1. Start the filling unit application by setting the input I 0.0.

   The output Q 1 of the FM 350-2 is set to bring the box into position.

2. Activate the 24-V initiator 2 (box in position / count pulses for boxes) when the box is in position.

   In VAT1 “fill_unit1”.CHECKBACK_SIGNALS.USER_STAT_ WORD1 (number of boxes) 1 is displayed.

   Then the valve is opened via the output Q 0 of the FM 350-2 and the parts are counted. When you activate the 24-V initiator 1, the number of filled parts in “fill_unit1”.CHECKBACK_SIGNALS. USER_STAT_ WORD0 (number of parts) is incremented.

   When the count reaches 10 parts the valve is closed and the transport of the box is activated.

   When the next box is in position the procedure is repeated.

You can change the number of parts as follows:

3. Enter the new quantity in VAT1 under “quant” in the modify value.

   The new quantity is specified with the menu command **Variable > Modify**.

4. Set the input I 0.2 to load the new quantity.

   When loading is completed the output Q 0.0 is set.

5. Delete the input I 0.2.

   The output Q 0.0 also goes out.

Frequency Recording Application Procedure

Below is a description of the sequence of operations of the frequency recording application:

1. Start the application for recording frequencies by setting the input I 0.1.
2. Activate the 24-V initiator 3 (frequency input), for example, by connecting a frequency generator. You must ensure that the input level is correct.

   The measured frequency value is displayed in VAT1 in DB2.DBD48.

   An underflow of the lower frequency limit 1 kHz is displayed at the output Q 0.4.

   An overflow of the upper frequency limit 9 kHz is displayed at the output Q 0.3.

You can also read the actual values (count and measurement values) of the count channels 4 to 7.

3. Set the input I 0.4 and the input I 0.3.

   As long as these are set, the actual values are displayed in VAT1 “fill_unit1”.ACT_CNTV4 to “fill_unit1”.ACT_MSRV7.

   You can also read the actual values for the count channels 0 to 3 by deleting the input I 0.4. These values are not displayed in VAT1.

Diagnostics

Incorrect wiring can lead to errors which the FM 350-2 indicates by means of the group error LED SF. The FM 350-2 can trigger a diagnostic interrupt in these cases if the basic parameters were set accordingly (“Generate Interrupt: Yes” and “Select Interrupt: Diagnostics or Diagnostics+Hardware”). In the sample program the diagnostic interrupt OB82 is programmed for this purpose. It enters the current diagnostic information for the FM 350-2 in the counter DB.

6.9 Technical Specifications of the Blocks

Technical Specifications	**CNT2_CTR**	**CNT2_WR**	**CNT2_RD**	**DIAG_RD**
Block number	FC2	FC3	FC4	FC5
Version	1.00	1.00	1.00	1.00
Assignment in work memory in bytes	212	796	366	162
Assignment in load memory in bytes	320	992	496	278
Assignment in local data area in bytes	6	24	24	34
System function called		SFC58 WR_REC	SFC59 RD_REC	SFC51 RDSYSST
Execution times typical runtime [ms]				
CPU 313 6ES7313-1AD01-0AB0	0.6	0.4 (without data transmission) 2.8 (data transmission job 42) 2.2 (data transmission job 10)	0.3 (without data transmission) 2.9 (with data transmission)	2.5
CPU 314 6ES7314-1AE02-0AB0 release 2 CPU 314 IFM 6ES7314-5AE01-0AB0	0.6	0.5 (without data transmission) 3.0 (data transmission job 42) 2.3 (data transmission job 10)	0.3 (without data transmission) 3.0 (with data transmission)	2.7
CPU 315 6ES7315-1AF01-0AB0 CPU 315-2DP 6ES7315-2AF01-0AB0	0.5	0.3 (without data transmission) 2.6 (data transmission job 42) 2.0 (data transmission job 10)	0.2 (without data transmission) 2.6 (with data transmission)	2.3
CPU 614 6ES7614-1AH01-0AB3	0.5	0.3 (without data transmission) 2.1 (data transmission job 42) 1.7 (data transmission job 10)	0.2 (without data transmission) 2.3 (with data transmission)	2.0

7 Starting Up the FM 350-2

7.1 Mechanical Installation Checklist

Action	Options/Procedure			(X)
Install FM 350-2	1. Loosen neighboring module and connect expansion bus. 2. Hook module into position and tighten screw. 3. Attach slot number. 4. Install shield attachment.			
Select cables	Observe rules and specifications in Section 4.2.			
Connect NAMUR encoders	**Terminal**	**Name**	**Function**	
	3	A0	Channel 0 count input NAMUR	
	4	A1	Channel 1 count input NAMUR	
	5	A2	Channel 2 count input NAMUR	
	6	A3	Channel 3 count input NAMUR	
	23	A4	Channel 4 count input NAMUR	
	24	A5	Channel 5 count input NAMUR	
	25	A6	Channel 6 count input NAMUR	
	26	A7	Channel 7 count input NAMUR	
	19	P8V2	NAMUR encoder supply	
	20	P8V2	NAMUR encoder supply	
	39	P8V2	NAMUR encoder supply	
	40	P8V2	NAMUR encoder supply	
Connect 24-V pulse encoder without direction level (initiator/BERO)	**Terminal**	**Name**	**Function**	
	3	A0	Channel 0 count input BERO	
	4	A1	Channel 1 count input BERO	
	5	A2	Channel 2 count input BERO	
	6	A3	Channel 3 count input BERO	
	23	A4	Channel 4 count input BERO	
	24	A5	Channel 5 count input BERO	
	25	A6	Channel 6 count input BERO	
	26	A7	Channel 7 count input BERO	

Action	**Options/Procedure**			**(X)**
Connect 24-V pulse encoder with direction level Connect 24-V incremental encoder	**Terminal**	**Name**	**Function**	
	3	A0	Channel 0 count input BERO	
	4	A1	Channel 1 count input BERO	
	5	A2	Channel 2 count input BERO	
	6	A3	Channel 3 count input BERO	
	23	A4	Channel 4 count input BERO	
	24	A5	Channel 5 count input BERO	
	25	A6	Channel 6 count input BERO	
	26	A7	Channel 7 count input BERO	
	7	B0	Channel 0 direction input BERO	
	8	B1	Channel 1 direction input BERO	
	9	B2	Channel 2 direction input BERO	
	10	B3	Channel 3 direction input BERO	
	27	B4	Channel 4 direction input BERO	
	28	B5	Channel 5 direction input BERO	
	29	B6	Channel 6 direction input BERO	
	30	B7	Channel 7 direction input BERO	
Wire digital inputs and outputs	**Terminal**	**Name**	**Function**	
	11	I0	Channel 0 digital input HW gate	
	12	I1	Channel 1 digital input HW gate	
	13	I2	Channel 2 digital input HW gate	
	14	I3	Channel 3 digital input HW gate	
	31	I4	Channel 4 digital input HW gate	
	32	I5	Channel 5 digital input HW gate	
	33	I5	Channel 6 digital input HW gate	
	34	I7	Channel 7 digital input HW gate	
	15	Q0	Channel 0 digital output 0.5 A	
	16	Q1	Channel 1 digital output 0.5 A	
	17	Q2	Channel 2 digital output 0.5 A	
	18	Q3	Channel 3 digital output 0.5 A	
	35	Q4	Channel 4 digital output 0.5 A	
	36	Q5	Channel 5 digital output 0.5 A	
	37	Q6	Channel 6 digital output 0.5 A	
	38	Q7	Channel 7 digital output 0.5 A	
Connect auxiliary voltage	**Terminal**	**Name**	**Function**	
	21	L+	24-V module supply	
	22	M	Ground module supply	

7.2 Parameter Assignment Checklist

Action	Options/Procedure	(X)
Basic parameters	Generate Interrupt Select Interrupt Reaction to CPU STOP	
Addresses	Inputs Outputs Interrupt OB	
Specify channels	Channels 0 to 7 as Single Counter Channel 0 as Proportioning Counter, Channels 4 to 7 as Single Counter Channels 0 to 3 as Single Counter, Channel 4 as Proportioning Counter Channel 0 and Channel 4 as Proportioning Counter	
	Counter Input Channel 0 to 3 Namur Counter Input Channel 4 to 7 Namur	
Status display User_Type 1	Channel Count value/measurement value Channel Count value/measurement value	
Status display User_Type 2	Channel Count value/measurement value Channel Count value/measurement value	

Action	Options/Procedure		(X)
Encoders Channel n	Signal Evaluation	Pulse and Direction	
		Single Rotary Transducer	
		Double Rotary Transducer	
		Quadruple Rotary Transducer	
	Inverted Direction		
	Pulses per Encoder Rotation		
	Hardware Monitoring	Off	
		On	
	Main Count Direction	Up	
		Down	
	Hysteresis		
Operating Modes Channel n	Continuous Counting	Use Hardware Gate	
		Cancel Count Process on Closing a Gate	
		Interrupt Count Process on Closing a Gate	
	Single Counting	Start/End Value	
		Use Hardware Gate	
		Cancel Count Process on Closing a Gate	
		Interrupt Count Process on Closing a Gate	
	Periodic Counting	Start/End Value	
		Use Hardware Gate	
		Cancel Count Process on Closing a Gate	
		Interrupt Count Process on Closing a Gate	
	Frequency Measurement	Time Window	
		Use Hardware Gate	
	Rotational Speed Measurement	Time Window	
		Use Hardware Gate	
	Period Duration Measurement	Time Window	
		Use Hardware Gate	
	Proportioning	Start/End Value	
		Use Hardware Gate	
		Cancel Count Process on Closing a Gate	
		Interrupt Count Process on Closing a Gate	
Outputs Channel n	Output Behavior	No Comparison	
		On if Count >= Comparison Value	
		On if Count <= Comparison Value	
	Substitute Values	Substitute Value 1 Substitute Value 2	
		Substitute Value 3 Substitute Value 4	
Interrupt Enable Channel n	Opening the Hardware Gate		
	Closing the Hardware Gate		
	Overflow/Underflow		
	Measurement End Reached		
	Below Limit		
	Above Limit		
	Reaching Comparison Value 1 Reaching Comparison Value 2		
	Reaching Comparison Value 3 Reaching Comparison Value 4		

8 Operating Modes, Settings, Parameters, and Jobs

8.1 Definitions

Which Operating Modes are Available?

There are seven operating modes with which you can operate the channels of the FM 350-2. The following Table gives an overview of these operating modes.

Name	Description
Continuous Counting	The FM 350-2 counts continuously from the current counter reading on opening the internal gate.
Single Counting	The FM 350-2 counts from the start value to the end value on opening the internal gate.
Periodic Counting	The FM 350-2 counts between the start value and the end value on opening the internal gate.
Frequency Measurement	The FM 350-2 determines the frequency of the pulse sequence applied at the input.
Rotational Speed Measurement	The FM 350-2 determines the rotational speed of the device connected at the input.
Period Duration Measurement	The FM 350-2 determines the pulse duration of the pulse sequence applied at the input.
Proportioning	Four channels of the FM 350-2 are used for proportioning.

The default setting is the continuous counting mode.

What Settings are Available?

You can adapt the FM 350-2 to your counting task with three settings. The following Table gives an overview of these settings.

Name	Description
Behavior of the digital outputs	You can choose between three possibilities for the behavior of the outputs on reaching the comparison value.
Triggering hardware interrupts	The FM 350-2 can trigger a hardware interrupt in the case of a variety of selectable events.
Encoders	You must specify different settings for the encoder used. These settings are described in Chapter 9.

Basic Parameter Assignment

You assign basic parameters for each FM 350-2 when you configure the hardware. The following Table gives the meanings of the relevant parameters.

Name	Option	Description
Generate Interrupt	No Yes	You enable interrupt generation with this selection
Select Interrupt	None Diagnostics Hardware Diagnostics + Hardware	You enable the relevant interrupts with this selection
Reaction to CPU STOP	Cancel	Immediate switch off of the outputs Termination of count
	Continue	The module continues
	Substitute Values	Current count functions are terminated. The module switches the set substitute values to the outputs channel by channel.
	Last Value	Current count functions are terminated. The outputs of the module are frozen at their state immediately before the stop.

8.2 Basic Information on Calling Operating Modes, Settings, and Jobs

How Do You Select Operating Modes and Settings?

You select the operating modes and settings in the parameter assignment dialog boxes of the FM 350-2.

You will find notes on installing the parameter assignment dialog boxes and on assigning parameters to the FM 350-2 in Chapter 5 and in the integrated online help.

How Do You Change Operating Modes and Settings?

You can change an operating mode or setting in the parameter assignment dialog boxes. The new operating mode or setting becomes valid after the next transition from STOP to RUN of the CPU.

Jobs

Jobs are: reading the count values and measurement values, writing the load values, count values, comparison values, and limit values.

Control Bits and Status Bits in the DB

In addition to the control bits, there are status bits in the DB that signal the status of the current operating mode.

Transferring the Control Bits and Status Bits

You transfer the status bits and the control bits to and from the module with the function CNT2_CTR that you must link into your user program.

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

You will find the exact description of the FC CNT2_CTR in Chapter 6 and you will find the DB assignments in Chapter 10.

8.3 Continuous Counting

Definition

In this mode the FM 350-2 counts continuously from the current counter reading (start value, default setting = 0):

- If the counter reaches the upper limit and a further count pulse is received, it jumps to the lower count limit and continues to count from there without any pulse losses.
- If the counter reaches the lower limit and a further count pulse is received, it jumps to the upper count limit and continues to count from there without any pulse losses.

The valid count range lies between -2147483648 and +2147483647 (-2^{31} and 2^{31} - 1). You cannot change this count range.

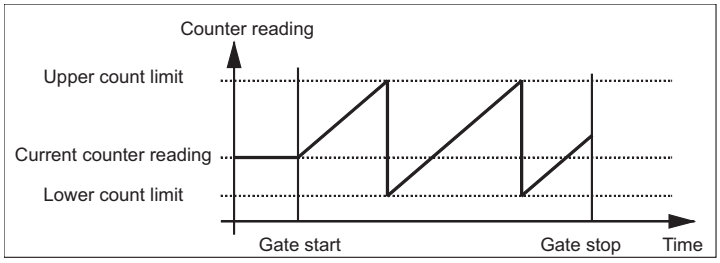


Figure 8-1 Continuous Counting with Gate Function

Selecting the Gate Function

You can select the gate function in this mode. The following possibilities are available to you (see also Section 2.2):

- Software gate
- Software gate and hardware gate

  You can add a hardware gate to the software gate. Both gates act together like a logic AND operation, meaning the FM 350-2 counts only when both gates are open.

Opening and Closing the Software Gate

You open and close the software gate for each channel with the control bits SW_GATE0...7 in the data block for the function CNT2_CTR.

Action	**...Is Initiated By**
Open software gate 0 to 7	Setting SW_GATE0...7, edge change 0->1
Close software gate 0 to 7	Resetting SW_GATE0...7

Opening and Closing the Hardware Gate

You open and close a hardware gate by applying the relevant signals to or removing the signals from the corresponding digital input I0 to I7.

Action	...Is Initiated By
Open hardware gate 0 to 7	Applying signal to input I0 to I7, 0 -> 1
Close hardware gate 0 to 7	Removing signal from input I0 to I7, 1 -> 0

Canceling or Interrupting the Count Process

The gate function can interrupt or cancel the count process. When canceled, the count starts again from the beginning following gate stop and gate start. When interrupted, the count is resumed from the last current count value following gate stop and gate start.

The following figures show how the gate functions interrupt and cancel the count process:

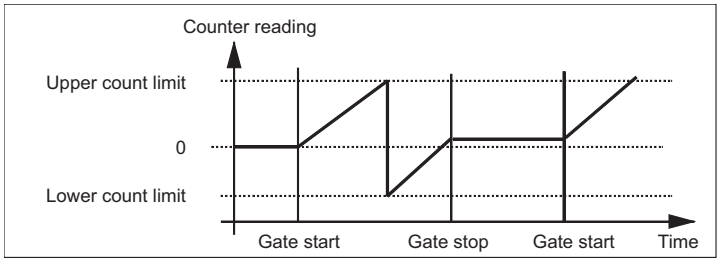


Figure 8-2 Continuous Counting, Interrupted by Gate Function

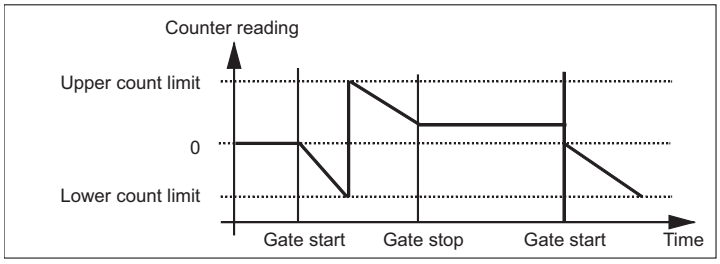


Figure 8-3 Continuous Counting, Canceled by Gate Function

Reading Count Values

You can read all count values with the jobs 100 (channels 0 to 3) and 101 (channels 4 to 7) of the function CNT2_RD. You can also assign a user-defined area in the process input area to a maximum of four channels using parameters from which you can read the current counter readings.

In this operating mode the count value is equivalent to the current count and the measurement value is always 0.

Comparison Value

For each count channel of the FM 350-2 you can assign a comparison value within the count range. You can also assign whether and under what conditions a digital output should be set and/or a hardware interrupt triggered in conjunction with this comparison value. You can set the following conditions for this:

- A hardware interrupt is triggered if the current count matches the comparison value.
- A digital output is set if the current count is greater than or equal to the comparison value.
- A digital output is set if the current count is less than or equal to the comparison value.

If you want a digital output to be set, you must have enabled the respective output in the counter DB of the function CNT2_CTR with the bit CTRL_DQ0...7.

You can change the set comparison values with the function CNT2_WR while the CPU is in RUN mode. You can also select how large a scope this change has:

- Every channel (job 30 to 37)
- A group of four channels (job 60 for channels 0 to 3, job 61 for channels 4 to 7)
- All eight channels (job 62)

Changing the Current Count

You can change the current counter reading with the function CNT2_WR while the CPU is in RUN mode. You can also select how large a scope this change has:

- Every channel (job 10 bis 17)
- A group of four channels (job 40 for channels 0 to 3, job 41 for channels 4 to 7)
- All eight channels (job 42)

8.4 Single Counting

Definition

In this mode, the FM 350-2 counts once when the gate is open:

- In the main count direction “up” between 0 and the set end value.
- In the main count direction “down” between the set start value and 0.

You specify the main count direction and the start and end values in the parameter assignment dialog boxes.

If you set the main count direction as “up,” the start value is 0 and you specify the end value.

If you set the main count direction as “down,” you specify the start value and the end value is 0.

Selecting the Gate Function

You can select the gate function in this mode. The following possibilities are available to you (see also Section 2.2):

- Software gate
- Software gate and hardware gate

  You can add a hardware gate to the software gate. Both gates act together like a logic AND operation, meaning the FM 350-2 counts only when both gates are open.

Opening and Closing the Software Gate

You open and close the software gate for each channel with the control bits SW_GATE0...7 in the data block for the function CNT2_CTR.

Action	**...Is Initiated By**
Open software gate 0 to 7	Setting SW_GATE0...7, edge change 0->1
Close software gate 0 to 7	Resetting SW_GATE0...7

Opening and Closing the Hardware Gate

You open and close a hardware gate by applying the relevant signals to or removing the signals from the corresponding digital input I0 to I7.

Action	**...Is Initiated By**
Open hardware gate 0 to 7	Applying signal to input I0 to I7, 0 -> 1
Close hardware gate 0 to 7	Removing signal from input I0 to I7, 1 -> 0

Behavior at the Count Limits

Main count direction “up”: If the counter has reached the value “end value -1” and a further count pulse is received, the counter is set to 0, the internal gate is closed, and the count is terminated even if the SW_GATE0...7 bit is still set. The respective status bit STS_OFLW0...7 is set in the data block of the function CNT2_CTR. The end value itself is therefore never reached.

Main count direction “down”: If the counter has reached the value “1” and a further count pulse is received, the counter is set to the start value, the internal gate is closed, and the count is terminated even if the SW_GATE0...7 bit is still set. The respective status bit STS_UFLW0...7 is set in the data block of the function CNT2_CTR. The value “0” is therefore never reached.

The status bits STS_OFLW0...7 and STS_UFLW0...7 are acknowledged by the function CNT2_CTR on every call (see also Chapter 6).

If you want to start the counter again, you must reset the bit SW_GATE0...7 and then set it again. If you assigned a hardware gate as well as a software gate, you must generate an edge change 0 -> 1 at the respective digital input; but not reset and then set the bit SW_GATE0...7.

Canceling or Interrupting the Count Process

The gate function can interrupt or cancel the count process. When canceled, the count starts again from the beginning following gate stop and gate start. When interrupted, the count is resumed from the last current count value following gate stop and gate start.

If you are using a hardware gate in addition to the software gate, the software gate only has an interrupt effect; the hardware gate can interrupt or cancel.

The following figures help to clarify the difference between gate functions which cancel and gate functions which interrupt:

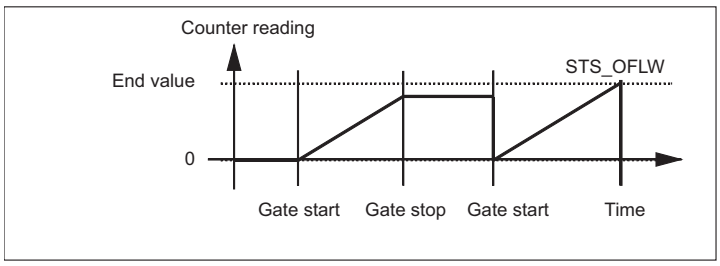


Figure 8-4 Single Counting Up, Canceled by Gate Function

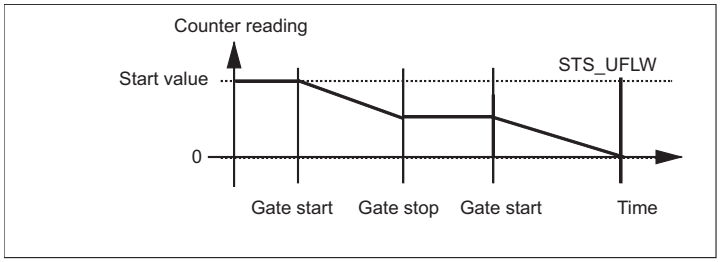


Figure 8-5 Single Counting Down, Interrupted by Gate Function

Reading Count Values

You can read all count values with the jobs 100 (channels 0 to 3) and 101 (channels 4 to 7) of the function CNT2_RD. You can also assign a user-defined area in the process input area to a maximum of four channels using parameters from which you can read the current counter readings.

In this operating mode the count value is equivalent to the current count and the measurement value is always 0.

Comparison Value

For each count channel of the FM 350-2 you can assign a comparison value within the set count range. You can also assign whether and under what conditions a digital output should be set and/or a hardware interrupt triggered in conjunction with this comparison value. You can set the following conditions for this:

- A hardware interrupt is triggered if the current count matches the comparison value.
- A digital output is set if the current count is greater than or equal to the comparison value.
- A digital output is set if the current count is less than or equal to the comparison value.

If you want a digital output to be set, you must have enabled the respective output in the counter DB of the function CNT2_CTR with the bit CTRL_DQ0...7.

Note

An enabled digital output is also set when the gate is closed.

You can change the set comparison values with the function CNT2_WR while the CPU is in RUN mode. You can also select how large a scope this change has:

- Every channel (job 30 to 37)
- A group of four channels (job 60 for channels 0 to 3, job 61 for channels 4 to 7)
- All eight channels (job 62)

Load Value in Preparation

Within the set count range you can assign a load value with the function CNT2_WR while the CPU is in RUN mode. This value is used by the counter as the new start value every time after the following events:

- Reaching the end value when counting up
- Reaching 0 when counting down
- Canceling of the count process by a software gate or a hardware gate (when the count process is interrupted the load value is not used).

The load value is then the new start value from which the next and all other single count processes begin. The set output and interrupt behavior remains the same.

You can select where the load value is valid:

- Every channel (job 20 to 27)
- A group of four channels (job 50 for channels 0 to 3, job 51 for channels 4 to 7)
- All eight channels (job 52)

Load Value Directly

You can change the current counter reading with the function CNT2_WR while the CPU is in RUN mode. The new counter reading is used by the counter directly as the current count value.

You can also select how large a scope this change has:

- Every channel (job 10 to 17)
- A group of four channels (job 40 for channels 0 to 3, job 41 for channels 4 to 7)
- All eight channels (job 42)

Value Range for Load Values

The value range for load values depends on the set main count direction. The range is:

- 0 to end value - 2 when counting up
- Start value to 2 when counting down

8.5 Periodic Counting

Definition

In this mode, the FM 350-2 counts:

- In the main count direction “up” from the start value 0 to the end value -1, then jumps back to the start value when the next count pulse is received and continues to count up from there.
- In the main count direction “down” from the set start value to 1, then jumps back to the start value when the next count pulse is received and continues to count down from there.

You specify the main count direction and the start and end values in the parameter assignment dialog boxes.

If you set the main count direction as “up,” the start value is 0 and you specify the end value.

If you set the main count direction as “down,” you specify the start value and the end value is 0.

Selecting the Gate Function

You can select the gate function in this mode. The following possibilities are available to you (see also Section 2.2):

- Software gate
- Software gate and hardware gate

  You can add a hardware gate to the software gate. Both gates act together like a logic AND operation, meaning the FM 350-2 counts only when both gates are open.

Opening and Closing the Software Gate

You open and close the software gate for each channel with the control bits SW_GATE0...7 in the data block for the function CNT2_CTR.

Action	...Is Initiated By
Open software gate 0 to 7	Setting SW_GATE0...7, edge change 0->1
Close software gate 0 to 7	Resetting SW_GATE0...7

Opening and Closing the Hardware Gate

You open and close a hardware gate by applying the relevant signals to or removing the signals from the corresponding digital input I0 to I7.

Action	...Is Initiated By
Open hardware gate 0 to 7	Applying signal to input I0 to I7, 0 -> 1
Close hardware gate 0 to 7	Removing signal from input I0 to I7, 1 -> 0

Behavior at the Count Limits

Main count direction “up”: If the counter has reached the value “end value -1” and a further count pulse is received, the counter is set to 0, and the count is continued from there. The respective status bit STS_OFLW0...7 is set in the data block of the function CNT2_CTR. The end value itself is therefore never displayed.

Main count direction “down”: If the counter has reached the value “1” and a further count pulse is received, the counter is set to the start value, and the count is continued from there. The respective status bit STS_UFLW0...7 is set in the data block of the function CNT2_CTR. The value “0” is therefore never displayed.

The status bits STS_OFLW0...7 and STS_UFLW0...7 are acknowledged by the function CNT2_CTR on every call (see also Chapter 6).

Canceling or Interrupting the Count Process

The gate function can interrupt or cancel the count process. When canceled, the count starts again from the beginning following gate stop and gate start. When interrupted, the count is resumed from the last current count value following gate stop and gate start.

If you are using a hardware gate in addition to the software gate, the software gate only has an interrupt effect; the hardware gate can interrupt or cancel.

The following figures help to clarify the difference between gate functions which cancel and gate functions which interrupt:

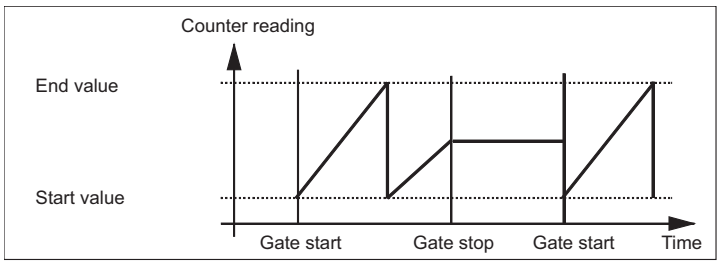


Figure 8-6 Periodic Counting Up, Canceled by Gate Function

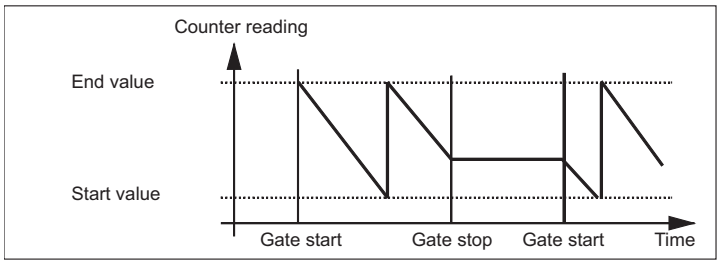


Figure 8-7 Periodic Counting Down, Interrupted by Gate Function

Reading Count Values

You can read all count values with the jobs 100 (channels 0 to 3) and 101 (channels 4 to 7) of the function CNT2_RD. You can also assign a user-defined area in the process input area to a maximum of four channels using parameters from which you can read the current counter readings.

In this operating mode the count value is equivalent to the current count and the measurement value is always 0.

Comparison Value

For each count channel of the FM 350-2 you can assign a comparison value within the set count range. You can also assign whether and under what conditions a digital output should be set and/or a hardware interrupt triggered in conjunction with this comparison value. You can set the following conditions for this:

- A hardware interrupt is triggered if the current count matches the comparison value.
- A digital output is set if the current count is greater than or equal to the comparison value.
- A digital output is set if the current count is less than or equal to the comparison value.

If you want a digital output to be set, you must have enabled the respective output in the counter DB of the function CNT2_CTR with the bit CTRL_DQ0...7.

You can change the set comparison values with the function CNT2_WR while the CPU is in RUN mode. You can also select how large a scope this change has:

- Every channel (job 30 to 37)
- A group of four channels (job 60 for channels 0 to 3, job 61 for channels 4 to 7)
- All eight channels (job 62)

Load Value in Preparation

Within the set count range you can assign a load value with the function CNT2_WR while the CPU is in RUN mode. This value is used by the counter as the new start value every time after the following events:

- Reaching the end value when counting up
- Reaching 0 when counting down
- Canceling of the count process by a software gate or a hardware gate (when the count process is interrupted the load value is not used).

The load value is then the new start value from which the next and all other periodic count processes begin. The set output and interrupt behavior remains the same.

You can select where the load value is valid:

- Every channel (job 20 to 27)
- A group of four channels (job 50 for channels 0 to 3, job 51 for channels 4 to 7)
- All eight channels (job 52)

Load Value Directly

You can change the current counter reading with the function CNT2_WR while the CPU is in RUN mode. The new counter reading is used by the counter directly as the current count value.

You can also select how large a scope this change has:

- Every channel (job 10 to 17)
- A group of four channels (job 40 for channels 0 to 3, job 41 for channels 4 to 7)
- All eight channels (job 42)

Value Range for Load Values

The value range for load values depends on the set main count direction. The range is:

- 0 to end value - 2 when counting up
- Start value to 2 when counting down

8.6 Frequency Measurement

Definition

In this mode, the FM 350-2 counts the pulses which are received in a set time window.

Parameter Assignment

You can set the length of the time window and two frequency comparison values (an upper and a lower limit value) using the parameter assignment dialog boxes.

The length of the time window is set via an integer parameter n ($1 \leq n \leq 1000$) in steps of 10 ms. When entered, a check is made to ensure the parameter lies within the permitted limits and a parameter assignment error is reported if this is not the case.

Using the two frequency comparison values (value range for the lower limit value: 0 to 9999999 Hz*10^{-3}, DWORD; value range for the upper limit value: 1 to 10000000 Hz*10^{-3}, DWORD) you can monitor whether the measured frequency remains within a specified range. If it overshoots this range, a hardware interrupt can be triggered. When entered, a check is made to ensure the upper limit is greater than the lower limit and a parameter assignment error is reported if this is not the case.

The upper and lower limits can be changed from the user program.

Multiple evaluation is not possible with rotary transducers.

Selecting the Gate Function

In this mode you can select the gate function with which the frequency measurement is started and stopped. The following possibilities are available to you:

- Software gate
- Software gate and hardware gate (= internal gate)

  You can add a hardware gate to the software gate. Both gates act together like a logic AND operation, meaning the FM 350-2 only measures frequencies when both gates are open.

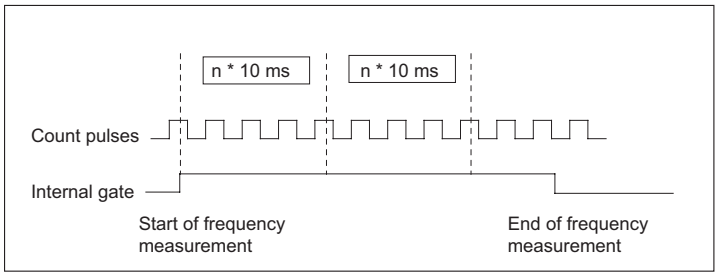


Figure 8-8 Frequency Measurement with Gate Function

Opening and Closing the Software Gate

You open and close the software gate for each channel with the control bits SW_GATE0...7 in the data block for the function CNT2_CTR to start and stop frequency measurement.

Action	...Is Initiated By
Open software gate 0 to 7	Setting SW_GATE0...7, edge change 0->1
Close software gate 0 to 7	Resetting SW_GATE0...7

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 corresponding digital input I0 to I7. The hardware gate is level-controlled and opened by a positive level (continuous).

Action	...Is Initiated By
Open hardware gate 0 to 7	Applying signal to input I0 to I7
Close hardware gate 0 to 7	Removing signal from input I0 to I7

Limit Values

After each time interval has expired, the frequency determined is compared with the set limit values (fu / fo). The following states are produced:

If the Frequency Is...	...the Following Bit Is Set
Greater than the upper limit value	STS_OFLW0...7
Less than the lower limit value	STS_UFLW0...7

The bits STS_OFLW0...7 and STS_UFLW0...7 are reset by each call of the function CNT2_CTR.

When you assign the parameters, you can specify whether you want a hardware interrupt to be triggered when a limit value is exceeded.

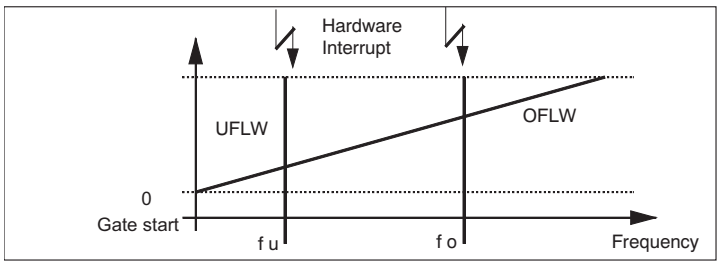


Figure 8-9 Frequency Measurement with Frequency Limit Values

Changing Limit Values

You can change the limit values with the function CNT2_WR while the CPU is in RUN mode. You can select how large a scope this change has:

Changing the **lower limit value**:

- Every channel (job 10 to 17)
- A group of four channels (job 40 for channels 0 to 3, job 41 for channels 4 to 7)
- All eight channels (job 42)

Changing the **upper limit value**:

- Every channel (job 20 to 27)
- A group of four channels (job 50 for channels 0 to 3, job 51 for channels 4 to 7)
- All eight channels (job 52)

Result

The end of frequency measurement (time interval elapsed) is reported using the status bits STS_CMP7...0. The measured frequency value can, if it was set in the peripheral input area, be read with the function CNT2_CTR or, depending on the channel, with the jobs 100 and 101 of the function CNT2_RD in the unit 1×10^{-3} Hz.

In this operating mode the count value is equivalent to the current count and the measurement value is equivalent to the measured frequency.

If the minimum of two rising edges were not present in the set time window, 0 is measured as the frequency (see Figure 8-10):

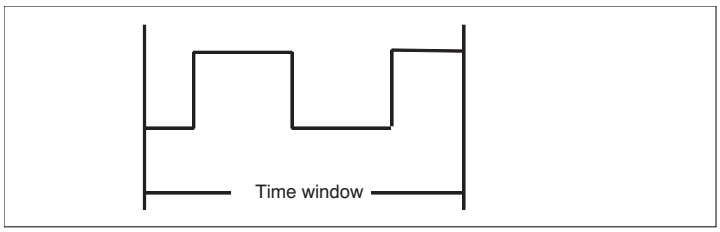


Figure 8-10 Two Rising Edges in the Time Window

Reversed Direction of Rotation

If the rotation direction is reversed within a time interval, the measurement value for this measurement period is undetermined.

8.7 Rotational Speed Measurement

Definition

In this mode which is almost identical to the “frequency measurement” mode, the FM 350-2 counts the pulses which are received in a defined time window from a rotational speed encoder and uses this to calculate the rotational speed of the connected motor.

Parameter Assignment

You can set the length of the time window, the number of pulses per encoder revolution, and two rotational speed comparison values (an upper and a lower limit value) using the parameter assignment dialog boxes.

The length of the time window is set via an integer parameter n ($1 \leq n \leq 1000$) in steps of 10 ms. When entered, a check is made to ensure the parameter lies within the permitted limits and a parameter assignment error is reported if this is not the case.

Using the two rotational speed comparison values (value range for the lower limit value: 0 to 24999999 10^{-3} rpm, DWORD; value range for the upper limit value: 1 to 25000000 10^{-3} rpm, DWORD) you can monitor whether the measured rotational speed remains within a specified range. If it overshoots this range, a hardware interrupt can be triggered. When entered, a check is made to ensure the upper limit is greater than the lower limit and a parameter assignment error is reported if this is not the case.

Single evaluation only can be set for the encoder signals.

Selecting the Gate Function

In this mode you can select the gate function with which the rotational speed measurement is started and stopped. The following possibilities are available to you:

- Software gate
- Software gate and hardware gate

  You can add a hardware gate to the software gate. Both gates act together like a logic AND operation, meaning the FM 350-2 only measures rotational speeds when both gates are open.

Opening and Closing the Software Gate

You open and close the software gate for each channel with the control bits SW_GATE0...7 in the data block for the function CNT2_CTR to start and stop rotational speed measurement.

Action	...Is Initiated By
Open software gate 0 to 7	Setting SW_GATE0...7, edge change 0->1
Close software gate 0 to 7	Resetting SW_GATE0...7

Opening and Closing the Hardware Gate

You open and close a hardware gate by applying the relevant signals to or removing the signals from the corresponding digital input I0 to I7.

Action	**...Is Initiated By**
Open hardware gate 0 to 7	Applying signal to input I0 to I7, 0 -> 1
Close hardware gate 0 to 7	Removing signal from input I0 to I7, 1 -> 0

Limit Values

After each time interval has expired, the rotational speed determined is compared with the set limit values. The following states are produced:

If the Rotational Speed Is...	**...the Following Bit Is Set**
Greater than the upper limit value	STS_OFLW0...7
Less than the lower limit value	STS_UFLW0...7

The bits STS_OFLW0...7 and STS_UFLW0...7 are reset by each call of the function CNT2_CTR.

When you assign the parameters, you can specify whether you want a hardware interrupt to be triggered when a limit value is exceeded.

Changing Limit Values

You can change the limit values with the function CNT2_WR while the CPU is in RUN mode. You can select how large a scope this change has:

Changing the **lower limit value**:

- Every channel (job 10 to 17)
- A group of four channels (job 40 for channels 0 to 3, job 41 for channels 4 to 7)
- All eight channels (job 42)

Changing the **upper limit value**:

- Every channel (job 20 to 27)
- A group of four channels (job 50 for channels 0 to 3, job 51 for channels 4 to 7)
- All eight channels (job 52)

Result

The end of rotational speed measurement (time interval elapsed) is reported using the status bits STS_CMP7...0. The measured rotational speed value can, if it was set in the peripheral input area, be read with the function CNT2_CTR or, depending on the channel, with the jobs 100 and 101 of the function CNT2_RD in the unit 1 x 10^{-3} rpm.

In this operating mode the count value is equivalent to the current count and the measurement value is equivalent to the measured rotational speed.

If the minimum of two rising edges were not present in the set time window, 0 is measured as the rotational speed (see Figure 8-11):

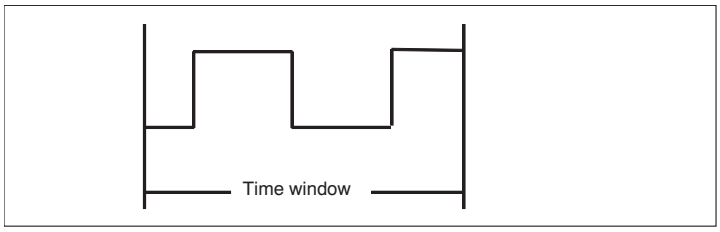


Figure 8-11 Two Rising Edges in the Time Window

Reversed Direction of Rotation

If the rotation direction is reversed within a time interval, the measurement value for this measurement period is undetermined.

8.8 Period Duration Measurement

Definition

In this mode, the FM 350-2 measures the exact time between two rising edges of the count signal by counting the pulses from an internal quartz-accuracy reference frequency (1 MHz).

Parameter Assignment

You can set two period duration comparison values (an upper and a lower limit value) using the parameter assignment dialog boxes.

Using the two period duration comparison values (value range for the lower limit value: 0 to 119999999 ms, DWORD; value range for the upper limit value: 100 to 120000000 ms, DWORD) you can monitor whether the measured period duration remains within a specified range. If it overshoots this range, a hardware interrupt can be triggered. When entered, a check is made to ensure the upper limit is greater than the lower limit and a parameter assignment error is reported if this is not the case.

Single evaluation only can be set for the encoder signals.

Selecting the Gate Function

In this mode you can select the gate function with which the period duration measurement is started and stopped. The following possibilities are available to you:

- Software gate
- Software gate and hardware gate (= internal gate)

  You can add a hardware gate to the software gate. Both gates act together like a logic AND operation, meaning the FM 350-2 only measures period durations when both gates are open.

Opening and Closing the Software Gate

You open and close the software gate for each channel with the control bits SW_GATE0...7 in the data block for the function CNT2_CTR to start and stop period duration measurement.

Action	...Is Initiated By
Open software gate 0 to 7	Setting SW_GATE0...7, edge change 0->1
Close software gate 0 to 7	Resetting SW_GATE0...7

Opening and Closing the Hardware Gate

You open and close a hardware gate by applying the relevant signals to or removing the signals from the corresponding digital input I0 to I7.

Action	...Is Initiated By
Open hardware gate 0 to 7	Applying signal to input I0 to I7, 0 -> 1
Close hardware gate 0 to 7	Removing signal from input I0 to I7, 1 -> 0

Limit Values

After each time interval has expired, the period duration determined is compared with the set limit values. The following states are produced:

If the Period Duration Is...	...the Following Bit Is Set
Greater than the upper limit value	STS_OFLW0...7
Less than the lower limit value	STS_UFLW0...7

The bits STS_OFLW0...7 and STS_UFLW0...7 are reset by each call of the function CNT2_CTR.

Changing Limit Values

You can change the limit values with the function CNT2_WR while the CPU is in RUN mode. You can select how large a scope this change has:

Changing the **lower limit value**:

- Every channel (job 10 to 17)
- A group of four channels (job 40 for channels 0 to 3, job 41 for channels 4 to 7)
- All eight channels (job 42)

Changing the **upper limit value**:

- Every channel (job 20 to 27)
- A group of four channels (job 50 for channels 0 to 3, job 51 for channels 4 to 7)
- All eight channels (job 52)

Result

The end of period duration measurement (time interval elapsed) is reported using the status bits STS_CMP7...0. The measured value can, if it was set in the peripheral input area, be read with the function CNT2_CTR or, depending on the channel, with the jobs 100 and 101 of the function CNT2_RD in the unit ms.

In this operating mode the count value is equivalent to the current count and the measurement value is equivalent to the measured period duration.

If the minimum of two rising edges were not present in the set time window, 0 is measured as the period duration (see Figure 8-12):

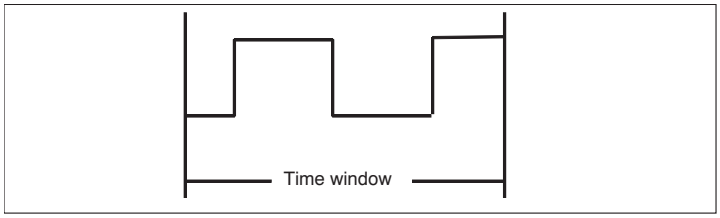


Figure 8-12 Two Rising Edges in the Time Window

Reversed Direction of Rotation

If the rotation direction is reversed within a time interval, the measurement value for this measurement period is undetermined.

8.9 Proportioning

Definition

In this mode, four count channels of the FM 350-2 are combined together in one proportioning channel. When the gate is open, the FM 350-2 counts once in the main count direction:

- In the main count direction “up” between 0 and the set end value.
- In the main count direction “down” between the set start value and 0.

You specify the main count direction and the start and end values in the parameter assignment dialog boxes.

If you set the main count direction as “up,” the start value is 0 and you specify the end value.

If you set the main count direction as “down,” you specify the start value and the end value is 0.

Parameter Assignment

Using the parameter assignment dialog boxes you can set the start and end values, the main count direction, and the channels to be used for proportioning (channels 0 to 3 as proportioning channel 0; channels 4 to 7 as proportioning channel 1, selected using the menu command **Edit > Specify Channels**).

Selecting the Gate Function

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

- Software gate
- Software gate and hardware gate

  You can add a hardware gate to the software gate. Both gates act together like a logic AND operation, meaning the FM 350-2 counts only when both gates are open.

Opening and Closing the Software Gate

You open and close the software gate for each channel with the control bits SW_GATE0 (channels 0 to 3) and SW_GATE 4 (channels 4 to 7) in the data block for the function CNT2_CTR to start and stop proportioning.

Action	**...Is Initiated By**
Open software gate 0, 4	Setting SW_GATE0, 4, edge change 0->1
Close software gate 0, 4	Resetting SW_GATE0, 4

Opening and Closing the Hardware Gate

You open and close a hardware gate by applying the relevant signals to or removing the signals from the corresponding digital input I0, I4.

Action	...Is Initiated By
Open hardware gate 0, 4	Applying signal to input I0, I4, 0 -> 1
Close hardware gate 0, 4	Removing signal from input I0, I4, 1 -> 0

Behavior at the Count Limits, Software Gate

Main count direction “up”: If the counter has reached the value “end value -1” and a further count pulse is received, the counter is set to 0, the internal gate is closed, and the count is terminated even if the SW_GATE0, 4 bit is still set. The respective status bit STS_OFLW0, 4 is set in the data block of the function CNT2_CTR. The end value itself is therefore never reached.

Main count direction “down”: If the counter has reached the value “1” and a further count pulse is received, the counter is set to the start value, the internal gate is closed, and the count is terminated even if the SW_GATE0, 4 bit is still set. The respective status bit STS_UFLW0, 4 is set in the data block of the function CNT2_CTR. The value “0” is therefore never reached.

If you want to start the counter again, you must reset the bit SW_GATE0, 4 and then set it again.

Behavior at the Count Limits, Hardware Gate

Main count direction “up”: If the counter has reached the value “end value -1” and a further count pulse is received, the counter is set to 0, the internal gate is closed, and the count is terminated even if the SW_GATE0, 4 bit and the input I0, I4 are still set. The end value itself is therefore never reached. The respective status bit STS_OFLW0, 4 is set in the data block of the function CNT2_CTR.

Main count direction “down”: If the counter has reached the value “1” and a further count pulse is received, the counter is set to the start value, the internal gate is closed, and the count is terminated even if the SW_GATE0, 4 and the input I0, I4 are still set. The value “0” is therefore never reached. The respective status bit STS_UFLW0, 4 is set in the data block of the function CNT2_CTR.

If you want to start the counter again, you must reset the input I0, I4, and then set it again. You can only start a new count with the hardware gate.

Canceling or Interrupting the Count Process

The gate function can interrupt or cancel the proportioning process. When canceled, the proportioning process starts again from the beginning following gate stop and gate start. When interrupted, the proportioning process is resumed from the last current count value following gate stop and gate start.

If you are using a hardware gate in addition to the software gate, the software gate only has an interrupt effect; the hardware gate can interrupt or cancel.

The following figures help to clarify the difference between gate functions which cancel and gate functions which interrupt:

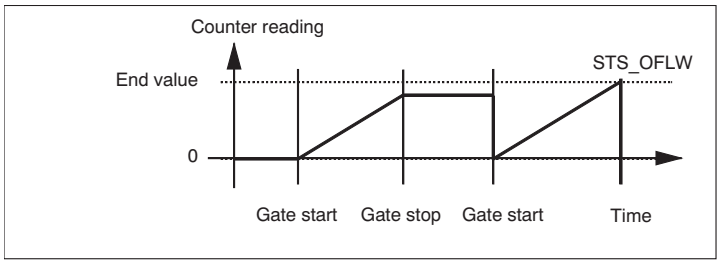


Figure 8-13 Proportioning in Main Count Direction Up, Canceled by Gate Function

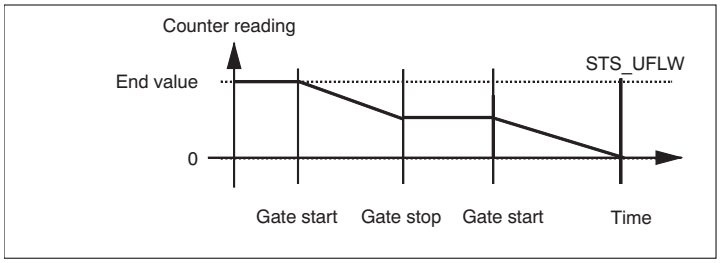


Figure 8-14 Proportioning in Main Count Direction Down, Interrupted by Gate Function

Reading Count Values

The count value can, if it was set in the peripheral input area, be read with the function CNT2_CTR or, depending on the channel, with the jobs 100 and 101 of the function CNT2_RD.

In this operating mode the count values 0 and 4 are equivalent to the current count and the other count values and the measurement values are 0.

Comparison Value

For each proportioning channel of the FM 350-2 you can assign four comparison values within the set count range. You can also assign whether and under what conditions a digital output should be set and/or a hardware interrupt triggered in conjunction with a comparison value. You can set the following conditions for this:

- A hardware interrupt is triggered if the current count matches the comparison value.
- A digital output is set if the current count is greater than or equal to a comparison value.
- A digital output is set if the current count is less than or equal to a comparison value.

If you want a digital output to be set, you must have enabled the respective output in the counter DB of the function CNT2_CTR with the bit CTRL_DQ0...7.

Note

Outputs can only be set while the CPU is in RUN mode if the gate is open.

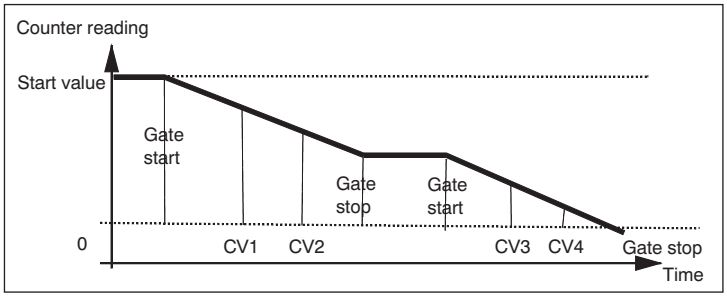


Figure 8-15 Proportioning in the Down Direction

You can change the set comparison values with the function CNT2_WR while the CPU is in RUN mode. The changes affect one proportioning channel only (jobs 30 to 33 for the individual comparison values of the first channel, jobs 34 to 37 for the individual comparison values of the second channel, job 60 for the first channel as a group, job 61 for the second channel as a group).

Load Value in Preparation

Within the set count range you can assign a load value with the function CNT2_WR while the CPU is in RUN mode. This value is used by the counter as the new start value every time after the following events:

- Reaching the end value when counting up
- Reaching 0 when counting down
- Canceling of the count process by a software gate or a hardware gate (when the count process is interrupted the load value is not used).

The load value is then the new start value from which the next and all other proportioning processes begin. The set output and interrupt behavior remains the same.

You can select where the load value is valid:

- First channel (job 20)
- Second channel (job 24)

Load Value Directly

You can change the current counter reading with the function CNT2_WR while the CPU is in RUN mode. The new counter reading is used by the counter directly as the current proportioning value.

You can also select how large a scope this change has:

- First channel (job 10)
- Second channel (job 14)

Caution

Danger of property damage.

Substitute values assigned are always output when the CPU is in STOP mode even if the gate is closed and also to outputs which are not enabled.

Only assign substitute values which will not lead to dangerous states in the plant if they are output.

Value Range for Load Values

The value range for load values depends on the set main count direction. The range is:

- 0 to end value - 2 when counting up
- Start value to 2 when counting down

8.10 Setting the Behavior of the Digital Outputs

Introduction

You can store eight comparison values on the FM 350-2 for each counter. These comparison values are assigned to the eight digital outputs (comparison value 0: Q0, comparison value 1: Q1, etc.). The respective output can be set depending on the counter reading and the comparison value. This section describes the various methods of setting the behavior of the outputs.

Comparison Values

You set the comparison values in the parameter assignment dialog boxes. When the CPU is in RUN mode you can enter the comparison values in the data block of the function CNT2_WR (CMP_VAL0...7) and transfer them to the FM 350-2 by using jobs 30 to 37 or 60 to 62 (see the description of the relevant operating mode). The count is not affected by this.

The comparison values must lie inside the count range of the respective operating mode; the count range limits are not permitted as comparison values.

If you want to set the comparison value to start value or end value in a main count direction operating mode, you have to reckon with the following behavior:

Parameter assignment behavior of digital inputs	Reaction of assigned digital ouputs
Switch on for counter reading >= comparison value	The output is always switched on independent of the counter reading
Switch on for counter reading <= comparison value	The output is always switched off independent of counter reading

Enabling the Outputs

Before the outputs can be set, you must enable them first by setting the relevant bits in the counter DB. If you reset one of these bits, the associated output is switched off immediately. The bits are transferred between the data block and the module by the function CNT2_CTR.

Output	...Is Enabled By
Q0 to Q7	CTRL_DQ0...7

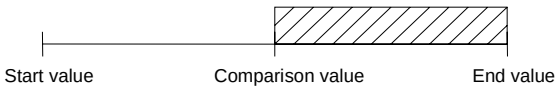
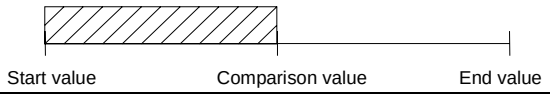
Status of the Outputs

You can see the status of the outputs from the green status LEDs and from the relevant bits in the data block.

Status of the Output	Status of the LEDs	Status of the Bit
Q0 to Q7 set	Q0 to Q7 lights up	STS_DQ0...7 set
Q0 to Q7 reset	Q0 to Q7 dark	STS_DQ0...7 reset

Behavior of the Outputs

For the outputs, you can program one of three possible responses to reaching the comparison value. The various possibilities are shown in the table below for the main count direction “up.”

Behavior of the Outputs	
Comparison not executed	
	The output remains deactivated and is not influenced by the events comparison value, zero crossing, jump from end value to start value, or jump from start value to end value.
Activate if counter reading >= comparison value	
	The output is activated if the counter is in the range between the comparison value n and the end value. Setting the counter to a value between the comparison value and the end value activates the output.
Activate if counter reading <= comparison value	
	The output is activated if the counter is in the range between the comparison value and the start value. Setting the counter to a value between the comparison value and the start value activates the output.

* Please note the requirement below

 = Output active

Requirement

If you want to set an output to “activate if counter reading >= comparison value” or “activate if counter reading <= comparison value,”, you must ensure that the time between reaching the comparison value and the start or end value is greater than the minimum switching time of the outputs (switching time: 300 s); otherwise, the control pulses at the outputs are lost.

Switching Off the Outputs

The outputs are switched off by the following events regardless of the parameter assignments:

- Module watchdog triggered (internal error)
- Removing the enable bits (CTRL_DQ0...7 for Q0 to Q7 in the DB)

Controlling the Outputs

Irrespective of switching the outputs using comparators, you can set and reset the outputs once they are enabled by CTRL_DQ0...7 using the SET_DQ0...7 bit.

The following applies to the relationship between controlling and switching: controlling has priority over switching using the comparators. This means:

- If switching using the comparator is not planned for the output, the output can be used as a digital output.

If you have selected a comparison function, you can continue controlling outputs with SET_DQ0..7. This will enable you simulate the effect of the comparison function via the controller program:

- The output is set with the positive edge SET_DQ0..7.
- A negative edge of SET_DQ0..7 resets the output.

Note that the comparators remain active and the output can be set or reset when the comparation result is changed.

Note

An output set with SET_DQ0..7 cannot be reset via the comparator.

Incoming and Outgoing Output Disable

The outputs behave as you set in the basic parameters under “Reaction to CPU STOP” (see page 8-3). Below you will find additional information on the individual settings and their effects on the reaction of the outputs when the OD (Output Disable) signal comes in and goes out, independent of whether a transition from RUN to STOP or from STOP to RUN occurs in the CPU.

- **RUN to STOP:**

  Substitute Values: The set substitute values are always output even if the gate is closed and the respective output is not enabled.

  Continue: The transition from RUN to STOP is ignored. This means the HOLD state of the CPU can also be overridden (for example, for debugging a user program).

- **STOP to RUN:**

  Cancel: The parameters in the latest parameter assignment are downloaded to the module. You can only operate the FM 350-2 once the “Reaction to CPU STOP” has been assigned new parameters.

  Substitute Values/Last Value: If the parameters did not change, the substitute values/last values on all channels are removed as soon as the **first** operation at a channel is detected.

  Continue: If the parameters did not change, the FM 350-2 expects that the user program can continue to work with a module which was not reset.

Default Setting

The default setting for the outputs is deactivated (no comparison).

8.11 Triggering a Hardware Interrupt

Introduction

With the FM 350-2, you can set which events are to trigger a hardware interrupt. For this purpose, assign the FM 350-2 interrupts in the parameter assignment dialog boxes.

What is a Hardware Interrupt?

If you want to program a response to a specific event independently of the CPU cycle, the FM 350-2 can trigger a hardware interrupt. The CPU interrupts the cyclic program on receiving the interrupts and executes the hardware interrupt OB40.

Which Events Can Trigger a Hardware Interrupt?

The following events during operation of the FM 350-2 can trigger a hardware interrupt:

- Opening the hardware gate
- Closing the hardware gate
- Overflow/underflow
- Reaching a comparison value (either direction)
- Undershooting/exceeding limit values
- Measurement end reached

Independent of the set operating mode, you can select a number of events to trigger a hardware interrupt. For hardware interrupts on reaching a comparison value, you must observe the requirement in Section 8.10.

Enabling the Hardware Interrupt

You enable the interrupts for the module in the parameter assignment dialog boxes when configuring the hardware and you decide whether the module is to trigger a diagnostic interrupt and/or a hardware interrupt.

Hardware Interrupt OB, OB40

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

If there is no OB40 programmed, the CPU goes into STOP. If you then switch back to RUN, the requirements for a hardware interrupt are deleted.

Hardware Interrupt Reaction Time

The hardware interrupt reaction time or the time between an event occurring to trigger the hardware interrupt and the message from the hardware interrupt to the CPU is between 0.5 and 2.5 ms.

Start Information

The temporary variable OB40_POINT_ADDR is written in the start information of OB40.

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

The following table shows which bits are set for which interrupt. All unlisted bits are insignificant and take the value zero.

Mode: Single counting, Continuous counting, Periodic counting									
Channel	Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	8					Com-parator tripped	Overflow/ Underflow	Close hardware gate	Open hardware gate
1		Com-parator tripped	Overflow/ Underflow	Close hardware gate	Open hardware gate				
2 to 7	9 to 11	See Byte 8							
Mode: Frequency measurement									
Channel	Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	8					Upper/ lower frequency limit exceeded	Frequency measure-ment ended	Close hardware gate	Open hardware gate
1		Upper/ lower frequency limit exceeded	Frequency measure-ment ended	Close hardware gate	Open hardware gate				
2 to 7	9 to 11	See Byte 8							
Mode: Rotational speed measurement									
Channel	Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	8					Upper/ lower rotataional speed limit exceeded	Rotational speed measure-ment ended	Close hardware gate	Open hardware gate
1		Upper/ lower rotational speed limit exceeded	Rotational speed measure-ment ended	Close hardware gate	Open hardware gate				
2 to 7	9 to 11	See Byte 8							

Mode: Period duration measurement									
Channel	Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	8					Upper/ lower time limit exceeded	Period duration measure-ment ended	Close hardware gate	Open hardware gate
1	1	Upper/ lower time limit exceeded	Period duration measure-ment ended	Close hardware gate	Open hardware gate				
2 to 7	9 to 11	See Byte 8							
Mode: Proportioning									
Channel	Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	8	-	Overflow/ Under-flow	Com-parator 4 tripped	Com-parator 3 tripped	Com-parator 2 tripped	Com-parator 1 tripped	Close hardware gate	Open hardware gate
1	10	See Byte 8							

Lost Hardware Interrupt

If an event occurs that is to trigger a hardware interrupt and the same previous event has not yet been acknowledged, no further hardware interrupt is triggered; the hardware interrupt is lost.

This can result in the diagnostic interrupt “hardware interrupt lost” depending on the parameters assigned.

If a time of less than 2 ms lies between two events which should trigger a hardware interrupt, the second hardware interrupt is lost but a diagnostic interrupt cannot be triggered.

Default Setting

No hardware interrupt is assigned in the default setting.

9 Encoder Signals and Their Evaluation

9.1 Overview

Introduction

The count signals that the FM 350-2 can process are rectangular signals generated either by incremental encoders or by signal encoders.

Incremental encoders scan a grating and so generate rectangular electrical pulses. They differ in pulse height and in the number of signals.

Pulse encoders such as light barriers or initiators (BEROs) supply only a rectangular signal with a specific voltage level.

Connecting Different Encoders

You can connect different bounce-free encoders (see also Catalog ST 71) to the FM 350-2 in order to supply the pulses for the count signals. The following Table gives an overview of the different encoders and the corresponding signals.

Encoder	Signal
24-V incremental encoder	
24-V pulse encoder with direction level	24 V with direction level
24-V pulse encoder	24 V without direction level
NAMUR encoder	8.2 V without direction level

For 24-V pulse encoders with direction level, a minimum time span of 50 µs must lie between direction signal (B) and count signal (A) (see Figure 9-1).

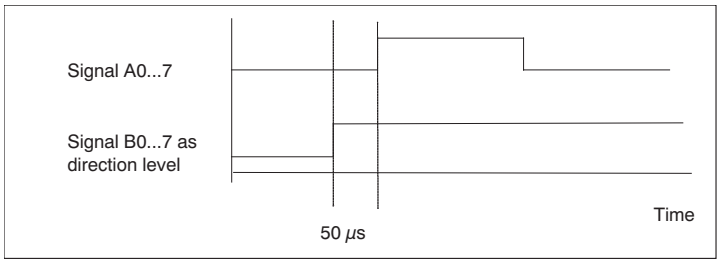


Figure 9-1 Time Span Between Direction Level and Count Signal

Default Setting

In the default setting, 24-V count signals with direction evaluation are set.

9.2 NAMUR Signals

NAMUR Encoder

The encoder supplies one count signal in accordance with DIN 19234 that must be connected to terminal A0...7 of the front connector.

You can connect a signal for direction detection (24 V) to terminal B0...7. If your encoder does not supply a corresponding signal, you can generate and connect a corresponding ID within the S7-300 or you can use an equivalent process signal.

Figure 9-2 shows the sequence over time of these signals.

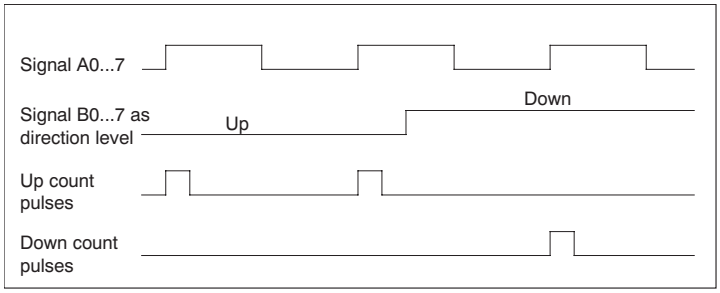


Figure 9-2 Signals of the NAMUR Encoder with Direction Level

You can assign parameters to the inputs A0...3, A4...7, or all inputs for connecting NAMUR encoders in the parameter assignment dialog boxes.

How are the Signals Monitored?

If you assigned the appropriate parameters to the FM 350-2, the module monitors whether a wire break or a short circuit is present at A0...7. Indirectly the 8.2-V encoder supply is monitored at the same time. This is only possible with NAMUR encoders.

If a wire break or short circuit is detected, the group error LED lights up, you can also assign a diagnostic interrupt to be triggered.

Caution

Danger of property damage.

If you use another encoder on a channel of the FM 350-2 which was assigned parameters for the connection of a NAMUR encoder, the module may be damaged.

Connect only a NAMUR encoder to a channel of the FM 350-2 which was assigned parameters for the connection of a NAMUR encoder.

9.3 24-V Signals

24-V Incremental Encoder

The 24-V incremental encoder supplies the signals A and B. The signals A and B are by 90° out of phase.

Encoders that do not supply inverse signals are known as asymmetric encoders.

You can change the count direction via the “inverted direction” parameter. Assigning the parameter “Main Count Direction: Down” does **not** automatically reverse the count direction.

24-V Pulse Encoder Without/With Direction Level

The encoder, for example, an initiator (BERO) or a light barrier, supplies only one count signal that must be connected to terminal A0...7 of the front connector.

In addition to this, you can connect a signal for direction detection to terminal B0...7. If your encoder does not supply a corresponding signal, you can generate and connect a corresponding direction within the S7-300 or you can use an equivalent process signal.

Figure 9-3 shows the sequence over time of the signals of a 24-V pulse encoder with direction level and the resulting count pulses.

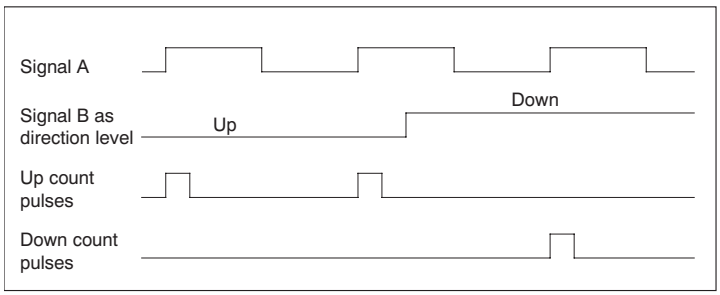


Figure 9-3 Signals of a 24-V Pulse Encoder with Direction Level

When selecting the encoder, you must select the “Pulse and direction” parameter.

Changing direction by inverting the B signal is possible with these count signals using the parameter setting “inverted direction.”

Note

With pulse encoders without direction level, the count value in the case of an oscillating count signal can `run away' as all the signals are added together.

How are the Signals Monitored?

24-V count signals are not monitored for wire break or short circuit.

9.4 Pulse Evaluation

Introduction

The counters of the FM 350-2 can count the edges of the signals. Normally, only the edge at A is evaluated (single evaluation). To achieve a higher resolution, you can decide when you assign parameters whether the signals are to have single, double, or quadruple evaluation.

Multiple evaluation is only possible in the case of asymmetric 24-V incremental encoders with signals A and B out of phase by 90°.

Single Evaluation

Single evaluation means that only one edge of A is evaluated; up count pulses are captured on a rising edge of A and low level at B, and down count pulses are captured on a rising edge of A and high level at B.

Figure 9-4 shows single evaluation of the signals.

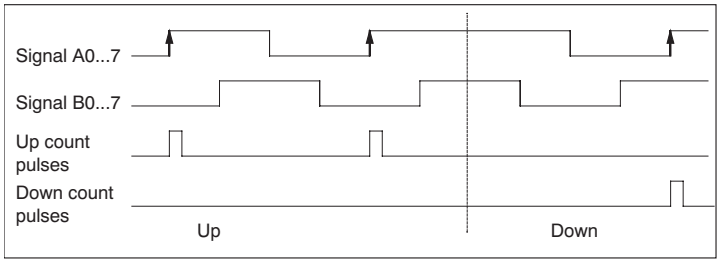


Figure 9-4 Single Evaluation

Double Evaluation

Double evaluation means that the rising and falling edges of signal A are evaluated; whether up or down count pulses are generated depends on the level of signal B.

Figure 9-5 shows double evaluation of the signals.

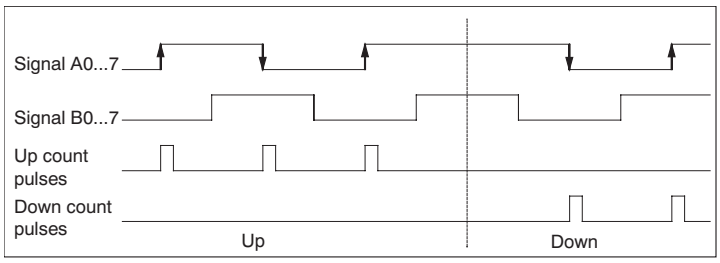


Figure 9-5 Double Evaluation

Quadruple Evaluation

Quadruple evaluation means that the rising and falling edges of A and B are evaluated; whether up or down count pulses are generated depends on the levels of signals A and B.

Figure 9-6 shows quadruple evaluation of signals.

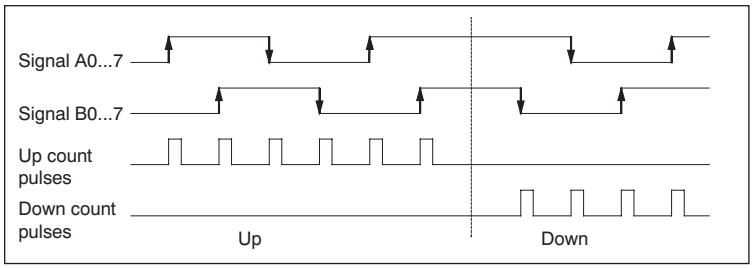


Figure 9-6 Quadruple Evaluation

9.5 Hysteresis

Introduction

An encoder can come to rest at a particular position and then “oscillate” about this position. This state means that the counter reading fluctuates around a particular value. If, for example, a comparison value lies in this area of fluctuation, the corresponding output would be switched on and off in the rhythm of these fluctuations. To prevent an output being switched on and off by very small fluctuations, the FM 350-2 has a programmable hysteresis function. You can assign a range between 0 and 255 (0 means: hysteresis deactivated) from which the input treats a fluctuation in the input signal as a real change and an output can be controlled as required.

How Does Hysteresis Work?

The following figure shows an example of the effect of hysteresis. The figure shows the different behavior of an output when a hysteresis of 0 (deactivated) and of 3 is set.

The counter is assigned the settings “Main Count Direction: Up” and output “On if Count >= Comparison Value”.

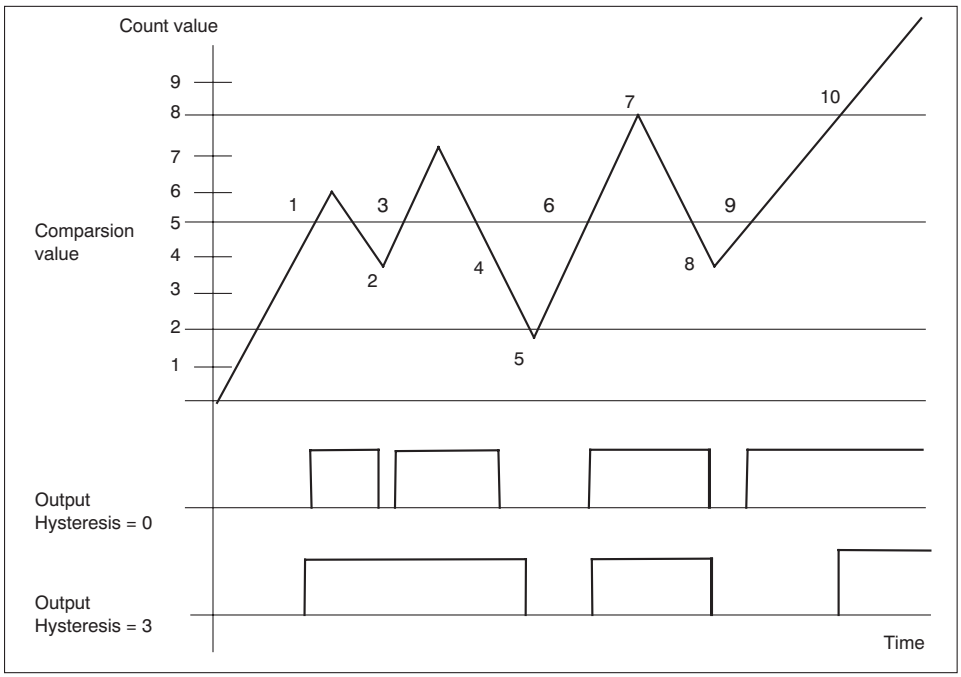


Figure 9-7 Example of the Effect of Hysteresis

Legend

To see the effect of hysteresis, note the behavior of the output depending on the hysteresis set and particularly the counter readings marked with numbers.

1. The counter reaches the comparison value:

   Hysteresis = 0: The output is set.

   Hysteresis = 3: The output is set.

2. The counter reaches comparison value -1:

   Hysteresis = 0: The output is reset.

   Hysteresis = 3: The output remains set because the counter has not exited the hysteresis range since the output was set.

3. The counter reaches the comparison value:

   Hysteresis = 0: The output is set.

   Hysteresis = 3: The output remains set.

4. The counter reaches comparison value -1:

   Hysteresis = 0: The output is reset.

   Hysteresis = 3: The output remains set because the counter has not exited the hysteresis range since the output was set.

5. The counter exits the hysteresis range (Hysteresis = 3):

   Hysteresis = 0: -

   Hysteresis = 3: The output is reset.

6. The counter reaches the comparison value:

   Hysteresis = 0: The output is set.

   Hysteresis = 3: The output is set.

7. The counter exits the hysteresis range (Hysteresis = 3):

   Hysteresis = 0: -

   Hysteresis = 3: -

8. The counter reaches comparison value -1:

   Hysteresis = 0: The output is reset.

   Hysteresis = 1: The output is reset because the counter has since exited the hysteresis range.

9. The counter reaches the comparison value:

   Hysteresis = 0: The output is set.

   Hysteresis = 1: The output is not set because the counter has not exited the hysteresis range since the output was reset.

10. The counter exits the hysteresis range (Hysteresis = 3):

    Hysteresis = 0: -

    Hysteresis = 1: The output is set.

10 DB Assignments

10.1 Data Block for the Function CNT2_CTR

All data belonging to one channel of the module are stored in the data block (DB) of the function CNT2_CTR. The data structure and the length of the DB are defined by UDT1. Before the module is assigned parameters, the DB must be assigned the following valid data (see Section 6.4):

- Module address (address 12.0)
- Channel address (address 14.0)
- DS offset (address 18.0), fixed at 0

The DB has been generated from UDT1 as a data block with associated user-defined data type. The DB assignments resulting from this are shown below.

Address	Variable	Data Type	Initial Value	Comments
0.0	NO	BYTE	B#16#0	Number
1.0	BUSY	BOOL	FALSE	TRUE: Write job in progress FALSE: Write job not in progress
1.1	DONE	BOOL	FALSE	TRUE: Write job finished FALSE: Write job not finished
1.2	IMPOSS	BOOL	FALSE	TRUE: Write job not possible FALSE: Write job possible
1.3	UNKNOWN	BOOL	FALSE	TRUE: Write job unknown FALSE: Write job known
2.0	NO	BYTE	B#16#0	Number
3.0	BUSY	BOOL	FALSE	TRUE: Read job in progress FALSE: Read job not in progress
3.1	DONE	BOOL	FALSE	TRUE: Read job finished FALSE: Read job not finished
3.2	IMPOSS	BOOL	FALSE	TRUE: Read job not possible FALSE: Read job possible
3.3	UNKNOWN	BOOL	FALSE	TRUE: Read job unknown FALSE: Read job known
4.0	RESERV_0	ARRAY [1..3] OF WORD	W#16#0	Reserved
10.0	RESERV_1	WORD	W#16#0	Reserved
12.0	MOD_ADR	WORD	W#16#0	Module address
14.0	CH_ADR	DWORD	DW#16#0	Channel address
18.0	DS_OFFS	BYTE	B#16#0	Data block offset
19.0	RESERV_2	BYTE	B#16#0	Reserved

Address	Variable	Data Type	Initial Value	Comments
20.0	BIT0_0	BOOL	FALSE	Reserved
20.1	BIT0_1	BOOL	FALSE	Reserved
20.2	BIT0_2	BOOL	FALSE	Reserved
20.3	BIT0_3	BOOL	FALSE	Reserved
20.4	BIT0_4	BOOL	FALSE	Reserved
20.5	BIT0_5	BOOL	FALSE	Reserved
20.6	BIT0_6	BOOL	FALSE	Reserved
20.7	BIT0_7	BOOL	FALSE	Reserved
21.0	CTRL_DQ0	BOOL	FALSE	TRUE: Output 0 enabled FALSE: Output 0 not enabled
21.1	CTRL_DQ1	BOOL	FALSE	TRUE: Output 1 enabled FALSE: Output 1 not enabled
21.2	CTRL_DQ2	BOOL	FALSE	TRUE: Output 2 enabled FALSE: Output 2 not enabled
21.3	CTRL_DQ3	BOOL	FALSE	TRUE: Output 3 enabled FALSE: Output 3 not enabled
21.4	CTRL_DQ4	BOOL	FALSE	TRUE: Output 4 enabled FALSE: Output 4 not enabled
21.5	CTRL_DQ5	BOOL	FALSE	TRUE: Output 5 enabled FALSE: Output 5 not enabled
21.6	CTRL_DQ6	BOOL	FALSE	TRUE: Output 6 enabled FALSE: Output 6 not enabled
21.7	CTRL_DQ7	BOOL	FALSE	TRUE: Output 7 enabled FALSE: Output 7 not enabled
22.0	SET_DQ0	BOOL	FALSE	TRUE: Output 0 set FALSE: Output 0 not set
22.1	SET_DQ1	BOOL	FALSE	TRUE: Output 1 set FALSE: Output 1 not set
22.2	SET_DQ2	BOOL	FALSE	TRUE: Output 2 set FALSE: Output 2 not set
22.3	SET_DQ3	BOOL	FALSE	TRUE: Output 3 set FALSE: Output 3 not set
22.4	SET_DQ4	BOOL	FALSE	TRUE: Output 4 set FALSE: Output 4 not set
22.5	SET_DQ5	BOOL	FALSE	TRUE: Output 5 set FALSE: Output 5 not set
22.6	SET_DQ6	BOOL	FALSE	TRUE: Output 6 set FALSE: Output 6 not set
22.7	SET_DQ7	BOOL	FALSE	TRUE: Output 7 set FALSE: Output 7 not set
23.0	SW_GATE0	BOOL	FALSE	TRUE: Software gate counter 0 open FALSE: Software gate counter 0 closed
23.1	SW_GATE1	BOOL	FALSE	TRUE: Software gate counter 1 open FALSE: Software gate counter 1 closed
23.2	SW_GATE2	BOOL	FALSE	TRUE: Software gate counter 2 open FALSE: Software gate counter 2 closed
23.3	SW_GATE3	BOOL	FALSE	TRUE: Software gate counter 3 open FALSE: Software gate counter 3 closed

Address	Variable	Data Type	Initial Value	Comments
23.4	SW_GATE4	BOOL	FALSE	TRUE: Software gate counter 4 open FALSE: Software gate counter 4 closed
23.5	SW_GATE5	BOOL	FALSE	TRUE: Software gate counter 5 open FALSE: Software gate counter 5 closed
23.6	SW_GATE6	BOOL	FALSE	TRUE: Software gate counter 6 open FALSE: Software gate counter 6 closed
23.7	SW_GATE7	BOOL	FALSE	TRUE: Software gate counter 7 open FALSE: Software gate counter 7 closed
24.0	CTRL_DWORD1	DWORD	DW#16#0	Reserved
28.0	CTRL_DWORD2	DWORD	DW#16#0	Reserved
32.0	CTRL_DWORD3	DWORD	DW#16#0	Reserved
36.0	BIT0_0	BOOL	FALSE	Reserved
36.1	STS_TFB	BOOL	FALSE	TRUE: PG operation active FALSE: PG operation deactivated
36.2	BIT0_2	BOOL	FALSE	Reserved
36.3	BIT0_3	BOOL	FALSE	Reserved
36.4	DATA_ERR	BOOL	FALSE	Data errors
36.5	BIT0_5	BOOL	FALSE	Reserved
36.6	BIT0_6	BOOL	FALSE	Reserved
36.7	PARA	BOOL	FALSE	TRUE: Module assigned parameters FALSE: Module not assigned parameters
37.0	STS_CMP0	BOOL	FALSE	TRUE: Comparator 0 triggered FALSE: Comparator 0 not triggered
37.1	STS_CMP1	BOOL	FALSE	TRUE: Comparator 1 triggered FALSE: Comparator 1 not triggered
37.2	STS_CMP2	BOOL	FALSE	TRUE: Comparator 2 triggered FALSE: Comparator 2 not triggered
37.3	STS_CMP3	BOOL	FALSE	TRUE: Comparator 3 triggered FALSE: Comparator 3 not triggered
37.4	STS_CMP4	BOOL	FALSE	TRUE: Comparator 4 triggered FALSE: Comparator 4 not triggered
37.5	STS_CMP5	BOOL	FALSE	TRUE: Comparator 5 triggered FALSE: Comparator 5 not triggered
37.6	STS_CMP6	BOOL	FALSE	TRUE: Comparator 6 triggered FALSE: Comparator 6 not triggered
37.7	STS_CMP7	BOOL	FALSE	TRUE: Comparator 7 triggered FALSE: Comparator 7 not triggered
38.0	STS_UFLW0	BOOL	FALSE	TRUE: Underflow counter 0 FALSE: No underflow counter 0
38.1	STS_UFLW1	BOOL	FALSE	TRUE: Underflow counter 1 FALSE: No underflow counter 1
38.2	STS_UFLW2	BOOL	FALSE	TRUE: Underflow counter 2 FALSE: No underflow counter 2
38.3	STS_UFLW3	BOOL	FALSE	TRUE: Underflow counter 3 FALSE: No underflow counter 3
38.4	STS_UFLW4	BOOL	FALSE	TRUE: Underflow counter 4 FALSE: No underflow counter 4

Address	Variable	Data Type	Initial Value	Comments
38.5	STS_UFLW5	BOOL	FALSE	TRUE: Underflow counter 5 FALSE: No underflow counter 5
38.6	STS_UFLW6	BOOL	FALSE	TRUE: Underflow counter 6 FALSE: No underflow counter 6
38.7	STS_UFLW7	BOOL	FALSE	TRUE: Underflow counter 7 FALSE: No underflow counter 7
39.0	STS_OFLW0	BOOL	FALSE	TRUE: Overflow counter 0 FALSE: No overflow counter 0
39.1	STS_OFLW1	BOOL	FALSE	TRUE: Overflow counter 1 FALSE: No overflow counter 1
39.2	STS_OFLW2	BOOL	FALSE	TRUE: Overflow counter 2 FALSE: No overflow counter 2
39.3	STS_OFLW3	BOOL	FALSE	TRUE: Overflow counter 3 FALSE: No overflow counter 3
39.4	STS_OFLW4	BOOL	FALSE	TRUE: Overflow counter 4 FALSE: No overflow counter 4
39.5	STS_OFLW5	BOOL	FALSE	TRUE: Overflow counter 5 FALSE: No overflow counter 5
39.6	STS_OFLW6	BOOL	FALSE	TRUE: Overflow counter 6 FALSE: No overflow counter 6
39.7	STS_OFLW7	BOOL	FALSE	TRUE: Overflow counter 7 FALSE: No overflow counter 7
40.0	STS_DIR0	BOOL	FALSE	TRUE: Count direction counter 0 down FALSE: Count direction counter 0 up
40.1	STS_DIR1	BOOL	FALSE	TRUE: Count direction counter 1 down FALSE: Count direction counter 1 up
40.2	STS_DIR2	BOOL	FALSE	TRUE: Count direction counter 2 down FALSE: Count direction counter 2 up
40.3	STS_DIR3	BOOL	FALSE	TRUE: Count direction counter 3 down FALSE: Count direction counter 3 up
40.4	STS_DIR4	BOOL	FALSE	TRUE: Count direction counter 4 down FALSE: Count direction counter 4 up
40.5	STS_DIR5	BOOL	FALSE	TRUE: Count direction counter 5 down FALSE: Count direction counter 5 up
40.6	STS_DIR6	BOOL	FALSE	TRUE: Count direction counter 6 down FALSE: Count direction counter 6 up
40.7	STS_DIR7	BOOL	FALSE	TRUE: Count direction counter 7 down FALSE: Count direction counter 7 up
41.0	STS_DI0	BOOL	FALSE	TRUE: Digital input 0 set FALSE: Digital input 0 not set
41.1	STS_DI1	BOOL	FALSE	TRUE: Digital input 1 set FALSE: Digital input 1 not set
41.2	STS_DI2	BOOL	FALSE	TRUE: Digital input 2 set FALSE: Digital input 2 not set
41.3	STS_DI3	BOOL	FALSE	TRUE: Digital input 3 set FALSE: Digital input 3 not set
41.4	STS_DI4	BOOL	FALSE	TRUE: Digital input 4 set FALSE: Digital input 4 not set

Address	Variable	Data Type	Initial Value	Comments
41.5	STS_DI5	BOOL	FALSE	TRUE: Digital input 5 set FALSE: Digital input 5 not set
41.6	STS_DI6	BOOL	FALSE	TRUE: Digital input 6 set FALSE: Digital input 6 not set
41.7	STS_DI7	BOOL	FALSE	TRUE: Digital input 7 set FALSE: Digital input 7 not set
42.0	STS_DQ0	BOOL	FALSE	TRUE: Digital output 0 set FALSE: Digital output 0 not set
42.1	STS_DQ1	BOOL	FALSE	TRUE: Digital output 1 set FALSE: Digital output 1 not set
42.2	STS_DQ2	BOOL	FALSE	TRUE: Digital output 2 set FALSE: Digital output 2 not set
42.3	STS_DQ3	BOOL	FALSE	TRUE: Digital output 3 set FALSE: Digital output 3 not set
42.4	STS_DQ4	BOOL	FALSE	TRUE: Digital output 4 set FALSE: Digital output 4 not set
42.5	STS_DQ5	BOOL	FALSE	TRUE: Digital output 5 set FALSE: Digital output 5 not set
42.6	STS_DQ6	BOOL	FALSE	TRUE: Digital output 6 set FALSE: Digital output 6 not set
42.7	STS_DQ7	BOOL	FALSE	TRUE: Digital output 7 set FALSE: Digital output 7 not set
43.0	STS_GATE0	BOOL	FALSE	TRUE: Internal gate counter 0 open FALSE: Internal gate counter 0 closed
43.1	STS_GATE1	BOOL	FALSE	TRUE: Internal gate counter 1 open FALSE: Internal gate counter 1 closed
43.2	STS_GATE2	BOOL	FALSE	TRUE: Internal gate counter 2 open FALSE: Internal gate counter 2 closed
43.3	STS_GATE3	BOOL	FALSE	TRUE: Internal gate counter 3 open FALSE: Internal gate counter 3 closed
43.4	STS_GATE4	BOOL	FALSE	TRUE: Internal gate counter 4 open FALSE: Internal gate counter 4 closed
43.5	STS_GATE5	BOOL	FALSE	TRUE: Internal gate counter 5 open FALSE: Internal gate counter 5 closed
43.6	STS_GATE6	BOOL	FALSE	TRUE: Internal gate counter 6 open FALSE: Internal gate counter 6 closed
43.7	STS_GATE7	BOOL	FALSE	TRUE: Internal gate counter 7 open FALSE: Internal gate counter 7 closed
44	USER_STAT_WORD0	WORD	W#16#0	Depends on parameter assignment of count/measurement values
46	USER_STAT_WORD1	WORD	W#16#0	Depends on parameter assignment of count/measurement values
48	USER_STAT_WORD2	WORD	W#16#0	Depends on parameter assignment of count/measurement values
50	USER_STAT_WORD3	WORD	W#16#0	Depends on parameter assignment of count/measurement values
52	LOAD-VAL0	DINT	L#0	Load counter 0 directly
56	LOAD-VAL1	DINT	L#0	Load counter 1 directly

Address	Variable	Data Type	Initial Value	Comments
60	LOAD-VAL2	DINT	L#0	Load counter 2 directly
64	LOAD-VAL3	DINT	L#0	Load counter 3 directly
68	LOAD-VAL4	DINT	L#0	Load counter 4 directly
72	LOAD-VAL5	DINT	L#0	Load counter 5 directly
76	LOAD-VAL6	DINT	L#0	Load counter 6 directly
80	LOAD-VAL7	DINT	L#0	Load counter 7 directly
84	LOAD-PREPARE-VAL0	DINT	L#0	Load counter 0 in preparation
88	LOAD-PREPARE-VAL1	DINT	L#0	Load counter 1 in preparation
92	LOAD-PREPARE-VAL2	DINT	L#0	Load counter 2 in preparation
96	LOAD-PREPARE-VAL3	DINT	L#0	Load counter 3 in preparation
100	LOAD-PREPARE-VAL4	DINT	L#0	Load counter 4 in preparation
104	LOAD-PREPARE-VAL5	DINT	L#0	Load counter 5 in preparation
108	LOAD-PREPARE-VAL6	DINT	L#0	Load counter 6 in preparation
112	LOAD-PREPARE-VAL7	DINT	L#0	Load counter 7 in preparation
116	CMP-VAL0	DINT	L#0	Load comparator 0
120	CMP-VAL1	DINT	L#0	Load comparator 1
124	CMP-VAL2	DINT	L#0	Load comparator 2
128	CMP-VAL3	DINT	L#0	Load comparator 3
132	CMP-VAL4	DINT	L#0	Load comparator 4
136	CMP-VAL5	DINT	L#0	Load comparator 5
140	CMP-VAL6	DINT	L#0	Load comparator 6
144	CMP-VAL7	DINT	L#0	Load comparator 7
148	ACT_CNTV0	DINT	L#0	Current counter reading 0
152	ACT_MSRV0	DINT	L#0	Measurement result 0
156	ACT_CNTV1	DINT	L#0	Current counter reading 1
160	ACT_MSRV1	DINT	L#0	Measurement result 1
164	ACT_CNTV2	DINT	L#0	Current counter reading 2
168	ACT_MSRV2	DINT	L#0	Measurement result2
172	ACT_CNTV3	DINT	L#0	Current counter reading 3
176	ACT_MSRV3	DINT	L#0	Measurement result 3
180	ACT_CNTV4	DINT	L#0	Current counter reading 4
184	ACT_MSRV4	DINT	L#0	Measurement result 4
188	ACT_CNTV5	DINT	L#0	Current counter reading 5
192	ACT_MSRV5	DINT	L#0	Measurement result 5
196	ACT_CNTV6	DINT	L#0	Current counter reading 6
200	ACT_MSRV6	DINT	L#0	Measurement result 6
204	ACT_CNTV7	DINT	L#0	Current counter reading 7
208	ACT_MSRV7	DINT	L#0	Measurement result 7
212.0	BYTE0	BYTE	B#16#0	Reserved

Address	Variable	Data Type	Initial Value	Comments
213.0	BYTE1	BYTE	B#16#0	Reserved
214.0	BYTE2	BYTE	B#16#0	Reserved
215.0	BYTE3	BYTE	B#16#0	Reserved
216.0	BYTE4	BYTE	B#16#0	Channel type
217.0	BYTE5	BYTE	B#16#0	Length of channel information
218.0	BYTE6	BYTE	B#16#0	Number of channels
219.0	BYTE7	BYTE	B#16#0	Channel fault vector
220.0	BYTE8	BYTE	B#16#0	Error counter 0
221.0	BYTE9	BYTE	B#16#0	Error counter 1
222.0	BYTE10	BYTE	B#16#0	Error counter 2
223.0	BYTE11	BYTE	B#16#0	Error counter 3
224.0	BYTE12	BYTE	B#16#0	Error counter 4
225.0	BYTE13	BYTE	B#16#0	Error counter 5
226.0	BYTE14	BYTE	B#16#0	Error counter 6
227.0	BYTE15	BYTE	B#16#0	Error counter 7

11 Faults and Diagnostics

What Does this Chapter Describe?

Defects on the module, operator errors, incorrect wiring, or contradictory parameter assignments can cause faults that the module indicates to the user.

The different types of faults are indicated and displayed at different positions and must be acknowledged in different ways.

You will find the following described in this chapter:

- The faults and errors that can occur
- Where these faults are indicated
- How you acknowledge the faults.

Errors/faults are divided into the following error classes:

Error Class	Cause
Data error	Incorrect jobs from the PLC or programming device
Message	Module status is reported
Module parameter error	Incorrect basic parameters in module
Channel parameter error	Incorrect channel parameter assignment
Diagnostic error	Diagnostic event occurred

11.1 Types of Faults/Errors

Overview of Fault/Error Types

The FM 350-2 distinguishes between the following types of faults/errors:

Type of Fault/Error	Description
Internal fault	Faulty status or defect on the module which cannot be assigned to a channel (counter). Example: watchdog timeout.
External fault	I/O fault or fault outside the module which cannot be assigned to a channel (counter).
External channel fault	I/O fault or fault outside the module which can be clearly assigned to a channel (counter). Example: fault in signal line from NAMUR encoder.
Data error	Errors which occur when a channel (counter) is controlled via system data records and limit values or counter states are not maintained or observed. Example: comparison value lies outside the count range.

Reactions

The FM 350-2 reacts as follows to the faults/errors:

Type of Fault	Reaction	LED	Message	Acknowledgement
Internal fault	All off	SF	Diagnostic interrupt	---
External fault	All off	SF	Diagnostic interrupt	---
External channel fault	All off	SF	Diagnostic interrupt	---
Data error	Job rejected		Entry in diagnostic buffer	New job with modified data

Triggering a Diagnostic Interrupt

Internal faults, external faults, and external channel faults can trigger a diagnostic interrupt provided you have enabled the diagnostic interrupt in the relevant parameter assignment dialog box. You can see which fault has caused the LED to light up from the diagnostics data sets DS0 and DS1. The assignments of the diagnostics data sets DS0 and DS1 are described in the next section.

11.2 Fault Indication via the Group Error LED

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), or the parameter assignment is faulty.

Which Faults are Indicated?

The following faults are indicated by the group error LED lighting up:

Type of Fault	Cause of Fault	Remedy
Internal faults	Watchdog tripped Hardware interrupt lost	Change the module Acknowledged by hardware interrupt processing
External faults	Module without parameters Parameter assignment error	Assign parameters and download them
External channel faults	Encoder supply short-circuited or overloaded Fault in NAMUR encoder signals (wire break, short circuit, cable missing)	Correct the connection Correct the connection

11.3 Triggering Diagnostic Interrupts

What is a Diagnostic Interrupt?

If a user program is to respond to an internal or external fault, you can assign a diagnostic interrupt that stops the cyclic program of the CPU and calls the diagnostic interrupt OB (OB82).

Which Events Can Trigger a Diagnostic Interrupt?

The list shows you which events can trigger a diagnostic interrupt:

- Channel error in set channel
- Module without parameters
- Incorrect parameters in module
- Watchdog tripped
- Hardware interrupt lost
- Signal line monitoring NAMUR encoder reports error
- Encoder supply 8.2 V NAMUR encoder faulty

Enabling the Diagnostic Interrupt

You disable or enable the interrupts for the module in the parameter assignment dialog boxes and you decide there whether the module is to trigger a diagnostic interrupt and/or a hardware interrupt.

Responses to a Diagnostic Interrupt

If an event occurs that can trigger a diagnostic interrupt, the following happens:

- The diagnostics information is stored in diagnostics data sets DS0 and DS1.
- The group error LED lights up.

  When the fault is remedied, the group error LED extinguishes.
- The diagnostic interrupt OB is called (OB82).
- The diagnostics data set DS0 is entered in the start information of the diagnostic interrupt OB.
- The count continues unchanged.

If OB82 has not been programmed, the CPU goes into STOP.

Diagnostics Data Set DS0 and DS1

The information as to which event triggered a diagnostic interrupt is stored in the diagnostics data sets DS0 and DS1. The diagnostics data set DS0 comprises four bytes; DS1 comprises 16 bytes with the first four bytes being identical to DS0.

Reading the Data Set from the Module

The diagnostics data set DS0 is automatically transferred to the start information when the diagnostic OB is called. These four bytes are stored there in the local data (bytes 8 to 11) of OB82.

You can read out diagnostics data set DS1 (and thus also the contents of DS0) from the module with the function DIAG_RD. It only makes sense to do this if a fault in a channel is signaled in DS0.

Assignments of the Diagnostics Data Set DS0 in the Start Information

The following Table shows the assignments of diagnostics data set DS0 in the start information. All unlisted bits are insignificant and take the value zero.

Byte	Bit	Meaning	Remarks	Event No.
0	0	Module failed	Set for every diagnostics event	8:x:00
	1	Internal error	Set for all internal faults	8:x:01
	2	External error	Set for all external faults	8:x:02
	3	Channel error	See DS1, byte 4 for further breakdown	8:x:03
	6	Module without parameters	Execute parameter assignment	8:x:06
	7	Incorrect parameters in module	See Section 11.4 for further breakdown	8:x:07
1	0 to 3	Type class	Always assigned 8	
	4	Channel information	Always assigned 1	
2	3	Watchdog tripped	Module defective or strong interference	8:x:33
3	6	Hardware interrupt lost	Check configuration. Hardware interrupt event has been detected and cannot be signaled since the same event has not yet been acknowledged by the user program/CPU	8:x:46

Diagnostics Data Set DS1

The diagnostics data set DS1 consists of 16 bytes. The first four bytes are identical to diagnostics data set DS0. The following Table shows the assignments of the remaining bytes. All unlisted bits are insignificant and take the value zero. This data set is entered in the data block of the function CNT2_CTR from DW212 by the function DIAG_RD.

Byte	Bit	Meaning	Remarks	Event No.
4	0 to 6	Channel type	Always assigned 76H	
	7	Further channel types	Always assigned 0	
5	0 to 7	Diagnostics information length	Always assigned 8	
6	0 to 7	Number of channels	Always assigned 8	
7	0	Channel fault vector	Channel bit	
8 Channel 0	4	Fault in 8.2 V encoder supply	NAMUR encoder	8:x:94
	6	Signal line NAMUR encoder	Short circuit/wire break	8:x:96
9 Channel 1	4	Fault in 8.2 V encoder supply	NAMUR encoder	8:x:94
	6	Signal line NAMUR encoder	Short circuit/wire break	8:x:96
10 Channel 2	4	Fault in 8.2 V encoder supply	NAMUR encoder	8:x:94
	6	Signal line NAMUR encoder	Short circuit/wire break	8:x:96
11 Channel 3	4	Fault in 8.2 V encoder supply	NAMUR encoder	8:x:94
	6	Signal line NAMUR encoder	Short circuit/wire break	8:x:96
12 Channel 4	4	Fault in 8.2 V encoder supply	NAMUR encoder	8:x:94
	6	Signal line NAMUR encoder	Short circuit/wire break	8:x:96
13 Channel 5	4	Fault in 8.2 V encoder supply	NAMUR encoder	8:x:94
	6	Signal line NAMUR encoder	Short circuit/wire break	8:x:96
14 Channel 6	4	Fault in 8.2 V encoder supply	NAMUR encoder	8:x:94
	6	Signal line NAMUR encoder	Short circuit/wire break	8:x:96
15 Channel 7	4	Fault in 8.2 V encoder supply	NAMUR encoder	8:x:94
	6	Signal line NAMUR encoder	Short circuit/wire break	8:x:96

How Does the Diagnostics Text Appear in the Diagnostic Buffer of the CPU?

If you want to enter the diagnostics message in the diagnostic buffer of the CPU, you must call the SFC52 ‘Write a user-defined diagnostic event to the diagnostic buffer’ in the user program. The event number of the diagnostics message in each case is specified in the input parameter EVENTN. The interrupt is entered in the diagnostic buffer with x=1 as incoming and with x=0 as outgoing. The diagnostic buffer contains the relevant diagnostics text in the ‘Meaning’ column as well as the time of the entry.

Default Setting

The diagnostic interrupt is disabled in the default setting.

11.4 Data Errors

When Do Data Errors Occur?

If jobs are given to the module by the programming device or by means of the function CNT2_WR, these are checked. If errors occur during this check, the module signals these data errors.

Incorrect jobs are not accepted by the module.

Where are Data Errors Indicated?

The data errors are displayed in the parameter assignment dialog boxes using the menu command **Debug > Diagnostics**.

If an error is located when jobs are checked, the bit CHECKBACK_SIGNALS, DATA_ERR=1 is set in the counter DB.

How are Data Errors Acknowledged?

Correct the jobs in accordance with the specifications. Download the corrected jobs again to the FM 350-2.

Diagnostic Buffer of the FM 350-2

Entries in the diagnostic buffer of the FM 350-2 are displayed in the parameter assignment dialog boxes using the menu command **Debug > Diagnostics**.

A Technical Specifications

What Does this Chapter Describe?

The technical specifications of the FM 350-2 are listed in this chapter.

UL/CSA Approvals

The following approvals have been obtained for the S7-300:

UL Recognition MarkUnderwriters Laboratories (UL) to Standard UL 508

CSA Certification MarkCanadian Standard Association (CSA) to Standard C 22.2 No. 142, File LR 48323

FM Approval

The following FM approval has been issued for the S7-300 system: Factory Mutual Approval Standard Class Number 3611, Class I, Division 2, Group A, B, C, D.

Warning

Personal injury or property damage can result.

In hazardous areas, personal injury or property damage can result if plug-in connections are interrupted during operation of an S7-300.

The S7-300 must always be de-energized prior to separating plug-in connections in hazardous areas.

Warning

WARNING - DO NOT DISCONNECT WHILE CIRCUIT IS LIVE

UNLESS LOCATION IS KNOWN TO BE NON-HAZARDOUS.

CE Mark

CE

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

In accordance with the above-mentioned EU Directive, Article 10, the EU declarations of conformity are held at the disposal of the competent authorities at the address below:

Siemens Aktiengesellschaft
Bereich Automatisierungstechnik A&D AS E 48
Postfach 1963

D-92209 Amberg
Federal Republic of Germany

Areas of Use

SIMATIC products have been designed for use in industry.

They can also be used in the domestic environment (household, business and trade area, small plants) with individual approval. You must acquire the individual approval from the respective national authority or testing body.

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

Observing the Installation Guidelines

SIMATIC products meet the requirements if you observe the installation guidelines described in the manual when installing and operating the equipment.

A.1 Technical Specifications

Dimensions and Weight	
Dimensions WxHxD (mm)	80 x 125 x 120
Weight	approx. 460 g
Voltages, Currents, Potentials	
Auxiliary voltage L+/M • Range • Reverse polarity protection • Galvanic isolation	24 VDC 20.4 to 28.8 V No Yes, from backplane bus and shield
NAMUR encoder supply • Output voltage • Output current	 8.2 V ±2% max. 200 mA, short-circuit protected
Current consumption • From S7-300 bus • From L+ (without load)	 approx. 100 mA approx. 150 mA
Power losses of the module	approx. 10 W
Status, Interrupts, Diagnostics	
Status indication	Yes, 16 green LEDs for status of I0 to 7, Q0 to 7
Interrupts • Hardware interrupt • Diagnostic interrupt	 Yes, can have parameters assigned Yes, can have parameters assigned
Diagnostics functions • Fault indication on the module for group errors • Diagnostics information read out	Yes Yes, red LED Yes
Data on Counter Signals and Digital Inputs and Outputs	
NAMUR encoder inputs A0 to 7 • Level • Line length shielded • Input current • Input delay • Max. count frequency • Galvanic isolation	 acc. to DIN 19234 100 m 0 signal: ≤ 1.2 mA 1 signal: ≥ 2.1 mA max. 50 µs 10 kHz Yes, from backplane bus and shield

24-V encoder inputs A0 to 7 Pulse encoder Incremental encoder • Input voltage • Input current • Input delay • Max. count frequency • Galvanic isolation • Connection of two-wire BERO, type 2 • Line length shielded • Coincidence factor with horizontal installation with vertical installation	 Count signal Track A 0 signal: -3 to 5 V 1 signal: 11 to 30.2 V 0 signal: ≤ 2 mA (zero-signal current) 1 signal: 9 mA (typ.) max. 50 µs 20 kHz (when t_pulse/ t_pause: 50/50) Yes, from backplane bus and shield possible 100 m to 40 °C: 100% to 60 °C: 50% to 40 °C: 50%
24-V encoder inputs B0 to 7 Pulse encoder Incremental encoder Max. count frequency All other values such as encoder inputs A0 to 7	 Direction signal Track B 10 kHz *)
Digital inputs I0 to 7 • Input voltage • Input current • Input delay • Connection of two-wire BERO, type 2 • Galvanic isolation • Line length shielded • Coincidence factor with horizontal installation with vertical installation	 0 signal: - 3 to + 5 V 1 signal: 11 to 30.2 V 0 signal: ≤ 2 mA (zero-signal current) 1 signal: 9 mA (typ.) 0>1 max. 50 ms 1>0 max. 50 ms possible Yes, from backplane bus and shield 100 m to 40 °C: 100% to 60 °C: 50% to 40 °C: 50%

Digital outputs	
• Output current	0 signal: 0.5 mA 1 signal: 0.5 A (permitted range 5 mA to 0.6 A)
• Coincidence factor	100%
• Status indication	Yes, green LED
• Output delay	0>1 typ. 300 ms with I_A 0.5 A 1>0 typ. 300 ms with I_A 0.5 A
• Signal level for 1 signal	L+ -0.8 V
• Controls a standard digital input	Yes
• Controls a fast digital input	Yes, see note below
• Short-circuit protection	Yes
• Limiting of inductive cut-off voltage	L+ -40 V (typ.)
• Switching frequency	resistive load max. 500 Hz inductive load max. 0.5 Hz
• Residual current of all digital outputs with horizontal installation	to 40 °C: 4 A to 60 °C: 2 A
• Residual current of all digital outputs with vertical installation	to 40 °C: 2 A
• Line length unshielded	100 m
• Line length shielded	600 m
• Galvanic isolation	Yes, from backplane bus and shield

*) Therefore only a maximum frequency of 10kHz is possible for incremental encoders.

Note

When you connect the 24-V supply voltage via a mechanical contact, the outputs of the FM 350-2 carry a “1” signal for approximately 50 µs owing to the switching. You must remember this if you use the FM 350-2 in combination with fast digital inputs.

More relevant data, for example, ambient conditions, are listed in *Manual: S7-300 Programmable Controller, Hardware and Installation.*

B Spare Parts

Spare Parts

The following Table lists all spare parts of the S7-300 that you can order for the FM 350-2 either additionally or later.

Parts for the S7-300	Order Number
Expansion bus	6ES7390-0AA00-0AA0
Labeling sheet	6ES7392-2XX00-0AA0
Slot number plate	6ES7912-0AA00-0AA0
Front connector (40-pin) Screw-type terminals	6ES7392-1AM00-0AA0
Front connector (40-pin) spring-loaded terminals	6ES7392-1BM01-0AA0
Shield attachment (with 2 screw-type bolts)	6ES7390-5AA00-0AA0
Shield connection terminals for	
2 cables with 2 to 6 mm shield diameter each	6ES7390-5AB00-0AA0
1 cable with 3 to 8 mm shield diameter	6ES7390-5BA00-0AA0
1 cable with 4 to 13 mm shield diameter	6ES7390-5CA00-0AA0

Glossary

Asymmetric Signals

Asymmetric signals are two pulse trains out of phase by 90 degrees (A and B) without negative traces (A, B).

Configuration

Assignment of modules to mounting racks, slots, and addresses. When configuring the hardware, the user fills in a configuration table under STEP 7.

Double Evaluation

Double evaluation means that the rising edges of pulse trains A and B are evaluated on an incremental encoder.

Encoder

Encoders are used for precise acquisition of, among others, paths, positions, velocities, rotational speeds, volumes, etc.

Function (FC)

In accordance with IEC 1131-3, a function (FC) is a logic block without static data. A function makes it possible to pass parameters in the user program. This makes functions suitable for programming frequently recurring complex functions.

Function Module (FM)

A function module (FM) is a module that relieves the CPU of the S7 and M7 programmable controllers of time-critical or memory-intensive process signal handling tasks. FMs normally use the internal communication bus for high-speed data exchange with the CPU. FM applications include: counting, positioning, closed-loop control.

Incremental Encoder

Incremental encoders capture paths, positions, velocities, rotational speeds, volumes, etc. by counting small increments.

Increments per Encoder Rotation

Increments per encoder rotation specifies the number of increments that an encoder gives in one rotation.

Initiator

An initiator is a simple BERO switch without direction information. It therefore supplies only a count signal. Only the rising edges of signal A are counted. The count direction must be specified by the user.

OD

The ‘output disable’ (OD) signal switches all modules in an S7 programmable controller to a safe state in the STOP and HOLD operating modes. Examples of safe states are when the outputs are not live or when they are switched with substitute values.

Quadruple Evaluation

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

SFC

An SFC (system function) is a function integrated in the operating system of the CPU that can be called in the STEP 7 user program when required.

Single Evaluation

Single evaluation means that only the rising edge of pulse train A is evaluated on an incremental encoder.

UDT

User-defined data types (UDT) are created with the data type declaration. They have their own name and can therefore be used more than once. For example, a user-defined data type can be used to create a number of data blocks with the same structure (for example, controllers).

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