SIEMENS

SIMATIC

ET 200SP
Digital input module
F-DI 8x24VDC HF
(6ES7136-6BA01-0CA0)

Equipment Manual

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11/2025
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Legal information

Warning notice system

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

⚠ DANGER

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

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

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

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified persons are those who, because of their training and experience, are familiar with the installation, assembly, commissioning, operation, decommissioning and disassembly of the product and can recognize risks and avoid possible hazards.

Proper use of Siemens products

Note the following:

⚠ WARNING

Siemens products may only be used for the application described in the catalog and the associated usage information. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

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

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Introduction

1

Purpose of the documentation

This device manual complements the system manual ET 200SP distributed I/O system. You can find functions that generally relate to the ET 200SP system in the system manual ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

The information provided in this device manual and the system manual enables you to commission the ET 200SP distributed I/O system.

Conventions

Note the following identified notes:

NOTE

A note includes important information on the product described in the documentation, on handling the product or on the part of the documentation to which you ought to pay special attention.

Important note for maintaining the operational safety of your plant

NOTE

Plants with safety-related features are subject to special operational safety requirements on the part of the operator. The supplier is also obliged to comply with special product monitoring measures. For this reason, we inform you in personal notifications about product developments and features that are (or could be) relevant to the operation of plants from a safety perspective.

You should subscribe to the corresponding notifications in order to obtain the latest information and to allow you to make any necessary modifications to your system.

Log onto Industry Online Support. Follow the links below and click on "Email on update" on the right-hand side in each case:

- SIMATIC S7-300/S7-300F (https://support.industry.siemens.com/cs/ww/en/ps/13751)
- SIMATIC S7-400/S7-400H/S7-400F/FH (https://support.industry.siemens.com/cs/ww/en/ps/13828)
- SIMATIC S7-1500/SIMATIC S7-1500F (https://support.industry.siemens.com/cs/ww/en/ps/13716)
- SIMATIC S7-1200/SIMATIC S7-1200F (https://support.industry.siemens.com/cs/ww/en/ps/13683)
- Distributed I/O (https://support.industry.siemens.com/cs/ww/en/ps/14029)
- STEP 7 (TIA Portal) (https://support.industry.siemens.com/cs/ww/en/ps/14667)

1.1 ET 200SP documentation guide

1.1.1 Information classes ET 200SP



The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information



The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information



Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information



The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.1.3 S7 Failsafe Configuration Tool (S7-FCT)

SIMATIC S7-FCT

Failsafe Configuration Tool (FCT) enables you to GSD configure the following devices in third-party engineering systems:

- Selected, functionally fail-safe SIMATIC I/O devices
- Functionally fail-safe SIRIUS ACT PROFINET interfaces

The engineering system must meet the following requirements for this:

- Support of the CPD system integration acc. to "PROFIsafe - Profile for Safety Technology on PROFIBUS DP and PROFINET IO"
- TCI implementation to Conformance Class C3

Additional information on S7-FCT can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109762827).

1.1.4 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

You can find general information and measures relating to industrial cybersecurity in the system manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

This section provides an overview of security-related information about your SIEMENS device.

NOTE

Security-related changes to software or devices are documented in the "New functions" section.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Product overview

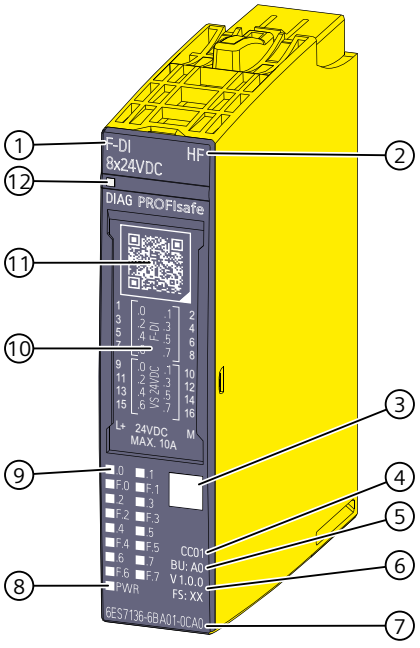
3

3.1 Properties

Article number

6ES7136-6BA01-0CA0

View of the module



① Module type and name
② Function class
③ Color coding module type
④ Color code for selecting the color-coded labels
⑤ BU type
⑥ Firmware and function version
⑦ Article number
⑧ LED for supply voltage
⑨ LEDs for channel status
⑩ Wiring diagram
⑪ QR code for identification link
⑫ LED for diagnostics

Figure 3-1 View of the F-DI 8×24VDC HF module

Properties

The module has the following technical properties:

- Fail-safe digital module
- PROFIsafe
- RIOforFA-Safety
- PROFIsafe address type 2
- 8 inputs (SIL3/Cat.3/PLd) or 4 inputs (SIL3/Cat.4/PLe)
- 8 outputs for sensor supply
- Use of various interconnection types (1oo1, 1oo2) is possible
- Suitable for the connection of 3-wire/4-wire sensors according to IEC 61131, Type 1
- Channel-specific assignable input delay 0.4 ms to 20 ms
- Internal short-circuit proof sensor supplies for each input
- External sensor supply possible
- Supply voltage L+
- Sink input (P-reading)
- Safety mat evaluation (firmware version V2.0.0 or higher)
- Suitable for the connection of 4-wire safety mats and pressure-sensitive protective devices (NO contact operating principle) according to ISO 13856-1, -2, -3
- Fail-safe counter (firmware version V3.0.0 or higher)
- Fail-safe standstill and overspeed monitoring (firmware version V3.0.0 or higher)
- Diagnostic display (DIAG red/green LED)
- Status display for each input (green LED)
- Error display for each input (red LED)
- Diagnostics
  - e.g., short-circuit, channel-specific
  - e.g., load voltage missing, module-specific
- Channel-based or module-based passivation

The module supports the following functions:

- Firmware update
- I&M identification data
- Service data

⚠ WARNING

If you have configured the digital input module F-DI 8x24VDC HF (6ES7136-6BA00-0CA0) in a plant, but have inserted the digital input module F-DI 8x24VDC HF (6ES7136-6BA01-0CA0) instead, the information from the manual of the digital input module F-DI 8x24VDC HF (6ES7136-6BA00-0CA0) still applies.

⚠ WARNING

The safety parameters in the technical data apply for a mission time of 20 years and a repair time of 100 hours. If repair is not possible within 100 hours, remove the respective module from the BaseUnit or switch off its supply voltage before the 100 hours have elapsed.

Proceed for the repair as described in the section Diagnostic messages.

Accessories

You can order the following accessories separately:

- Labeling strips
- Color identification labels
- Reference identification labels
- Shield connection
- Electronic coding element as replacement part (part number 6ES7193-6EF00-1AA0)

For more information on accessories, refer to the system manual ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293).

3.2 Operating modes

The digital input module F-DI 8x24VDC HF can be operated in the following operating modes:

- "Digital inputs (Page 18)"operating mode
- "Counter (Page 56)" operating mode
- "Standstill and overspeed monitoring (Page 86)" operating mode

Digital inputs operating mode

4

4.1 Wiring

4.1.1 Pin assignment for "Digital inputs" operating mode

Pin assignment for "Digital inputs" operating mode

Table 4-1 Pin assignment for "Digital inputs" operating mode

Pin assignment for "Digital inputs" operating mode						
Terminal	**Assignment**	**Terminal**	**Assignment**	**Description**	**BaseUnit**[1]	**Color identification label (terminals 1 to 16)**
1	DI_0	**2**	DI_1	• DI_n: Input signal, channel n • VS_n: Internal sensor supply, channel n	A0	 CC01 6ES7193-6CP01-2MA0
3	DI_2	**4**	DI_3			
5	DI_4	**6**	DI_5			
7	DI_6	**8**	DI_7			
9	VS_0	**10**	VS_1			
11	VS_2	**12**	VS_3			
13	VS_4	**14**	VS_5			
15	VS_6	**16**	VS_7			
L+	DC24V	**M**	M			

[1] Usable BaseUnit types can be identified by the last two digits of their order number. See also *ET 200SP Distributed I/O System* system manual

NOTE

The first BaseUnit of a potential group must be a light-colored BaseUnit.

NOTE

Make sure that you only use digital modules with BaseUnit type A0 during commissioning.

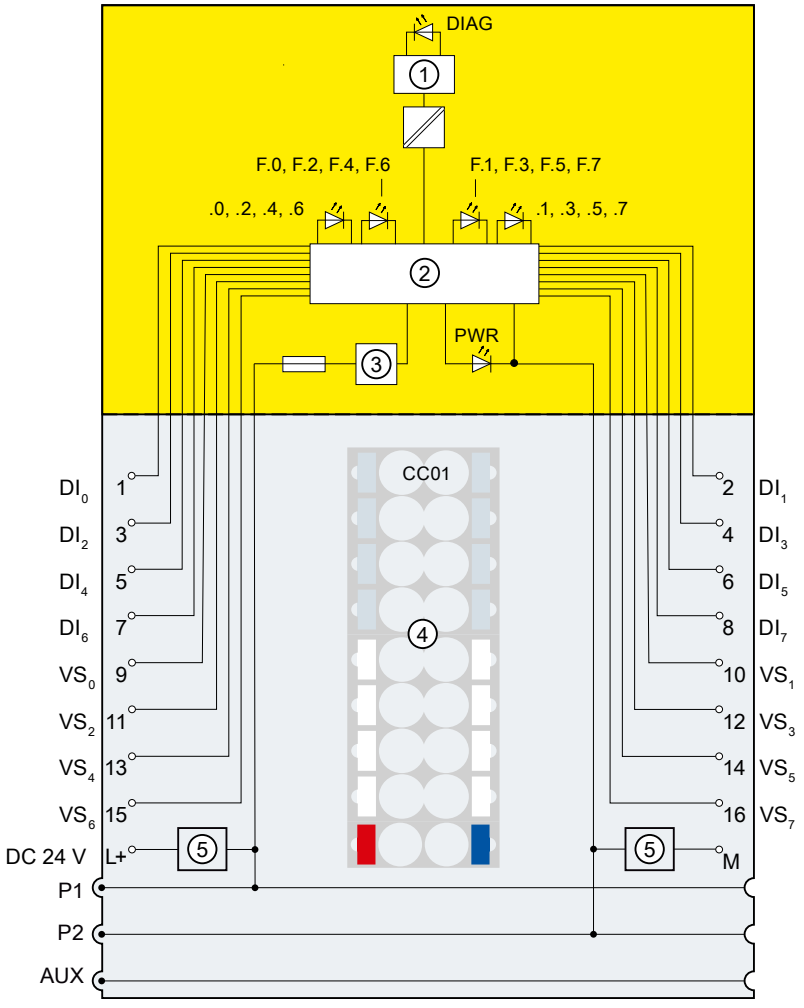
4.1.2 Wiring and block diagram

This section includes the block diagram of the digital input module F-DI 8×24VDC HF with the pin assignment.

You can find more information about wiring the BaseUnit in the Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

Block diagram

The following figure shows the pin assignment of the F-DI 8×24VDC HF digital input module on BaseUnit BU type A0.



①	Backplane bus interface	VS_n	Internal sensor supply, channel n
②	Input electronics	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
③	Reverse polarity protection	DI_n	Input signal, channel n
④	Color identification label with color code CC01 (optional)	DIAG	Error or diagnostics LED (green, red)

⑤	Filter circuit supply voltage (available in light-colored BaseUnit only)	.0 to .7	Channel status LED (green)
L+	24 V DC (infeed only with light-colored BaseUnit)	F.0 to F.7	Channel fault LED (red)
M	Mass supply voltage	PWR	Power LED (green)

Figure 4-1 Block diagram

4.2 Parameters/address space

"Digital inputs" operating mode is only effective if the operating mode selection is configured as "Digital inputs".

Parameters for the "Digital Inputs" operating mode

⚠ WARNING

You must enable or disable the diagnostic functions in accordance with the application; see section Application cases for inputs (Page 35).

The following parameters are possible:

Table 4-2 Adjustable parameters

Parameter	Value range	Default	Parameter reassignment in RUN	Scope
Module parameters:				
Operating mode	• Digital inputs • Counter • Standstill and Overspeed monitoring	Digital inputs	No	Module
F-parameters:				
Manual assignment of the F-monitoring time	• Disable • Enable	Disable	No	Module
F-monitoring time	1 to 65535 ms	150 ms	No	Module
F-source address	1 to 65534	Depends on the parameter assignment of the F-CPU	No	Module
F-destination address	1 to 65534	Is proposed by the F-system	No	Module
F-parameter signature (without address)	0 to 65535	Is calculated by the F-system	No	Module
Behavior after channel fault	• Passivate the entire module • Passivate channel	Passivate channel	No	Module

Parameter	Value range	Default	Parameter reassignment in RUN	Scope
Reintegration after channel fault	• Adjustable • All channels automatically • All channels manually	(S7-300/400) Adjustable (S7-1200/1500) All channels manually	No	Module
F-I/O DB manual number assignment	• Disable • Enable	Disable	No	Module
F-I/O DB number	—	Is proposed by the F-system	No	Module
F-I/O DB name	—	Is proposed by the F-system	No	Module
DI parameters:				
Sensor supply				
Sensor supply n				
Short-circuit test	• Disable • Enable	Enable	No	Channel
Time for short-circuit test	0.5 ms to 2 s	4.2 ms	No	Channel
Startup time of sensor after short-circuit test	0.5 ms to 2 s	4.2 ms	No	Channel
Channel parameters				
Channel n, n+4				
Sensor evaluation	• 1oo1 evaluation • 1oo2 evaluation, equivalent • 1oo2 evaluation, non-equivalent • Safety mat evaluation	1oo2 evaluation, equivalent	No	Channel pair
Discrepancy behavior	• Supply value 0 • Supply last valid value	Supply value 0	No	Channel pair
Discrepancy time	5 ms to 30 s	5 ms	No	Channel pair
Reintegration after discrepancy error	• Test 0-Signal not necessary • Test 0-Signal necessary	Test 0-Signal not necessary	No	Channel pair
Channel n				
Activated	• Enable • Disable	Enable	No	Channel
Channel failure acknowledge	• Manual • Automatic The value range offered depends on the F-CPU used and the parameter assignment of the F-parameter	(S7-300/400) Parameter is not supported (S7-1200/1500) Manual	No	Channel

Parameter	Value range	Default	Parameter reassignment in RUN	Scope
	"Reintegration after channel fault".			
Sensor supply	• Sensor supply 0 to 7 • External sensor supply	Sensor supply n	No	Channel
Input delay	• 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 6.4 ms • 10.0 ms • 12.8 ms • 20 ms The provided value range depends on the parameter assignment of the employed sensor supply.	3.2 ms	No	Channel
Chatter monitoring	• Disable • Enable	Disable	No	Channel
Number of signal changes	2 to 31	5	No	Channel
Monitoring window	0 to 100 s (If 0 s is configured, the monitoring window is 0.5 s long.)	2 s	No	Channel

4.2.1 Explanation of parameters

4.2.1.1 Module parameters

Operating mode

This parameter is used to specify the desired operating mode.

The digital input module F-DI 8×24VDC HF can be operated in the following operating modes:

- "Digital inputs"
- “Counter"
- "Standstill and Overspeed monitoring"

4.2.1.2 F-parameters

F-parameters

You have to assign the PROFIsafe address (F-destination address together with F-source address) to the F-module before you start operation.

- You specify the F-source address with the "Central F-source address" parameter in the F-CPU.
- The F-destination address is assigned automatically for each F-module CPU-wide. You can change the specified F-destination address in the hardware configuration manually.

Information on the F-parameters for the F-monitoring time, the PROFIsafe addressing (F-source address, F-destination address) and the F-I/O DB can be found in the manual SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

See also

S7 Distributed Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/22099875)

Behavior after channel fault

This parameter is used to specify whether the entire F-module is passivated or just the faulty channel(s) in the event of channel faults:

- "Passivate the entire module"
- "Passivate channel"

Reintegration after channel fault

Use this parameter to select how the channels of the fail-safe module are reintegrated after a fault.

Use on S7-300/400 F-CPUs

This parameter is always set to "Adjustable" when you use the fail-safe module in S7-300/400 F-CPUs.

You make the required setting in the F-I/O DB of the fail-safe module.

Use on S7-1200/1500 F-CPUs

When using the F-module on F-CPUs S7-1200/1500, set this parameter in the STEP 7 dialog of the F-module:

- "Adjustable"
- "All channels automatically"
- "All channels manually"

If you have set the "Behavior after channel fault" parameter to "Passivate channel", you enable individual setting of the reintegration type per channel with the parameter assignment "Adjustable". The reintegration type of the respective channel is specified with the "Channel failure acknowledge" channel parameter.

If you have set the "Behavior after channel fault" parameter to "Passivate the entire module", you can only select the same reintegration type for all channels.

4.2.1.3 Parameters of the sensor supply

Short-circuit test

Here you activate the short-circuit detection for the channels of the F-module for which an internal sensor supply is set.

The short-circuit test can always be performed when you use simple switches which do not have an own power supply. For switches with an own power supply, e.g. 3-/4-wire proximity switches or optical sensors with OSSD outputs (Output Signal Switching Device), you have to adjust the parameter "Startup time of sensor after short-circuit test" depending on the sensor used.

The short-circuit detection switches off the sensor supply briefly. The length of the deactivation period is equivalent to the configured "Time for short-circuit test".

If a short-circuit is detected, the F-module triggers a diagnostic interrupt and the input is passivated.

The following short-circuits are detected:

- Short-circuit of input to L+
- Short-circuit of the input with another channel, if this has a 1-signal
- Short-circuit between the input and sensor supply of another channel
- Short-circuit between the sensor supply and the sensor supply of another channel

If the short-circuit test is disabled, you must make your wiring short-circuit and cross-circuit proof or select a connection type (discrepancy, non-equivalent) which also detect the cross-circuits using discrepancy.

NOTE

During the execution time (Time for short-circuit test + Startup time of sensor after short-circuit test) of the short-circuit test, the last valid value of the input before the start of the short-circuit test is passed to the F-CPU. The activation of the short-circuit test thus affects the response time of the respective channel or channel pair.

NOTE

Safety mat evaluation

If you have configured "Safety mat evaluation" for a channel pair under "Sensor evaluation", short-circuit tests are performed on the internal sensor supplies that were assigned to this channel pair. These short-circuit tests are performed with a defined test pattern. The parameters "Time for short-circuit test" and "Startup time of sensor after short-circuit test" cannot be changed.

Time for short-circuit test

Function

When the short-circuit test is enabled, the corresponding sensor supply is switched off for the configured time. If the module does not detect a "0" signal at the input within the assigned time, a diagnostic message is generated.

Note the following during parameter assignment:

- If the channel is passivated, this may be due to too high capacitance between sensor supply and input. This consists of the capacitance per unit length of the cable and the capacitance of the employed sensor. If the connected capacitance does not discharge within the assigned time, you need to adjust the "Time for short-circuit test" parameter.
- The values available for the input delay depend on the "Startup time of sensor after short-circuit test" and the "Time for short-circuit test" of the configured sensor supply.

Requirement

The short-circuit test is activated.

NOTE

Safety mat evaluation

If you have configured "Safety mat evaluation" for a channel pair under "Sensor evaluation", short-circuit tests are performed on the internal sensor supplies that were assigned to this channel pair. These short-circuit tests are performed with a defined test pattern. The parameters "Time for short-circuit test" and "Startup time of sensor after short-circuit test" cannot be changed.

Startup time of sensor after short-circuit test

Function

Apart from the switch-off time ("Time for short-circuit test"), a startup time must also be specified for the execution of the short-circuit test. With this parameter you inform the module how long the used sensor requires for the startup after the sensor supply is switched on. This way you avoid an undefined input status due to transient responses in the sensor.

Note the following during parameter assignment:

- This parameter must be larger than the settling time of the sensor used.
- Since the parameterized time affects the response time of the module, we recommend setting this time as short as possible but large enough so that the sensor has stabilized.
- The values available for the input delay depend on the "Startup time of sensor after short-circuit test" and the "Time for short-circuit test" of the configured sensor supply.

Requirement

The short-circuit test is activated.

NOTE

Dependencies between the parameters "Startup time of sensor after short-circuit test" and "Time for short-circuit test"

The startup time of the sensor after the short-circuit test must amount to at least 1 % of the time for the short-circuit test.

NOTE

Safety mat evaluation

If you have configured "Safety mat evaluation" for a channel pair under "Sensor evaluation", short-circuit tests are performed on the internal sensor supplies that were assigned to this channel pair. These short-circuit tests are performed with a defined test pattern. The parameters "Time for short-circuit test" and "Startup time of sensor after short-circuit test" cannot be changed.

4.2.1.4 Parameters of the channel pairs

Sensor evaluation

Overview

Select the type of sensor evaluation with the "Sensor evaluation" parameter:

- 1oo1 evaluation
- 1oo2 evaluation, equivalent
- 1oo2 evaluation, non-equivalent
- Safety mat evaluation

1oo1 evaluation

The sensor uses only one input channel for the 1oo1 evaluation.

1oo2 evaluation, equivalent/non-equivalent

With a 1oo2 evaluation equivalent/non-equivalent, two input channels are occupied by:

- One two-channel sensor
- Two one-channel sensors
- One non-equivalent sensor

The input signals are compared internally for equivalence or non equivalence.

Note that in 1oo2 evaluation, two channels are combined into a channel pair. The number of available process signals of the F-module is reduced accordingly.

Discrepancy analysis

When using a two-channel sensor or two one-channel sensors which measure the same process variable, the sensors interact with a slight time delay due to the limited precision of their arrangement.

The discrepancy analysis for equivalence/non equivalence is used for fail-safe applications to prevent errors from time differences between two signals for the same function. The discrepancy analysis is initiated when different levels are detected in two associated input signals (when testing for non equivalence: the same levels). A check is made to determine whether the difference in levels (when testing for non equivalence: the same levels) has disappeared after an assignable time period, the so-called discrepancy time. If not, this means that a discrepancy error exists.

Safety mat evaluation

With safety mat evaluation, two input channels and two internal sensor supplies are occupied by a 4-wire safety mat (NO contact operating principle). If necessary, you can also connect several 4-wire safety mats connected in series.

Discrepancy behavior

Function

For the "Discrepancy behavior", you assign the value that is supplied to the safety program in the F-CPU during a discrepancy between two relevant input channels, which means while discrepancy time is running. You assign the discrepancy behavior as follows:

- "Supply last valid value"
- "Supply value 0"

Requirements

You have assigned the following:

- "Sensor evaluation": "1oo2 evaluation, equivalent" or "1oo2 evaluation, non-equivalent"

"Supply last valid value"

The most recent valid value (old value) before the discrepancy occurred is made available to the safety program in the F-CPU as soon as a discrepancy is detected between the signals of the two affected input channels. This value is supplied until the discrepancy disappears or the discrepancy time expires and a discrepancy error is detected. The sensor-actuator response time is correspondingly increased by this time.

This means the discrepancy time of connected sensors with 1oo2 evaluation must be adjusted to short response times. It makes no sense, for example, if connected sensors with a discrepancy time of 500 ms trigger a time-critical shutdown. In the worst possible case, the sensor-actuator response time is extended by the discrepancy time:

- For this reason, position the sensors in the process in such a way as to **minimize discrepancy**.
- Then select the **shortest possible** discrepancy time which is also sufficient to compensate for faulty triggering of discrepancy errors.

"Supply value 0"

As soon as a discrepancy between the signals of the two relevant input channels is detected, the value "0" is made available to the safety program in the F-CPU.

If you have set "Supply value 0", the sensor-actuator response time is not affected by the discrepancy time.

Discrepancy time

Function

You can set the discrepancy time for each channel pair.

Requirements

You have assigned the following:

- "Sensor evaluation": "1oo2 evaluation, equivalent" or "1oo2 evaluation, non-equivalent"

In most cases, a discrepancy time is started, but does not fully expire because the signal differences are cleared within a short time.

Set the discrepancy time high enough that in the error-free case the difference between the two signals (when testing for non equivalence: the same levels) has always disappeared before the discrepancy time has expired.

Behavior while discrepancy time is running

While the programmed discrepancy time is running internally on the module, either the **last valid value** or **"0"** is returned to the safety program on the F-CPU by the input channels involved, depending on the parameter settings for the behavior at discrepancy.

Behavior after expiration of the discrepancy time

If no agreement (when checking for non equivalence: inequality) of the input signals exists once the assigned discrepancy time expires, for example, due to a break in a sensor wire, a discrepancy error is detected and the "Discrepancy error" diagnostic message containing information on which channels are faulty is generated.

NOTE

Dependencies between the parameters "Discrepancy time" und "Input delay"

The discrepancy time must be parameterized greater than the input delay.

Reintegration after discrepancy error

Function

This parameter specifies the criteria for when a discrepancy error is regarded as corrected, thus enabling reintegration of the relevant input channels. The following parameter assignment options are available:

- "Test 0-Signal necessary"
- "Test 0-Signal not necessary"

Requirements

You have assigned the following:

- "Sensor evaluation": "1oo2 evaluation, equivalent" or "1oo2 evaluation, non-equivalent"

"Test 0-Signal necessary"

If you have assigned "Test 0-Signal necessary", a discrepancy error is not regarded as corrected until a 0-signal is present at both of the relevant input channels.

If you are using non equivalent sensors, which means you have set "Sensor evaluation" to "1oo2 evaluation, non-equivalent", the result of the channel pair must be "0" again.

"Test 0-Signal not necessary"

If you have assigned "Test 0-Signal not necessary", a discrepancy error is regarded as corrected when a discrepancy no longer exists at both of the relevant input channels.

4.2.1.5 Parameters of the channels

Activated

You hereby enable the corresponding channel for signal processing in the safety program.

Channel failure acknowledge

Use on S7-1200/1500 F-CPUs

The parameter is only relevant if the F-module is operated on an S7-1200/1500 F-CPU.

The parameter can only be set if the F-parameter "Behavior after channel fault" is set to "Passivate channel" and the F-parameter "Reintegration after channel fault" is set to "Adjustable".

The value of this parameter specifies how the channel reacts after a channel fault:

- Manual: A channel failure is reintegrated after manual acknowledgment.
- Automatically: The channel is reintegrated automatically after a channel fault. Manual acknowledgment is not necessary.

Use on S7-300/400 F-CPUs

The value of this parameter is not relevant in the case of operation on S7-300/400 F-CPUs. For S7-300/400 F-CPUs you set the corresponding property at the F-I/O DB by means of the ACK_NEC tag.

For detailed information about the F-I/O DB, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

Sensor supply

You can select one of the internal sensor supplies VS_0 to VS_7 or an external sensor supply.

The selection of an internal sensor supply is required for using the short-circuit test.

With safety mat evaluation, the internal sensor supplies are assigned to the channel pair. For additional information, see the section Safety mat evaluation application (from firmware version V2.0.0) (Page 52).

⚠ WARNING

Sensor supply with safety mat evaluation

With safety mat evaluation, the internal sensor supply assigned to the respective channel must be used. The internal sensor supply must not be used for any other channel. The use of a different internal sensor supply or an external sensor supply is prohibited.

See also

Time for short-circuit test (Page 25)

Input delay

Function

To suppress injected interference, you can set an input delay for a channel or a channel pair.

Interference pulses whose pulse time is less than the set input delay are suppressed. Suppressed interference pulse are not visible in the safety program.

A high input delay suppresses longer interference pulses, but results in a longer response time.

The set value for the input delay has to be smaller than the configured "Startup time of sensor after short-circuit test" and smaller than the configured "Time for short-circuit test".

With 1oo2 evaluation, the input delay of the lower-order channel (channel n) automatically applies to the higher-order channel (channel n+4).

NOTE

Input delay with Safety mat evaluation

If the Safety mat evaluation is set, you must configure an input delay of 1.6 ms.

NOTE

Due to the physical properties, there is a possibility of crosstalk between signals in the case of long, unshielded signal lines (see section "Electromagnetic compatibility" in the system manual ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293)).

Adapt the input delay or use shielded signal lines in order to prevent possible passivation of the fail-safe digital inputs and switch-off of the sensor supply.

See also

Response times (Page 127)

Technical specifications (Page 123)

Chatter monitoring

Function

Chatter monitoring is a process control function for digital input signals. It detects and reports unusual signal sequences in the process with 1oo1 evaluation, for example, an input signal fluctuating between "0" and "1" too frequently. The occurrence of such signal characteristics is an indication of faulty sensors or process control instability.

Recognizing unusual signal patterns

An assigned monitoring window is available for each input channel. The monitoring window starts with the first signal change of the input signal. If the input signal changes within the monitoring window at least as often as the assigned "Number of signal changes", a chatter error is detected. If no chatter error is detected within the monitoring window, the next signal change restarts the monitoring window.

If a chatter error is detected, a diagnostic is signaled. If the chatter error does not occur for the monitoring window for three times the configured period, the diagnostic is reset.

Principle

The figure below shows the principle of chatter monitoring as a graphic.

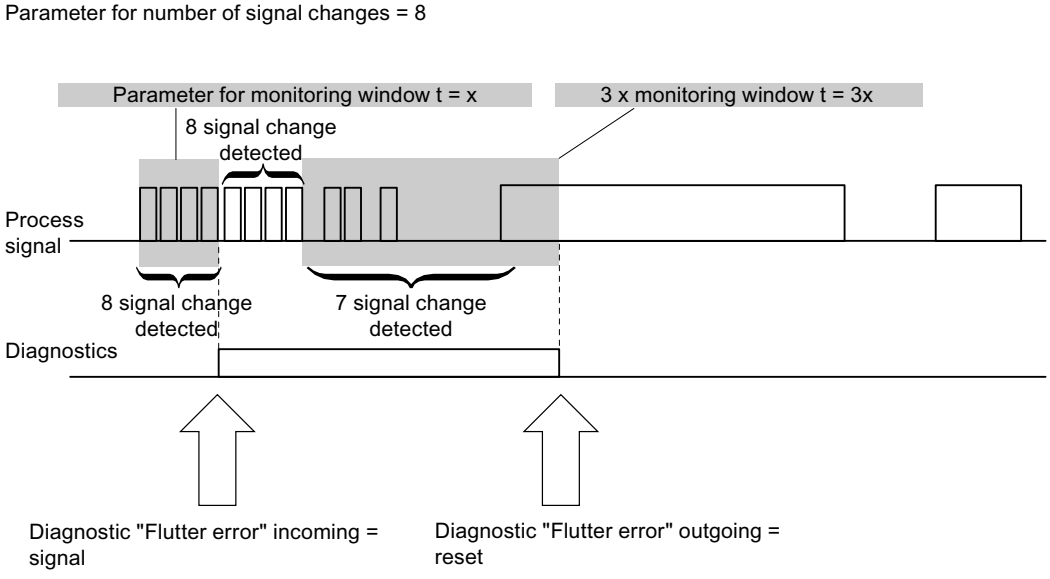


Figure 4-2 Figure chatter monitoring

Number of signal changes

Defines the number of signal changes after whose sequence a chatter error is to be reported.

Monitoring window

Sets the time for the monitoring window of chatter monitoring.

You can set times of 1 s to 100 s in whole seconds for the monitoring window.

If you parameterize 0 s, the monitoring window is 0.5 s long.

4.2.2 Address space

Address assignment of the digital input module F-DI 8×24VDC HF in "Digital inputs" operating mode

The digital input module F-DI 8×24VDC HF occupies the following address areas in the F-CPU:

Table 4-3 Address assignment in the F-CPU

	Occupied bytes in the F-CPU:	
F-CPU	**In the input range**	**In the output range**
F-CPUs S7-300/400	IB x + 0 to x + 5	QB x + 0 to x + 3
F-CPUs S7-1200/1500	IB x + 0 to x + 6	QB x + 0 to x + 4

x = Module start address

Address assignment of the user data and the value status of digital input module F-DI 8×24VDC HF in "Digital inputs" operating mode

The user data occupy the following addresses in the F-CPU out of all the assigned addresses of the digital input module F-DI 8×24VDC HF:

Table 4-4 User data address assignment in the input range

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB x + 0	DI_7	DI_6	DI_5	DI_4	DI_3	DI_2	DI_1	DI_0
IB x + 1	Value status for DI_7	Value status for DI_6	Value status for DI_5	Value status for DI_4	Value status for DI_3	Value status for DI_2	Value status for DI_1	Value status for DI_0

x = Module start address

NOTE

You may only access the addresses occupied by user data and value status.

The other address areas occupied by the F-modules are assigned for functions including safety-related communication between the F-modules and F-CPU in accordance with PROFIsafe.

With safety mat evaluation and 1oo2 evaluation of the sensors, the two channels are combined, for example, DI_0 and DI_4. With safety mat evaluation and 1oo2 evaluation of the sensors, you may only access the low order channel in the safety program, for example, DI_0.

More information

For detailed information about F-I/O access, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

See also

S7 Distributed Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/22099875)

4.3 Applications for inputs

Selecting the application

The diagram below supports you in selecting the application that suits your fail-safe requirements. In the following sections, you will learn how to wire the F-module, the specific parameters you must assign in STEP 7 Safety and the errors that are detected.

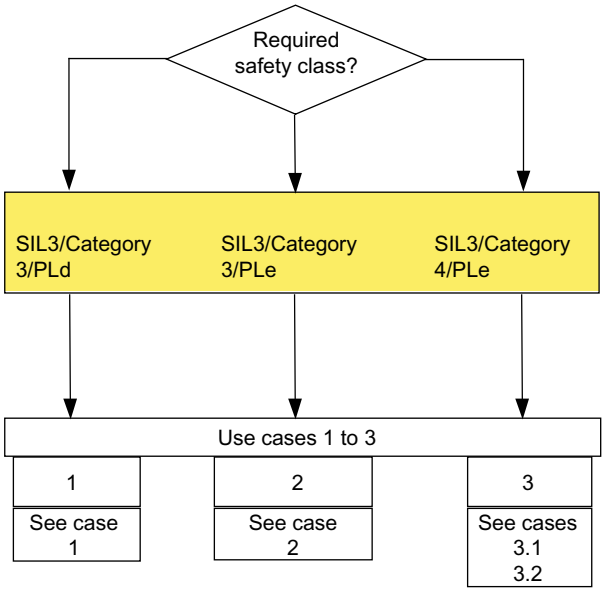


Figure 4-3 Selecting the application – digital input module F-DI 8×24VDC HF

⚠ WARNING

The achievable safety class depends on the quality of the sensor and the duration of the proof-test interval in accordance with IEC 61508:2010. If the quality of the sensor is lower than the quality required by the safety class, redundant sensors connected via two channels must be used and evaluated.

Conditions for achieving SIL/Cat./PL

The table below lists the conditions which have to be met for achieving at least the corresponding safety requirements.

Table 4-5 Conditions for achieving SIL/Cat./PL

Application	Sensor evaluation	Sensor supply	Achievable SIL/Cat./PL
1	1oo1	Internal, with short-circuit test	3 / 3 / d
		Internal, without short-circuit test	
		External	

Application	Sensor evaluation	Sensor supply	Achievable SIL/Cat./PL
2	1oo2 equivalent	Internal, without short-circuit test	3 / 3 / e
		External	
3.1	1oo2 equivalent	Internal, with short-circuit test	3 / 4 / e
3.2	1oo2 non-equivalent	Internal, with short-circuit test	
		Internal, without short-circuit test	
		External	

NOTE

With a module you can realize the applications listed in Table 5-1 simultaneously on different inputs. You only have to interconnect the inputs and assign parameters as described in the following sections.

Sensor requirements

Information on the safety-oriented use of sensors can be found in the section Requirements for sensors and actuators for fail-safe modules and fail-safe motor starters in the system manual ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293).

4.3.1 Application 1: Safety mode SIL3/Cat.3/PLd

Wiring

The wiring is performed on a suitable BaseUnit.

Sensor supply

The sensor supply can be internal or external.

Wiring diagram – connecting one sensor via one channel

Per process signal, one sensor is connected via one channel (1oo1 evaluation).

You can assign any module sensor supply to each input, as well as an external sensor supply, via which the sensor is then supplied.

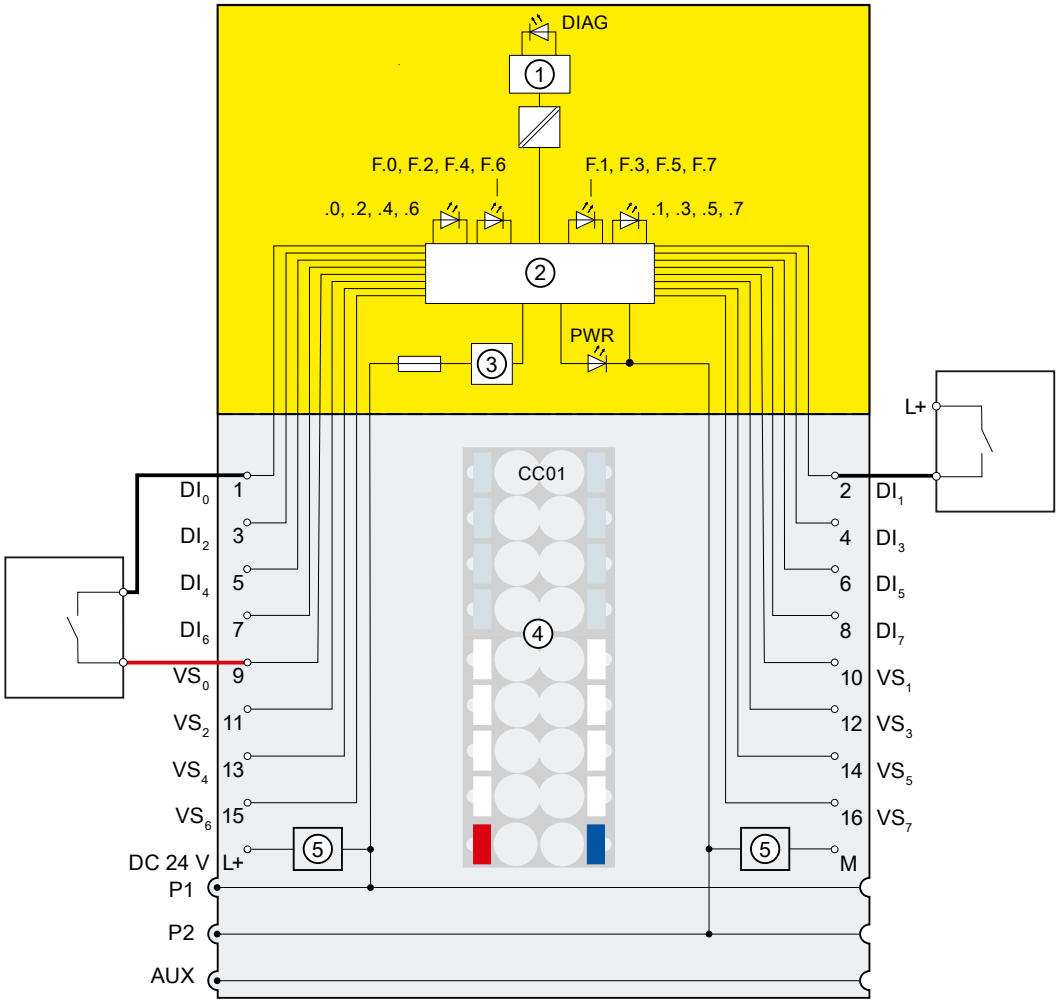


Figure 4-4 One sensor connected via one channel, internal and external sensor supply

WARNING

To achieve SIL3/Cat.3/PLd using this wiring, you must use a qualified sensor.

WARNING

To achieve SIL3/Cat.3/PLd with this wiring, you have to route the cables cross-circuit proof and apply the positive opening operation principle for the sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 4-6 Parameter assignment

Parameter	Channel with internal sensor supply	Channel with external sensor supply
Sensor evaluation	1oo1 evaluation	
Sensor supply	Sensor supply n	External sensor supply*
Short-circuit test	• Disable • Enable	Disable

*) Otherwise a diagnostic message will be generated when short-circuit test is activated.

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short-circuit test:

Table 4-7 Fault detection

Fault	Fault detection		
	Internal sensor supply and short-circuit test activated	Internal sensor supply and short-circuit test deactivated	External sensor supply
Short-circuit of the input with other channels or other sensor supplies (short-circuit with other channels is detected only if they use a different sensor supply)	Yes*	No	No
Short-circuit of the input with the associated sensor supply	No	No	No
Short-circuit with L+ to DI_n	Yes	No	No
Short-circuit with M to DI_n	Yes*	Yes*	No
Discrepancy error	—	—	—
Short-circuit with L+ to VS_n	Yes	No	—
Short-circuit with M to VS_n or defective	Yes	Yes	—

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

4.3.2 Application 2: Safety mode SIL3/Cat.3/PLe

Assigning inputs to each other

The digital input module F-DI 8×24VDC HF has 8 fail-safe inputs, DI_0 to DI_7 (SIL3). You can combine two of these inputs to one input.

You can combine the following inputs:

- DI_0 and DI_4
- DI_1 and DI_5
- DI_2 and DI_6
- DI_3 and DI_7

The process signals are provided by channels DI_0, DI_1, DI_2 and DI_3.

Wiring

The wiring is performed on a suitable BaseUnit.

Sensor supply

The sensor supply can be internal or external.

Wiring diagram - connecting a two-channel sensor equivalent via two channels

Per process signal, a two-channel sensor is connected equivalent via two channels to two inputs of the F-module (1oo2 evaluation).

You can assign any module sensor supply to each input, as well as an external sensor supply, via which the sensor is then supplied.

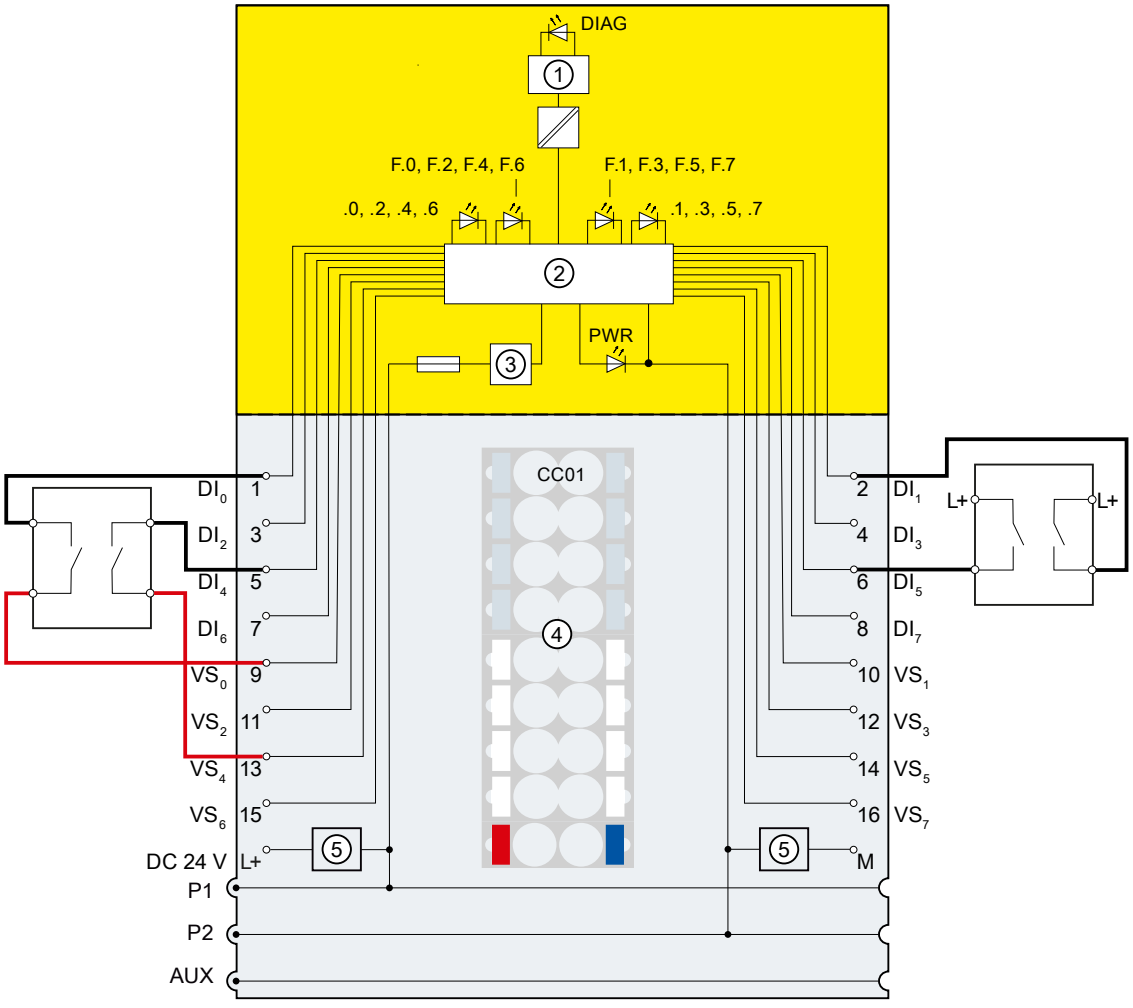


Figure 4-5 A two-channel sensor connected via two channels, internal and external sensor supply

WARNING

To achieve SIL3/Cat.3/PLe using this wiring, you must use a suitably qualified sensor.

Wiring diagram - connecting two one-channel sensors equivalent via two channels

Per process signal, two one-channel sensors, which record the same process value, are connected equivalent via two channels to two inputs of the F-module (1oo2 evaluation).

You can assign any module sensor supply to each input, as well as an external sensor supply, via which the sensors are then supplied.

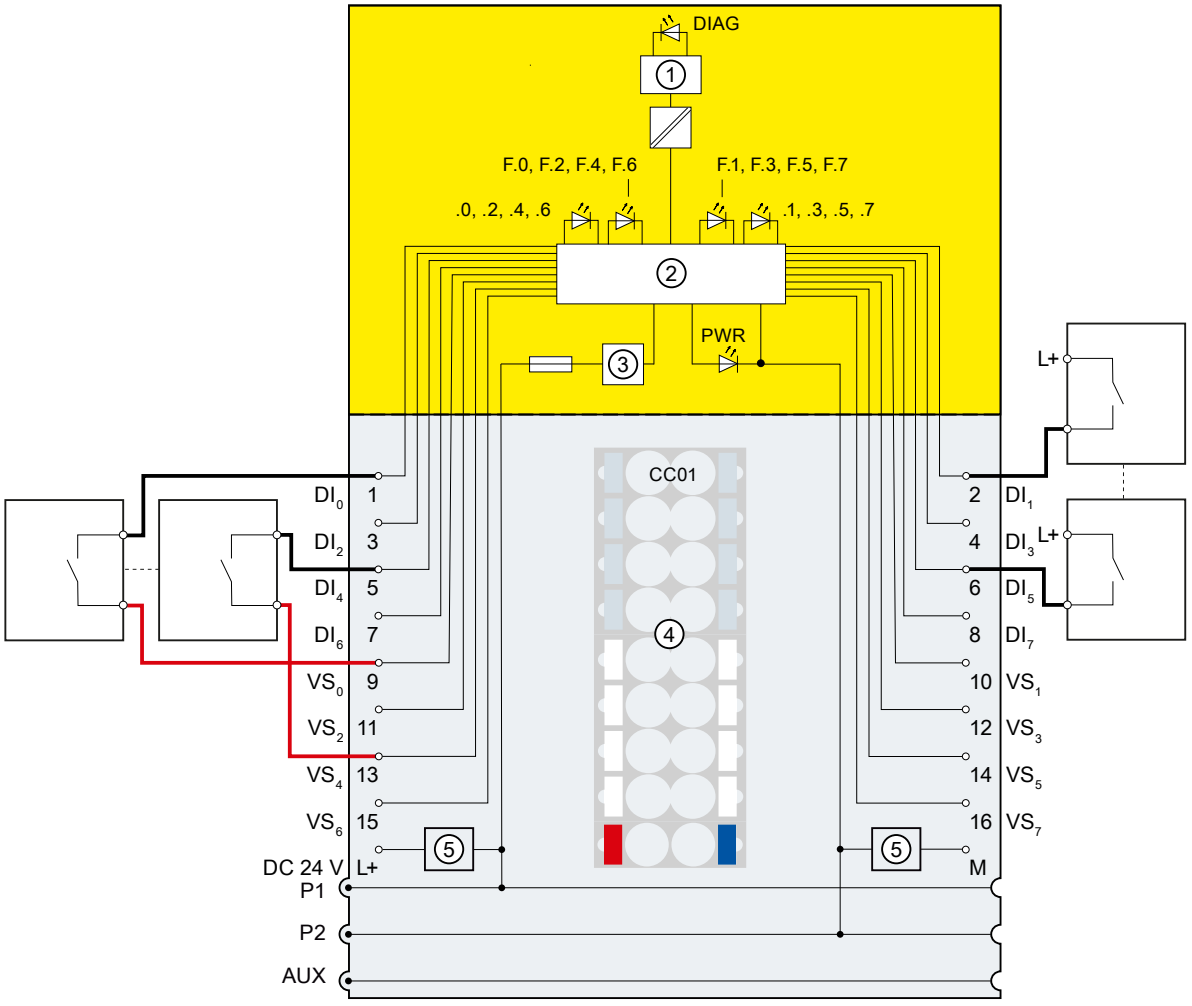


Figure 4-6 Two one-channel sensors connected via two channels, internal and external sensor supply

WARNING

To achieve SIL3/Cat.3/PLe using this wiring, you must use a suitably qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 4-8 Parameter assignment

Parameter	Channel with internal sensor supply	Channel with external sensor supply
Sensor evaluation	1oo2 evaluation, equivalent	
Sensor supply	Sensor supply n	External sensor supply*
Short-circuit test	• Disable • Enable	Disable

*) Otherwise a diagnostic message will be generated when short-circuit test is activated.

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short-circuit test:

Table 4-9 Fault detection

Fault	Fault detection	
	Internal sensor supply and short-circuit test deactivated	External sensor supply
Short-circuit within the channel pair	No	No
Short-circuit with other channels or other sensor supplies	Yes*	Yes*
Short-circuit with L+ to DI_n	Yes*	Yes*
Short-circuit with M to DI_n	Yes*	Yes*
Discrepancy error	Yes	Yes
Short-circuit with L+ to VS_n	No	—
Short-circuit with M to VS_n or defective	Yes	—

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal (discrepancy error). If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

4.3.3 Application 3: Safety mode SIL3/Cat.4/PLe

Assigning inputs to each other

The digital input module F-DI 8×24VDC HF has 8 fail-safe inputs, DI_0 to DI_7 (SIL3). You can combine two of these inputs to one input.

You can combine the following inputs:

- DI_0 with DI_4
- DI_1 with DI_5
- DI_2 with DI_6
- DI_3 with DI_7

The process signals are provided by channels DI_0,DI_1,DI_2 and DI_3.

Wiring

The wiring is performed on a suitable BaseUnit.

Sensor supply

For application 3.1, the sensor supply must be set up for at least one channel internally with activated short-circuit test.

The sensor can be supplied internally or externally for application 3.2.

Requirements for applications in machinery protection with Cat.4

Both conditions must be met for applications in machine protection with Cat.4:

- The wiring between sensors and automation system and between automation system and actuators must be designed to state-of-the-art engineering and standards to prevent short-circuits.
- The actuators must be wired as seen in sections Application 3.1: Safety mode SIL3/Cat.4/PLe (Page 46) or Application 3.2: Safety mode SIL3/Cat.4/PLe (Page 49). You only need to detect **one** short-circuit because two faults are required to generate it. This means both signal cables in short-circuit have an isolation fault. A multiple short-circuit analysis is not required.

Procedures for locating all short-circuits are also permitted if single short-circuits are not located. One of the two conditions must be met for this purpose:

- Short-circuits may not corrupt the read signals compared to the sensor signals.
- Short-circuits cause a corruption of the read signals compared to sensor signals in the direction that ensures safety.

4.3.3.1 Application 3.1: Safety mode SIL3/Cat.4/PLe

Wiring diagram - connecting a two-channel sensor equivalent via two channels

Per process signal, a two-channel sensor is connected equivalent via two channels to two inputs of the F-module (1oo2 evaluation).

Supply the sensor from two different internal sensor supplies or from an internal and an external sensor supply.

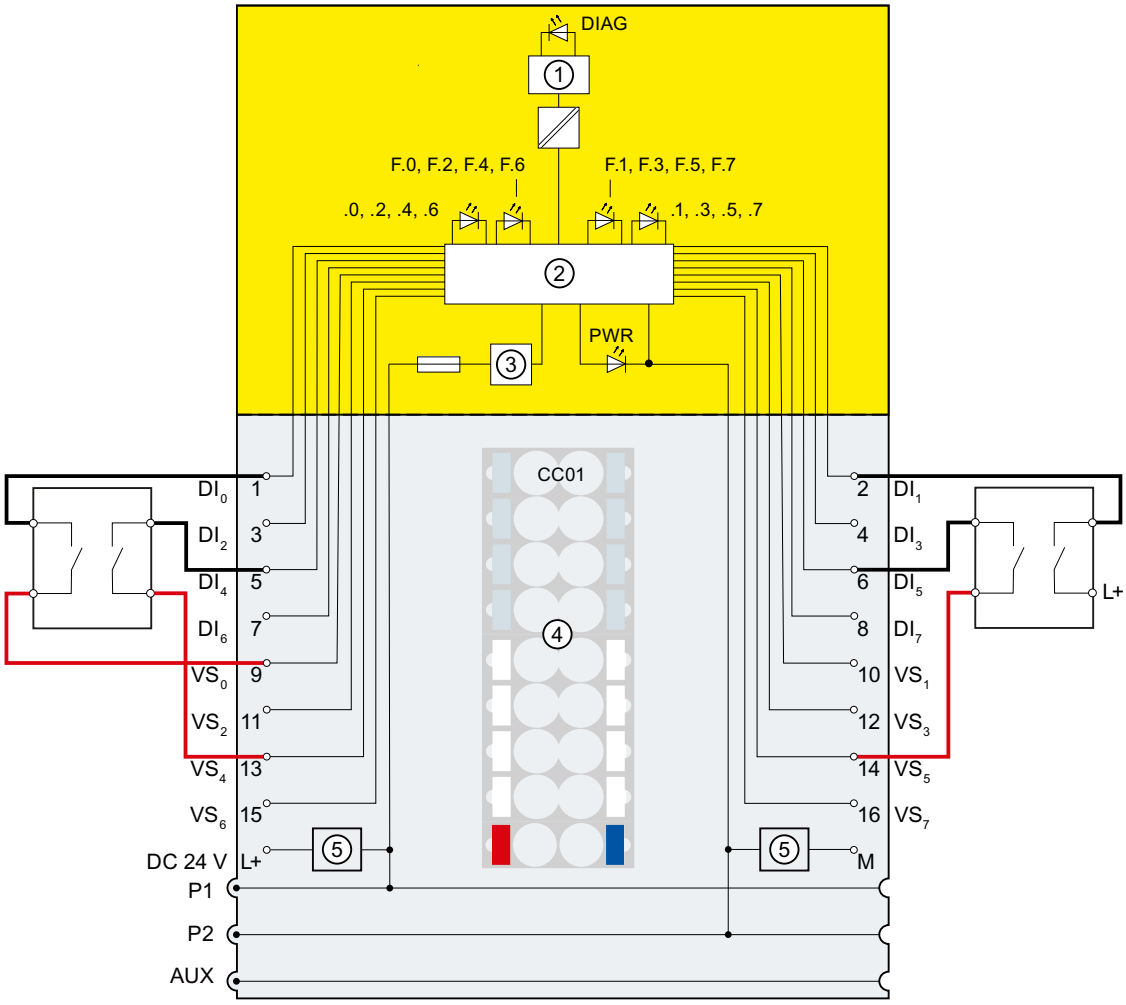


Figure 4-7 A two-channel sensor connected via two channels, internal sensor supply and a two-channel sensor connected via two channels, internal and external sensor supply

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a qualified sensor.

Wiring diagram - connecting two one-channel sensors equivalent via two channels

Per process signal, two one-channel sensors, which record the same process value, are connected equivalent via two channels to two inputs of the F-module (1oo2 evaluation).

Supply the sensors from two different internal sensor supplies or from an internal and an external sensor supply.

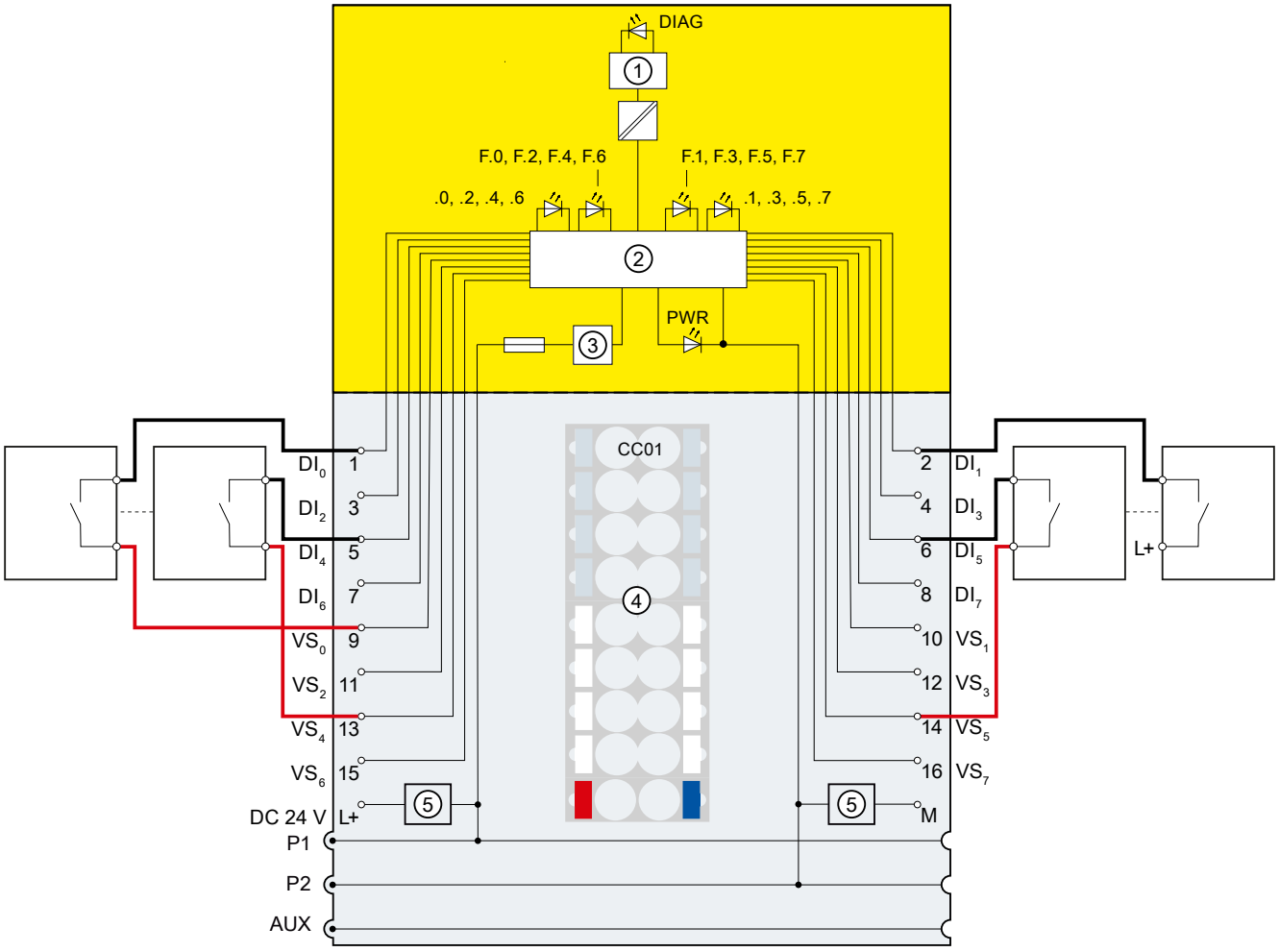


Figure 4-8 Two one-channel sensors connected via two channels, internal sensor supply and two one-channel sensors connected via two channels, internal and external sensor supply.

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 4-10 Parameter assignment

Parameter	Channel with internal sensor supply*	Channel with external sensor supply
Sensor evaluation	1oo2 evaluation, equivalent	
Sensor supply	Sensor supply n	External sensor supply**
Short-circuit test	Enable*	Disable

*) The sensor supply must be set up for at least one channel internally with activated short-circuit test.

**) Otherwise a diagnostic message is generated for an activated short-circuit test.

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short-circuit test:

Table 4-11 Fault detection

Fault	Fault detection	
	Internal sensor supply and short-circuit test activated	External sensor supply
Short-circuit within the channel pair	Yes*	Yes*
Short-circuit with other channels or other sensor supplies	Yes*	Yes*
Short-circuit with L+ to DI_n	Yes	Yes*
Short-circuit with M to DI_n	Yes*	Yes*
Discrepancy error	Yes	Yes
Short-circuit with L+ to VS_n	Yes	-
Short-circuit with M to VS_n or defective	Yes	-

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal (discrepancy error). If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

4.3.3.2 Application 3.2: Safety mode SIL3/Cat.4/PLe

Wiring diagram – connecting a non-equivalent sensor

Per process signal, a non-equivalent sensor is connected to two inputs of the F-module (1oo2 evaluation).

You can supply the sensor via an internal or external sensor supply.

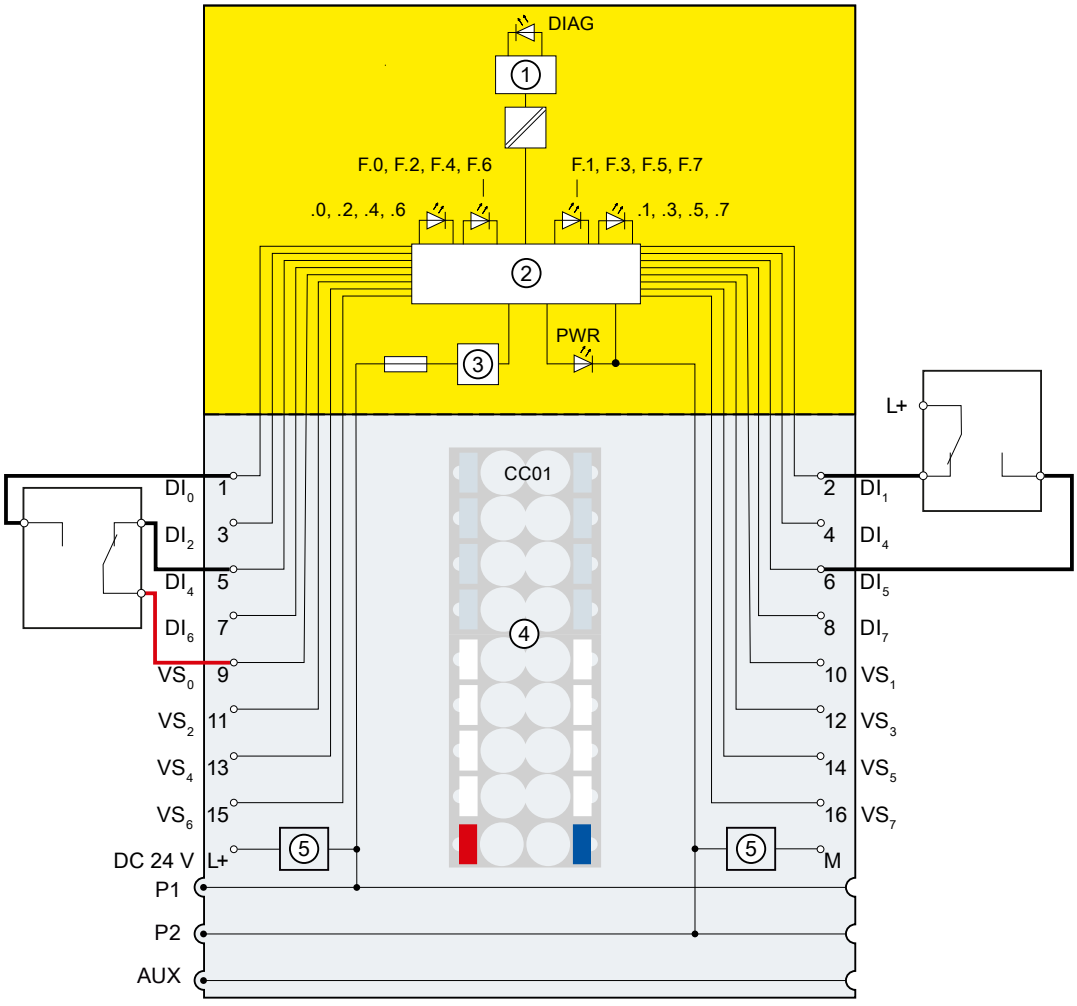


Figure 4-9 One non-equivalent sensor connected, internal sensor supply and one non-equivalent sensor connected, external sensor supply

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Wiring diagram - connecting two one-channel sensors non-equivalent via two channels

Per process signal, two one-channel sensors, which record the same process value, are connected non-equivalent via two channels to two inputs of the F-module (1oo2 evaluation).

You can assign any module sensor supply to each input, as well as an external sensor supply, via which the sensors are then supplied.

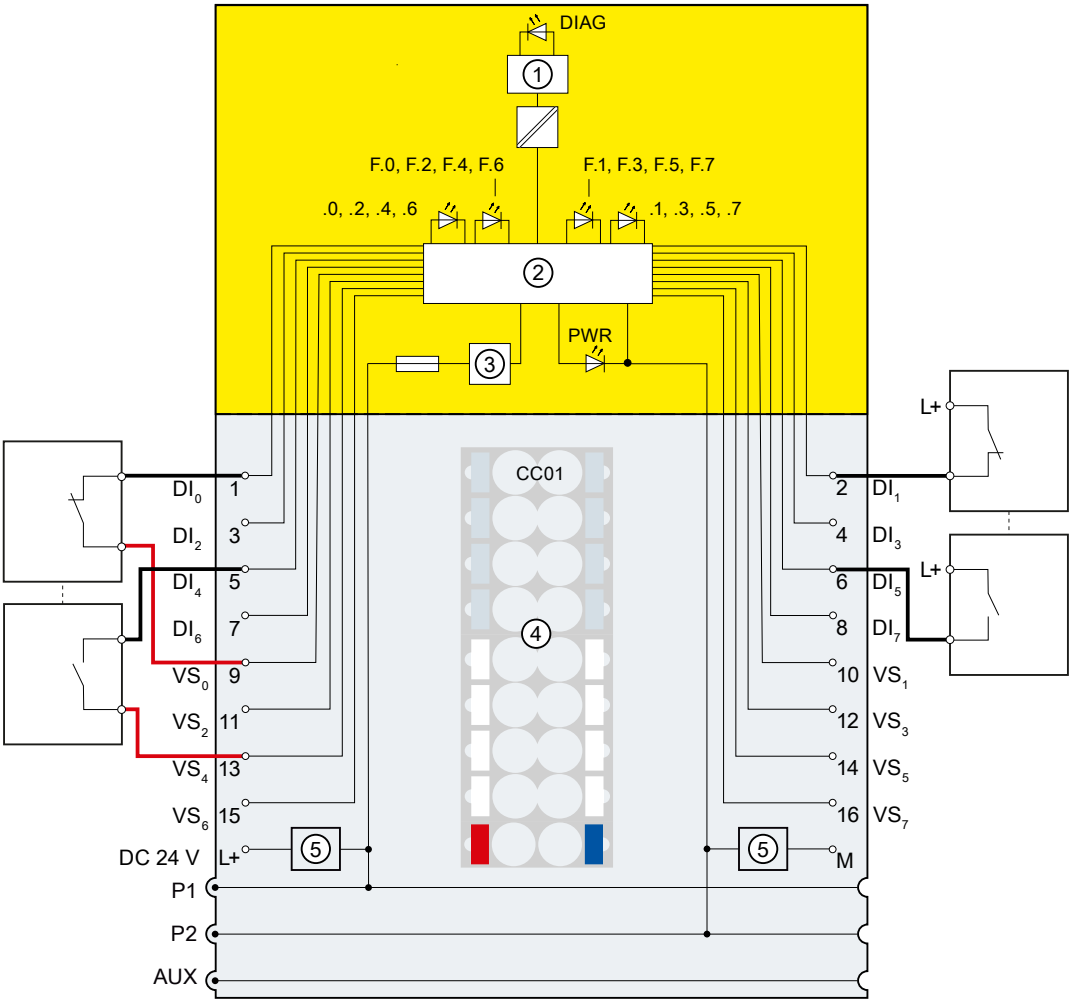


Figure 4-10 Two one-channel sensors connected via two channels non-equivalent, internal sensor supply and two one-channel sensors connected via two channels non-equivalent, external sensor supply.

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 4-12 Parameter assignment

Parameter	Channel with internal sensor supply	Channel with external sensor supply
Sensor evaluation	1oo2 evaluation, non-equivalent	
Sensor supply	Sensor supply n	External sensor supply*
Short-circuit test	• Disable • Enable	Disable

*) Otherwise a diagnostic message will be generated when short-circuit test is activated.

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short-circuit test:

Table 4-13 Fault detection

Fault	Fault detection		
	Internal sensor supply and short-circuit test activated	Internal sensor supply and short-circuit test deactivated	External sensor supply
Short-circuit within the channel pair	Yes	Yes	Yes
Short-circuit with other channels or other sensor supplies	Yes*	Yes*	Yes*
Short-circuit with L+ to DI_n	Yes	Yes*	Yes*
Short-circuit with M to DI_n	Yes*	Yes*	Yes*
Discrepancy error	Yes	Yes	Yes
Short-circuit with L+ to VS_n	Yes	No	-
Short-circuit with M to VS_n or defective	Yes	Yes	-

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal (discrepancy error). If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

4.3.4 Safety mat evaluation application (from firmware version V2.0.0)

Assigning inputs to each other

The digital input module F-DI 8×24VDC HF has 8 fail-safe inputs, DI_0 to DI_7 (SIL3). You can combine two of these inputs to one input and use for the monitoring of safety mats.

You can combine the following inputs:

- DI_0 and DI_4
- DI_1 and DI_5
- DI_2 and DI_6
- DI_3 and DI_7

The process signals are provided by channels DI_0, DI_1, DI_2 and DI_3.

NOTE

Process signal

When a safety mat is activated, the process signal "0" is provided. When a safety mat is not activated, the process signal is "1".

Wiring

The wiring is performed on a suitable BaseUnit.

Sensor supply

The sensor supplies are operated in the "Safety mat evaluation" mode and must be assigned to the digital inputs as follows:

- VS_0 to DI_0 and VS_4 to DI_4
- VS_1 to DI_1 and VS_5 to DI_5
- VS_2 to DI_2 and VS_6 to DI_6
- VS_3 to DI_3 and VS_7 to DI_7

Wiring diagram – connecting multiple safety mats in series

For each process signal, you can connect multiple 4-wire safety mats in series to two inputs and two internal sensor supplies of the F-module.

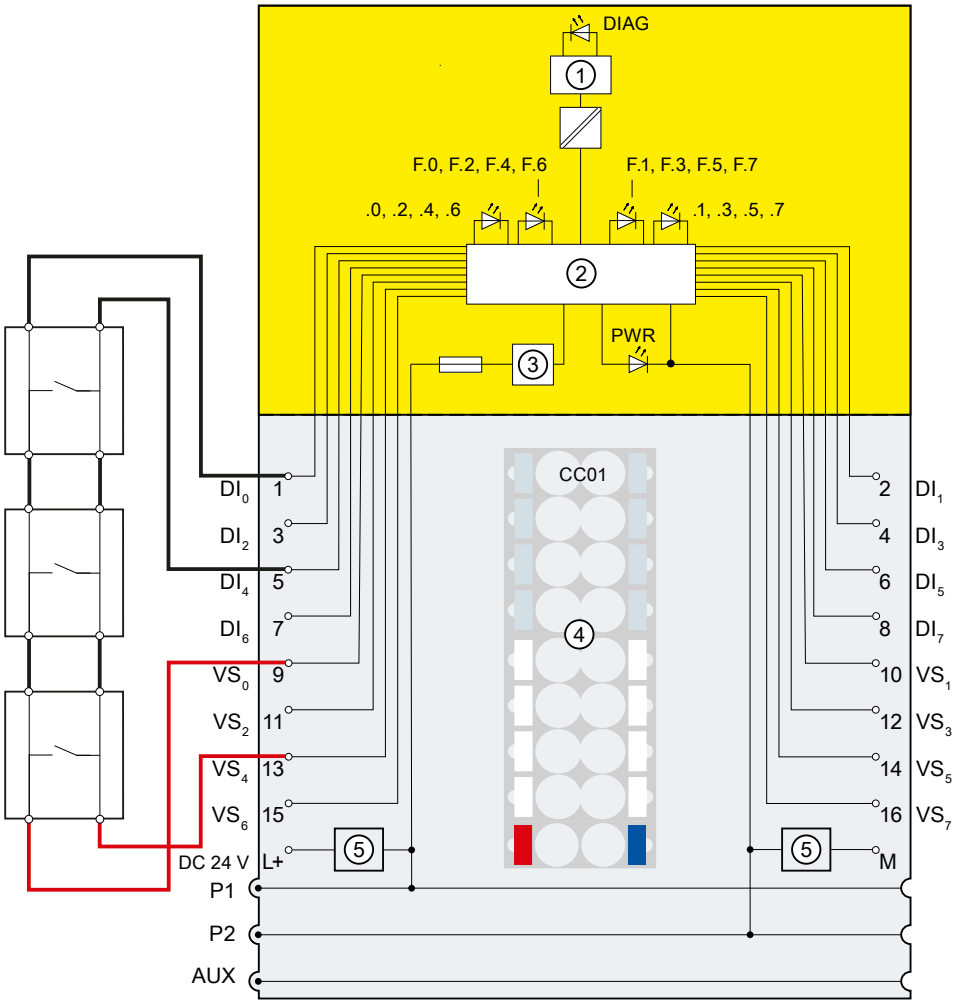


Figure 4-11 Safety mats connected via two channels to two internal sensor supplies

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor. If a regular function test is required, observe the requirements in the application standard or in the manual of the sensor in use.

WARNING

You must ensure short-circuit-proof wiring. Cables intended for the connection of the safety mats must be laid separately from the cables for applications 1 to 3 (Page 35).

WARNING

You may only use 4-wire safety mats with a current-carrying capacity of at least 100 mA.

WARNING

If a short-circuit of the sensor supply to ground occurs, you must check after resolving the short-circuit whether the safety mat is functional by activating it. An excessive current load may damage the contact of the safety mat.

WARNING

When selecting the cables and safety mats, note that the ohmic resistance of the cables including an activated safety mat must not exceed 100 ohms.

Determining the ohmic resistance for connecting a safety mat

If you do not know the resistance of the cables including activated safety mat, you must determine the resistance through measurements.

Proceed as follows:

- Unplug the digital input module from the BaseUnit.
- Measure the resistance of the cables including activated safety mat between VS_n and DI_{n+4}.
- Measure the resistance of the cables including activated safety mat between VS_{n+4} and DI_n.

For the above-mentioned measurements, the resistance must not exceed 100 ohms.

You can use the measuring tap of the BaseUnit for the measurements. For more information, refer to the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 4-14 Parameter assignment

Parameter	Channel with internal sensor supply
Sensor evaluation	Safety mat evaluation
Sensor supply	Sensor supply n
Short-circuit test	Enable
Time for short-circuit test	Default value 4.2 ms (not used)

Parameter	Channel with internal sensor supply
Startup time of sensor after short-circuit test	Default value 4.2 ms (not used)
Input delay	1.6 ms
Chatter monitoring	Disable

NOTE

With configured safety mat monitoring, the parameters "Short-circuit test", "Input delay" and "Chatter monitoring" cannot be adjusted since they are fixed with the listed values.

Fault detection

The following table presents fault detection:

Table 4-15 Fault detection

Fault	Fault detection
Short-circuit within the channel pair of the safety mat evaluation	No (activation of the safety mat is detected)
Short-circuit with other channel pairs with configured safety mat evaluation	Yes
Short-circuit with other channels that are used for the applications 1 to 3	No
Short-circuit with L+ to DI_n or DI_{n+4}	Yes*
Short-circuit with M to DI_n or DI_{n+4}	Yes
Wire break	Yes
Short-circuit with L+ to VS_n or VS_{n+4}	Yes*
Short-circuit with M to VS_n or VS_{n+4}	Yes

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

NOTE

The fault detection diagnostics is not signaled as outgoing until the safety mat function is once again error-free after running self-tests. The safety mat must not be activated in this case.

Counter operating mode

5

5.1 Wiring

5.1.1 Pin assignment “Counter" operating mode

Pin assignment for “Counter" operating mode

Table 5-1 Pin assignment for “Counter" operating mode

Pin assignment for “Counter" operating mode						
Terminal	**Assignment**	**Terminal**	**Assignment**	**Description**	**BaseUnit**[1]	**Color identification label (terminals 1 to 16)**
1	DI_0	**2**	DI_1	• DI_n: Input signal, channel n • VS_n: Internal sensor supply, channel n	A0	 CC01 6ES7193-6CP01-2MA0
3	DI_2	**4**	DI_3			
5	DI_4	**6**	DI_5			
7	DI_6	**8**	DI_7			
9	VS_0	**10**	VS_1			
11	VS_2	**12**	VS_3			
13	VS_4	**14**	VS_5			
15	VS_6	**16**	VS_7			
L+	DC24V	**M**	M			

[1] Usable BaseUnit types can be identified by the last two digits of their order number. See also *ET 200SP Distributed I/O System* system manual

NOTE

The first BaseUnit of a potential group must be a light-colored BaseUnit.

NOTE

Make sure that you only use digital modules with BaseUnit type A0 during commissioning.

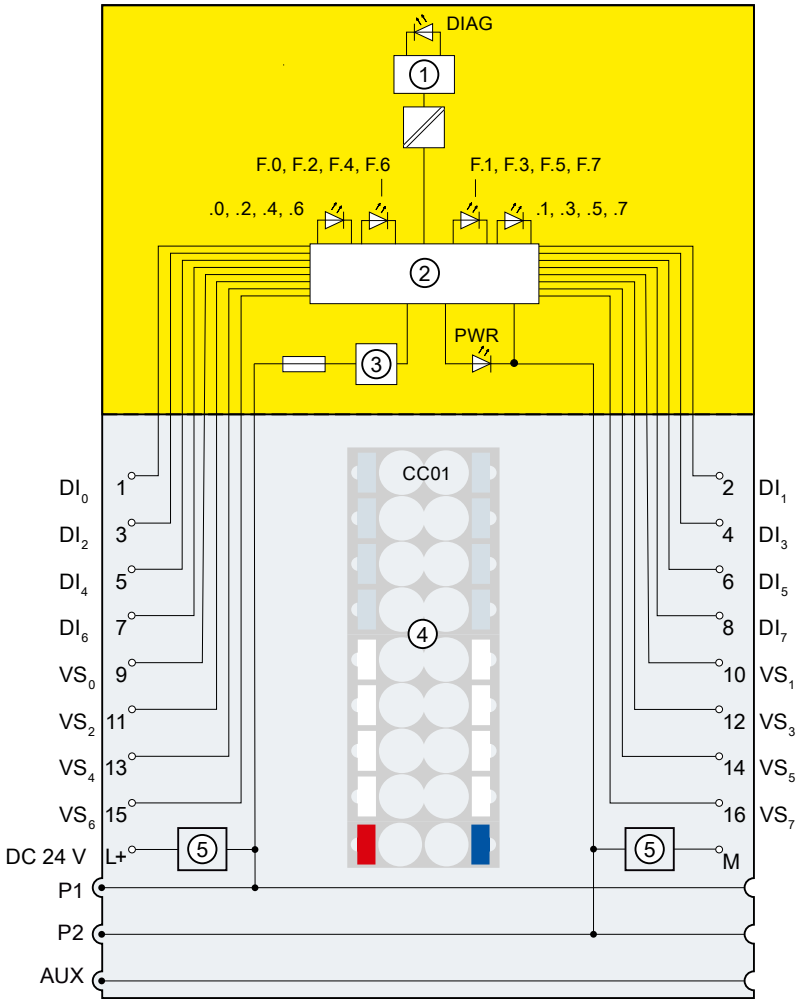
5.1.2 Wiring and block diagram

This section includes the block diagram of the digital input module F-DI 8×24VDC HF with the pin assignment.

You can find more information about wiring the BaseUnit in the Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

Block diagram

The following figure shows the pin assignment of the F-DI 8×24VDC HF digital input module on BaseUnit BU type A0.



①	Backplane bus interface	VS_n	Internal sensor supply, channel n
②	Input electronics	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
③	Reverse polarity protection	DI_n	Input signal, channel n
④	Color identification label with color code CC01 (optional)	DIAG	Error or diagnostics LED (green, red)

⑤	Filter circuit supply voltage (available in light-colored BaseUnit only)	.0 to .7	Channel status LED (green)
L+	24 V DC (infeed only with light-colored BaseUnit)	F.0 to F.7	Channel fault LED (red)
M	Mass supply voltage	PWR	Power LED (green)

Figure 5-1 Block diagram

5.2 Parameters/address space

5.2.1 Counter

Function

Counting is the detecting and adding up of events. The counter of the module detects sensor signals and pulses and evaluates them accordingly, e.g.:

- For counting piece goods up to a maximum limit
- For counting of continuous pulses

The counting process is performed by non-equivalent 1oo2 evaluation of the DI_0 and DI_4 inputs. You define the properties of the counter with the functions described below.

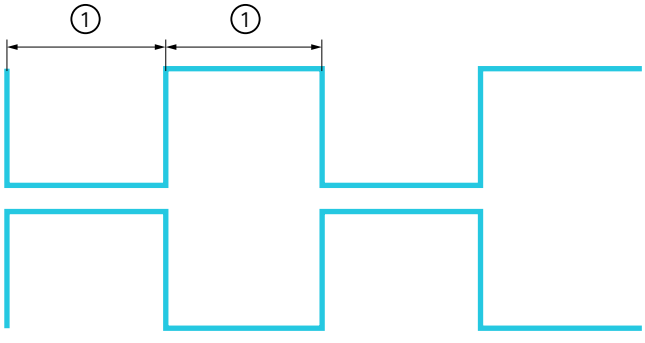
The counter matches relevant edges on DI_0 with relevant edges on DI_4.

The relevant edges are:

- Rising edges for DI_0
- Falling edges for DI_4

If a relevant edge is detected, the counter is incremented by the value 1 (when counting up) or decremented (when counting down).

In order for a rising or falling edge to be detected, a constant input signal must be present for the minimum pulse duration. See the figure below.



① Minimum pulse duration

Figure 5-2 Minimum pulse duration

Table 5-2 Numerical values

Input delay	Minimum pulse duration	Maximum frequency
0.4 ms	0.71 ms	500 Hz
0.8 ms	1.10 ms	400 Hz
3.2 ms	3.60 ms	130 Hz

NOTE

Maximum frequency exceeded

If the maximum frequency is exceeded, a diagnostic message (Frequency too high) may occur, even if the gate is closed.

⚠ WARNING

Input signals shorter than the minimum pulse duration may not be detected. This can lead to a falsification of the count value.

Counting limits

The counting limits define the range of the count value. You can only change the counting limits during parameter assignment. It is not possible to change the counting limits during runtime.

The following counting limits can be configured:

- **High counting limit**

The maximum configurable counting limit is 2000000000.

- **Low counting limit**

The minimum configurable counting limit is –2000000000.

You can continue or stop the counting processes when a counting limit is violated (Reaction to violation of a counting limit). In the event of an overflow or underflow of the count value, the respective event bit in the feedback interface is set to "1". See section Assignment of the counter feedback interface (Page 71).

Application examples for counter mode

Information on possible application examples can be found in the section Application examples for counter mode (Page 80).

Reset control

You have two options to reset the counter:

- Using the user program
- Via the digital inputs DI_2 and DI_6 or the user program

You can select one of these two options through parameter assignment. Resetting sets the counter value to the configured start value and clears all counter errors present on counter input channels DI_0 and DI_4. Counting errors can thus be eliminated and the passivated channel can be reintegrated.

In both cases, a rising edge on a control element (SW or HW) triggers the reset.

A reset is also necessary if errors have occurred on the other HW inputs.

After resetting, the counter starts counting automatically when the gate is at logic 1.

Gate control

The opening and closing of the hardware gate (HW gate) and software gate (SW gate) define the time window in which the counting signals are detected.

You have two options to control the gate:

- Via the user program (SW gate)
- Via the digital inputs DI_1 and DI_5 (HW gate)

You can select one of these two options through parameter assignment. The gate is closed when the control signal is at logic 0 and open when the control signal is at logic 1.

With the gate open, ensure that the two signals adopt unequal (antivalent) states ($DI_0 = 1$, $DI_4 = 0$ or $DI_0 = 0$, $DI_4 = 1$). If the signal on one channel changes, the other channel must change to the opposite state within the adjustable discrepancy time.

The gate control is active as long as no error is present. The gate control remains inactive even after a discrepancy error has been resolved and can only be reactivated by a reset. Only then will the error be reported as resolved and the outgoing error acknowledged.

When the gate is closed, the discrepancy evaluation of the digital inputs DI_0 and DI_4 is not active. However, exceeding the maximum possible frequency will continue to be monitored and will result in an error message even when the gate is closed.

After you have closed the gate, the two digital inputs of the counter must have adopted unequal (antivalent) states within the set "Discrepancy time limit" ($DI_0 = 1$, $DI_4 = 0$ or $DI_0 = 0$, $DI_4 = 1$). Otherwise, a diagnostic interrupt "Discrepancy error" can be triggered.

NOTE

Automatic closing of the gate

The gate is automatically closed in the following situations:

- If the CPU is in STOP mode
- CRC error in PROFIsafe communication
- In the event of a timeout of the PROFIsafe communication
- In the event of errors in the safety program that lead to a CPU STOP

⚠ WARNING

Reinitialization after parameter download

When you download the parameter assignment to the F-CPU, the internal module states are reinitialized. The internal module states thus correspond to the state on startup.

The reinitialization affects the following internal module states:

- Status and event bits in the process image are reset
- The count value is set to the start value

In addition to a user-command-controlled download of parameters from STEP 7 (TIA Portal), parameters are downloaded and the module is reinitialized in the following situations:

- Power cycling the F-CPU
- Pulling/plugging the module
- Power cycling the module supply voltage L+
- Power cycling the interface module in a distributed setup
- Pulling/plugging the PROFINET cable to the interface module in a distributed setup

Direction control

You have two options to control the counting direction:

- Using the user program
- Via the digital inputs DI_3 and DI_7

You can select one of these two options through parameter assignment. Changes in direction are only made when the gate is closed. The counting direction is up if the control signal is at logic 0 and down if the control signal is at logic 1.

Exceeding the counting limit

Exceeding the high or falling below the low counting limit is signaled by setting the corresponding event bit in the feedback interface.

You can acknowledge and clear these events via the user data interface (reset event) in the user program.

If a counting limit is exceeded twice without acknowledgment, the counter is deactivated and the "Channel passivated" diagnostics is generated.

5.2.2 Parameters

The "Counter" operating mode is only effective if the operating mode selection is configured as "Counter".

Parameters for "Counter" operating mode

The following parameters are possible:

Table 5-3 Adjustable parameters

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
Module parameters:				
Operating mode	• Digital inputs • Counter • Standstill and Overspeed monitoring	Digital inputs	No	Module
F-parameters				
Manual assignment of the F-monitoring time	• Disable • Enable	Disable	No	Module
F-monitoring time	1 to 65535 ms	150 ms	No	Module
F-source address	1 to 65534	Depends on the parameter assignment of the F-CPU	No	Module
F-destination address	1 to 65534	Is proposed by the F-system	No	Module
F-parameter signature (without address)	0 to 65535	Is calculated by the F-system	No	Module
Behavior after channel fault	Passivate channel	Passivate channel (unchangeable)	No	Module
Reintegration after channel fault	• Adjustable • All channels automatically	Adjustable	No	Module
F-I/O DB manual number assignment	• Disable • Enable	Disable	No	Module
F-I/O DB number	—	Is proposed by the F-system	No	Module
F-I/O DB name	—	Is proposed by the F-system	No	Module

Table 5-4 Configurable counter parameters

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
Counter - Channel 0, 4				
Input delay	• 0.4 ms • 0.8 ms • 3.2 ms	3.2 ms	No	Channel pair

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
Reset when counting limit is violated	• Start value • Opposite counting limit value	Start value	No	Channel pair
Reaction to violation of a counting limit	• Stop counting • Continue counting	Continue counting	No	Channel pair
Discrepancy limit [number of pulses]	1	1 (unchangeable)	No	Channel pair
Discrepancy time limit	5 ms to 30 s	5 ms	No	Channel pair
High counting limit	-2000000000 to 2000000000	2000000000	No	Channel pair
Low counting limit	-2000000000 to 2000000000	-2000000000	No	Channel pair
Start value	-2000000000 to 2000000000	0	No	Channel pair
Counting value change reported	When present on a single channel	When present on a single channel (unchangeable)	No	Channel pair
Channel failure acknowledge	• Manual • Automatic	Manual	No	Channel pair
Gate, reset, direction control				
Gate controlled by	• Software • Hardware	Software	No	Module
Reset controlled by	• Software • Software or Hardware	Software	No	Module
Direction controlled by	• Software • Hardware	Software	No	Module
Gate, reset, direction hardware control				
Sensor evaluation	1oo2 evaluation, nonequivalent	1oo2 evaluation, nonequivalent (unchangeable)	No	Channel pair
Discrepancy behavior	Supply last valid value	Supply last valid value (unchangeable)	No	Channel pair
Reintegration after discrepancy error	Test 0-Signal not necessary	Test 0-Signal not necessary (unchangeable)	No	Channel pair
Discrepancy time	5 ms to 30 s	5 ms	No	Channel pair
Channel failure acknowledge	Automatic	Automatic (unchangeable)	No	Channel pair
Input delay	• 0.4 ms • 0.8 ms • 3.2 ms	3.2 ms (3.2 ms is fixed and unchangeable for reset hardware control)	No	Channel pair

5.2.3 Explanation of parameters

5.2.3.1 Module parameters

Operating mode

This parameter is used to specify the desired operating mode.

The digital input module F-DI 8×24VDC HF can be operated in the following operating modes:

- "Digital inputs"
- "Counter"
- "Standstill and Overspeed monitoring"

5.2.3.2 F-parameters

F-parameters

You have to assign the PROFIsafe address (F-destination address together with F-source address) to the F-module before you start operation.

- You define the F-source address with the "Central F-source address" parameter in the F-CPU.
- The F-destination address is assigned automatically for each F-module CPU-wide. You can change the specified F-destination address in the hardware configuration manually.

Information on the F-parameters for the F-monitoring time, the PROFIsafe addressing (F-source address, F-destination address) and the F-I/O DB can be found in the manual SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

Behavior after channel fault

This parameter is used to specify whether the entire F-module is passivated or just the faulty channel(s) in the event of channel faults. In "Counter" mode, the parameter must be set to "Passivate channel".

Reintegration after channel fault

Use this parameter to select how the channels of the fail-safe module are reintegrated after a fault.

Use on S7-1200/1500 F-CPUs

When using the F-module on F-CPUs S7-1200/1500, set this parameter in the STEP 7 dialog of the F-module:

- "Adjustable"
- "All channels automatically"

The parameter "Behavior after channel fault" is set to "Passivate the channel". You allow the individual configuration of the reintegration type per channel using the "Adjustable" parameter assignment. The reintegration type of the respective channel is specified with the "Channel failure acknowledge" channel parameter.

5.2.3.3 Counter parameters

Input delay

Input delay applied to the counting channels. See section Input delay (Page 31).

Reset when counting limit is violated

Determines whether the count value is to be set to the start value or to the opposite counting limit when the high or low counting limit is violated.

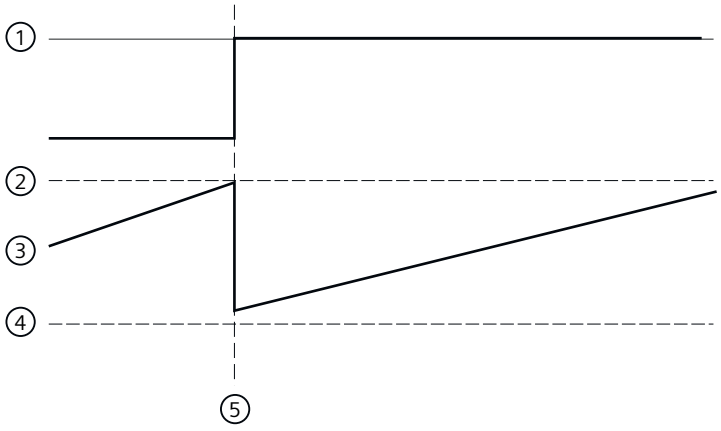
After a count overflow, the specified reset value is adjusted by one counting step to take the overflow pulse into account:

- When counting up: Reset value + 1
- When counting down: Reset value - 1

Reaction to violation of a counting limit

Determines the behavior when the high and low counting limit is violated. You can select whether counting continues or is stopped. If counting is to be stopped, you must close and reopen the gate to resume counting.

The following figure shows the reaction when a counting limit is violated and configured with "Continue counting":



① Overflow status
② High counting limit
③ Evaluated count value
④ Start value/opposite counting limit
⑤ Count value exceeds the configured high counting limit, is reset to the initial value/opposite counting limit value +1 and counting continues.
The user program detects that the "Overflow status" bit changes to high, indicating that the upper counting limit has been exceeded. The user program detects an updated count value.

Discrepancy limit [number of pulses]

The discrepancy limit is the difference in the number of pulses between the two counting channels. The permissible discrepancy is fixed to one pulse. Because a pulse consists of two edges, the detection of a third unequal edge triggers a counting discrepancy error and the diagnostic message "Counter discrepancy limit exceeded" is generated for both channels.

Discrepancy time limit

The time limit for discrepancy is the maximum time within which, after a pulse edge is detected on one input signal (DI_0 or DI_4), a corresponding edge must be detected on the opposite input signal (DI_4 or DI_0). The discrepancy time is measured for each individual unequal edge.

If an edge does not match after the set discrepancy time has expired, e.g. due to a wire break in a sensor cable, a discrepancy error is detected and the diagnostic message "Discrepancy error" is generated for both channels.

High counting limit

You limit the counting range by specifying the high counting limit. When the current count value exceeds the high counting limit, an overflow event is triggered in the feedback interface. You can select if counting is stopped or continued after the high counting limit is exceeded. The current count value is then set to the start value +1 or the low counting limit +1, depending on the parameter assignment. The high counting limit must be greater than the start value. The permissible range is between -2000000000 and 2000000000. The default setting is 2000000000.

Low counting limit

You limit the counting range by specifying the low counting limit. If the current count value falls below the low counting limit, an underflow event is triggered in the feedback interface. You can select if counting is stopped or continued after the low counting limit is undershot. The current count value is then set to the start value -1 or the high counting limit -1, depending on the parameter assignment. The low counting limit must be lower than the start value. The permissible range is between -2000000000 and 2000000000. The default setting is -2000000000.

Start value

You determine the count value at the beginning of the counting by configuring the start value. The current count value is reset to the start value in the following situations:

- After startup
- After parameter download
- After reset
- When the counting limit is exceeded, if configured

The start value must be a value between the high and low counting limit. The permissible range is between -2000000000 and 2000000000. The default setting is 0.

Counting value change reported

Determines when the count value is updated. This parameter is always set to "When present on a single channel". This results in an update being triggered as soon as a "single" rising edge on the primary channel DI_0 or a "single" falling edge on the secondary channel DI_4 is detected. In this context, "single" means that it is not a matching edge. A matching edge is an edge that coincides with an opposite edge already detected on the other channel.

Channel failure acknowledge

Determines how faults on channels 0 and 4 are acknowledged.

You can select from the following options:

- Manual
- Automatic

5.2.3.4 Parameters for gate, reset and direction control

Gate, reset and direction control

Specifies the source for gate, reset, and direction control.

You can select the following options for the gate or direction control:

- "Software"
- "Hardware"

You can choose the following options for the reset control:

- "Software"
- "Software or Hardware"

The default setting is "Software".

NOTE

If you select the "Hardware" option, the respective internal sensor supply is automatically enabled. However, their use in the wiring is optional.

5.2.3.5 Parameters for gate, reset and direction hardware control

Sensor evaluation

If the hardware control option is selected, the setting is always "1oo2 evaluation, non-equivalent". For more information, see section Sensor evaluation (Page 26).

Discrepancy behavior

If the hardware control option is selected, the setting is always "Supply last valid value". For more information, see section Discrepancy behavior (Page 27).

Reintegration after discrepancy error

If the hardware control option is selected, the setting is always "Test 0-Signal not necessary". For more information, see section Reintegration after discrepancy error (Page 29).

Discrepancy time

For more information, see section Discrepancy time (Page 28).

Channel failure acknowledge

This setting is always "Automatic". For more information, see section Channel failure acknowledge (Page 30).

Input delay

For more information, see section Input delay (Page 31).

5.2.4 Address space

Address assignment of the digital input module F-DI 8×24VDC HF in "Counter" operating mode

The digital input module F-DI 8×24VDC HF occupies the following address areas in the F-CPU:

Table 5-5 Address assignment in the F-CPU

Occupied bytes in the F-CPU:		
F-CPU	**In the input range**	**In the output range**
S7-1200/1500 F-CPUs*	IB x + 0 to x + 14	QB x + 0 to x + 5

*) The counter only works with F-CPUs that support PROFIsafe version 2.6.1

x = Module start address

Address assignment of the user data and the value status of digital input module F-DI 8×24VDC HF in "Counter" operating mode

The user data occupy the following addresses in the F-CPU out of all the assigned addresses of the digital input module F-DI 8×24VDC HF:

Table 5-6 User data address assignment in the input range

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB x + 0	Reserved				HW direction signal	HW reset signal	HW gate signal	Reserved
IB x + 1	Reserved		Underflow status	Overflow status	Direction status	Reset status	Gate status	Reserved
IB x + 2	Count value							
IB x + 3								
IB x + 4								
IB x + 5								
IB x + 6	Reserved				HW direction value status	HW reset value status	HW gate value status	Reserved
IB x + 7	Reserved		Value status of underflow status	Value status of overflow status	Value status of direction status	Value status of reset status	Value status of gate status	Reserved
IB x + 8	Reserved							Value status of count value
IB x + 9	Reserved			Event reset controlled by SW	Direction controlled by SW	Reset controlled by SW	Gate controlled by SW	Reserved

Table 5-7 User data address assignment in the output range

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
QB x + 0	Reserved			Event reset	SW direction control	SW reset control	SW gate control	Reserved

5.2.5 Assignment of the control interface counter

The safety program can influence the behavior of the module in "Counter" operating mode via the control interface.

Assignment of the control interface

The following table shows the assignment of the control interface:

Table 5-8 Address assignment in the F-CPU

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
QB x + 0	Reserved			Event reset	SW direction control	SW reset control	SW gate control	Reserved

Explanations

Table 5-9 Explanations

Byte	Bit	Control bit/value	Explanations
QB x + 0	1	SW gate control	Use this bit to control whether the software gate is open, and thus counting is activated. • 0: SW gate closed, counting stopped • 1: SW gate open, counting possible
QB x + 0	2	SW reset control	Use this bit to reset the current value to the configured start value. • 0: No action • 1: Resets the counter to the start value and clears all counter errors present on the channels. The "SW reset" action is always initiated when this bit transitions from 0 to 1. The counter is set to the "Start value" and any error status present on the channels of the counter is cleared.
QB x + 0	3	SW direction control	Use this bit to specify the counting direction. • 0: Counting direction up • 1: Counting direction down Changes in direction are only made when the gate is closed.
QB x + 0	4	Event reset	Use this bit to reset the following status bits in the feedback interface: • Underflow status • Overflow status As long as the "Reset event" bit is set to 1, the "Underflow status" and "Overflow status" bits are continuously reset.

5.2.6 Assignment of the feedback interface counter

In "Counter" operating mode, the safety program can receive actual values and status information via the feedback interface.

Feedback interface

The following table shows the assignment of the feedback interface:

Table 5-10 Assignment of the feedback interface

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
IB x + 0	Reserved				HW direction signal	HW reset signal	HW gate signal	Reserved
IB x + 1	Reserved		Underflow status	Overflow status	Direction status	Reset status	Gate status	Reserved
IB x + 2	Count value							
IB x + 3								
IB x + 4								
IB x + 5								
IB x + 6	Reserved				HW direction value status	HW reset value status	HW gate value status	Reserved
IB x + 7	Reserved		Value status of underflow status	Value status of overflow status	Value status of direction status	Value status of reset status	Value status of gate status	Reserved
IB x + 8	Reserved							Value status of count value
IB x + 9	Reserved			Event reset controlled by SW	Direction controlled by SW	Reset controlled by SW	Gate controlled by SW	Reserved

Explanations

Table 5-11 Explanations

Byte	Bit	Feedback bit/value	Description
IB x + 0	1	HW gate signal	Only valid if the HW control is configured for the gate. The signal value is formed via a 1oo2 evaluation, non-equivalent of the digital inputs DI_1 and DI_5.
IB x + 0	2	HW reset signal	Only valid if the HW control is configured for the reset. The signal value is formed via a 1oo2 evaluation, non-equivalent of the digital inputs DI_2 and DI_6.
IB x + 0	3	HW direction signal	Only valid if the HW control is configured for the direction. The signal value is formed via a 1oo2 evaluation, non-equivalent of the digital inputs DI_3 and DI_7.

Byte	Bit	Feedback bit/value	Description
IB x + 1	1	Gate status	The "Gate status" bit indicates that the module has received the gate control from either the SW control interface or the HW control and has responded as follows: • If the gate control is set to 1, the "Gate status" bit is also set to 1. The module begins monitoring the counter channel pair. • If the gate control is set to 0, the "Gate status" bit is also set to 0. Changes to the counter channel pair are ignored.
IB x + 1	2	Reset status	The "Reset status" bit indicates that the module has received the "Reset" from the control interface and responded as follows: • If the reset control transitions from 0 to 1, the module sets the count value to the start value and clears the counter error states. The "Reset status" bit is set to 1. • If the reset control is set to 0, the "Reset status" bit is also set to 0. If both HW and SW control are used, both must be set to 0 to clear the status bit.
IB x + 1	3	Direction status	The "Direction status" bit indicates the counting direction. • 0: Counting direction is up • 1: Counting direction is down
IB x + 1	4	Overflow status	The "Overflow status" bit is always set when the current count value exceeds the configured "High counting limit". • 0: High counting limit not violated • 1: High counting limit was violated The overflow status bit remains set to 1 until the "Event reset" bit of the module is set to 1, and remains cleared as long as the “Event reset” bit is set to 1.
IB x + 1	5	Underflow status	The "Underflow status" bit is always set when the current count value falls below the configured "Low counting limit". • 0: Low counting limit not violated • 1: Low counting limit was violated The “Underflow status” bit remains set to 1 until the "Event reset" bit of the module is set to 1, and remains cleared as long as the "Event reset" bit is set to 1.
IB x + 2 **IB x + 3** **IB x + 4** **IB x + 5**	0-7	Count value	The count value is a 32-bit signed integer value with a high limit of 2 billion and a low limit of -2 billion.
IB x + 6	1	HW gate value status	Contains the value status of the hardware control inputs in the event that gate is controlled by the hardware.
IB x + 6	2	HW reset value status	Contains the value status of the hardware control inputs in the event that reset is controlled by the hardware.
IB x + 6	3	HW direction value status	Contains the value status of the hardware control inputs in the event that direction is controlled by the hardware.
IB x + 7	1	Value status of gate status	Contains the value status of gate status
IB x + 7	2	Value status of reset status	Contains the value status of reset status
IB x + 7	3	Value status of direction status	Contains the value status of direction status
IB x + 7	4	Value status of overflow status	Contains the value status of overflow status
IB x + 7	5	Value status of underflow status	Contains the value status of underflow status

Byte	Bit	Feedback bit/value	Description
IB x + 8	0	Value status of count value	Contains the value status of count value
IB x + 9	1	Gate controlled by SW	Contains bit that indicates whether gate is software-controlled.*
IB x + 9	2	Reset controlled by SW	Contains bit that indicates whether reset is software-controlled.*
IB x + 9	3	Direction controlled by SW	Contains bit indicating whether direction is software-controlled.*
IB x + 9	4	Event reset controlled by SW	Contains bit indicating whether reset event is software-controlled.*

*) This can only be changed by parameter assignment.

A detailed bit assignment of the bytes IB x + 6 to IB x + 9 can be found in the table "Address assignment by user data in the input range (Page 68)".

5.3 Use cases for Counter (as of firmware version V3.0.0)

⚠ WARNING

Make sure that the highest frequency occurring in the application does not exceed 500 Hz.

⚠ WARNING

Reinitialization after parameter download

When you download the parameter assignment to the F-CPU, the internal module states are reinitialized. The internal module states thus correspond to the state on startup.

The reinitialization affects the following internal module states:

- Status and event bits in the process image are reset
- The count value is set to the start value

In addition to a user-command-controlled download of parameters from STEP 7 (TIA Portal), parameters are downloaded and the module is reinitialized in the following situations:

- Power cycling the F-CPU
- Pulling/plugging the module
- Power cycling the module supply voltage L+
- Power cycling the interface module in a distributed setup
- Pulling/plugging the PROFINET cable to the interface module in a distributed setup

⚠ WARNING

In the time range 2*T_{cycle} before the gate opens, signal changes at the inputs DI_0 and DI_4 can be included in the count value.

In the time range 2*T_{cycle} before the gate closes, signal changes at the inputs DI_0 and DI_4 are not necessarily included in the count value.

Ensure that, in these time ranges, either no signal changes occur at DI_0 and DI_4, or the influence of signal changes occurring in these time ranges on the count value is tolerated by the application.

When using the software gate, the times described in the section "Monitoring and response times" in the programming and operating manual "Industrial Software SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126)" influence the gate control. These times can influence the count value and must be taken into account in the application.

Details on this can be found in the application examples (Page 80).

Inputs for counter

The digital input module F-DI 8x24VDC HF has 8 fail-safe inputs, DI_0 to DI_7.

The inputs are paired in a non-equivalent 1oo2 logic and are used as follows:

- DI_0 and DI_4 are used as counting channels.
- DI_1 and DI_5 are used optionally for HW gate control.
- DI_2 and DI_6 are used optionally for HW reset control.
- DI_3 and DI_7 are used optionally for HW direction control.

The process signals for the HW controls are provided by channels DI_1, DI_2 and DI_3.

The counter counts the number of relevant edges detected on both DI_0 and DI_4. The higher count value on relevant edges of both channels is output as the count value by the module.

Relevant edges are:

- Rising edges for DI_0
- Falling edges for DI_4

Wiring

The wiring is performed on a suitable BaseUnit.

Sensor supply

In “Counter” mode, the internal sensor supplies are permanently assigned to the inputs and cannot be changed.

- VS_0 to DI_0 and VS_4 to DI_4 (always activated)
- VS_1 to DI_1 and VS_5 to DI_5 (activated if the HW gate control is configured)
- VS_2 to DI_2 and VS_6 to DI_6 (activated if the HW reset control is configured)
- VS_3 to DI_3 and VS_7 to DI_7 (activated if the HW direction control is configured)
- The short-circuit tests of the sensor supplies are permanently deactivated.

NOTE

The use of the internal sensor supply in the wiring is optional.

NOTE

Avoidance of interference due to high-energy surge voltages

To avoid interference caused by high-energy surge voltages, you must observe the following restrictions when operating in "Counter" mode:

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 3.2 ms:

No restrictions

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 0.8 ms:

For the DI_0 and DI_4 inputs, you need to use either shielded cables with a maximum length according to the technical specifications (Page 123) or unshielded cables with a maximum length of 30 m. When unshielded cables are used, they can only be installed inside a building.

The following applications are not supported:

- Applications according to NAMUR recommendation NE 21
- Applications according to EN 298
- Shipbuilding applications

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 0.4 ms:

For the DI_0 and DI_4 inputs, you need to use either shielded cables with a maximum length according to the technical specifications (Page 123) or unshielded cables with a maximum length of 30 m. When unshielded cables are used, they can only be installed inside a building.

The following applications are not supported:

- Applications according to NAMUR recommendation NE 21
- Applications according to EN 298
- Shipbuilding applications

The length of the cable between the power supply unit and the F-module cannot be greater than 30 m. The cable can only be installed inside a building.

NOTE

Interruptions of the supply voltage according to IEC 61131-2 are not buffered by the F-module and thus influence the internal sensor supplies. This can lead to the occurrence of diagnostics and passivation of the F-module in "Counter" operating mode. To ensure problem-free functioning of the F-module and the sensors, we recommend the following:

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 3.2 ms:

No additional measures necessary.

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 0.8 ms or 0.4 ms:

For the power supply, use a separate power supply unit that only supplies voltage to digital input modules F-DI 8x24VDC HF in "Counter" operating mode and the associated sensors.

⚠ WARNING

When selecting the sensors, take into account that test pulses at the output of the sensor may influence the counter value.

Wiring diagram - Use case with external sensor supply

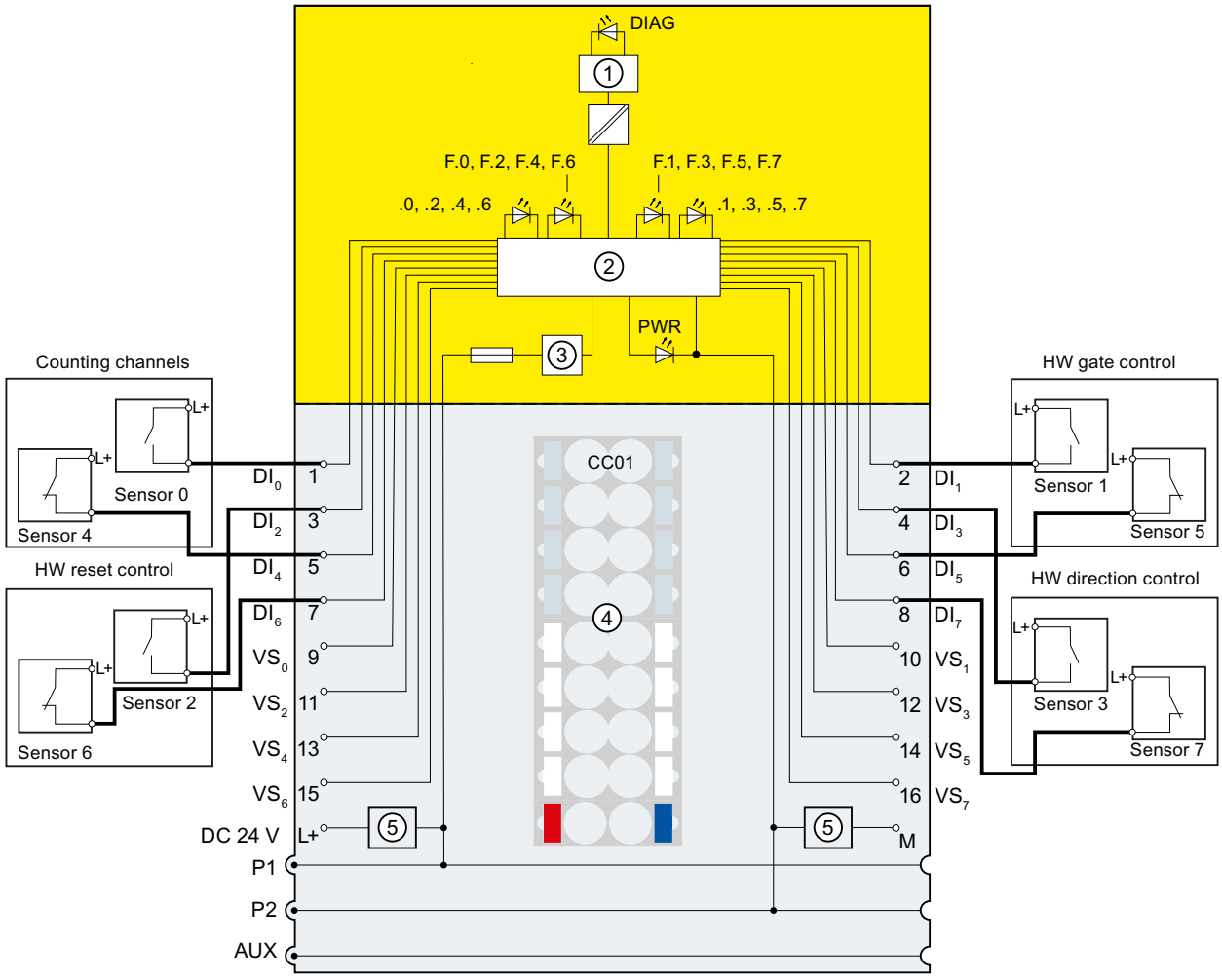


Figure 5-3 Use case with external sensor supply

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Wiring diagram - Use case with internal sensor supply

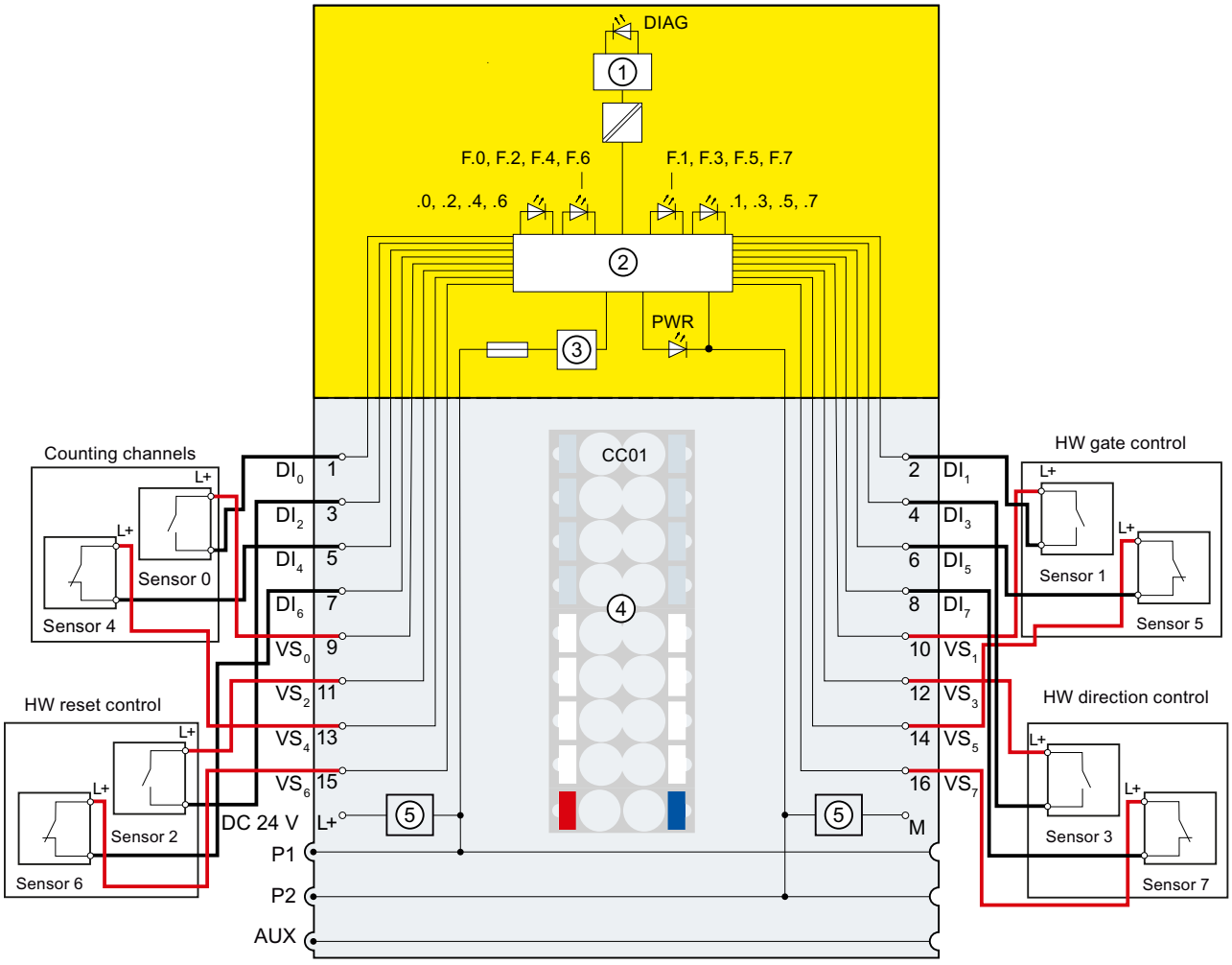


Figure 5-4 Use case with internal sensor supply

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Fault detection

The following tables show the fault detection depending on the sensor supply:

Table 5-12 Error detection at counter inputs (DI_0 and DI_4)

Faults	Fault detection at counter inputs	
	Internal sensor supply	External sensor supply
Short-circuit within the channel pair	Yes	Yes
Short-circuit with other channel pairs or with other sensor supplies	Yes*	Yes*
Short-circuit with L+ to DI_0 or DI_4	Yes*	Yes*
Short-circuit with M to DI_0 or DI_4	Yes*	Yes*
Short-circuit with L+ to SV_n	No	-
Short-circuit with M to SV_n or defective	Yes	-
Discrepancy error	Yes	Yes
Counter discrepancy limit exceeded	Yes	Yes
Wire break	Yes*	Yes*

*) All these errors are detected based on the discrepancy. A discrepancy error is reported after the discrepancy time. Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption compared to the sensor signal, error detection is neither possible nor required from a safety standpoint.

Table 5-13 Fault detection at HW inputs (DI_1, DI_2, DI_3, DI_5, DI_6 and DI_7)

Faults	Fault detection at HW control inputs	
	Internal sensor supply	External sensor supply
Short-circuit within the channel pair	Yes	Yes
Short-circuit with other channel pairs or with other sensor supplies	Yes*	Yes*
Short-circuit with L+ to DI_n	Yes*	Yes*
Short-circuit with M to DI_n	Yes*	Yes*
Discrepancy error	Yes	Yes
Short-circuit with L+ to SV_n	No	-
Short-circuit with M to SV_n or defective	Yes	-

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption compared to the sensor signal, error detection is neither possible nor required from a safety standpoint.

5.4 Application examples for counter mode

The following are two possible application examples for counter mode:

- Piece count
- Counting of continuous pulses

Piece count

In the illustrated example, the number of items transported on a conveyor belt is counted. The counting is performed via two sensors connected to DI_0 and DI_4.

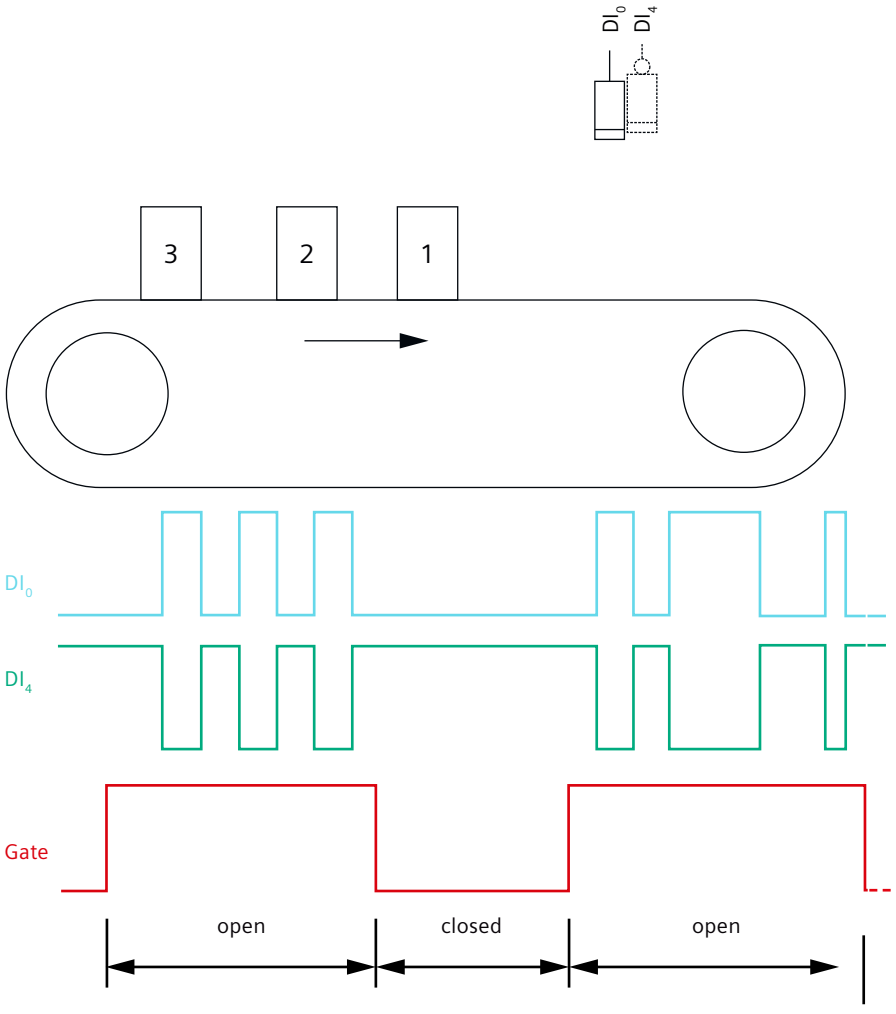


Figure 5-5 Piece count

The piece count refers to cases where an exact number of events is to be counted.

The piece count is defined by the following main characteristics:

- The signal change at the inputs occurs at an unpredictable time.
- The cycle duration and width of the pulses are variable.
- If the gate of the counter is open, the signal changes at the inputs can be stopped, paused, or resumed.
- This application example allows for an exact count value. (For details, see Rules and restrictions)

Rules and restrictions:

⚠ WARNING

In the time range $2*T_{cycle}$ before the gate opens, signal changes at the inputs DI_0 and DI_4 can be included in the count value.

In the time range $2*T_{cycle}$ before the gate closes, signal changes at the inputs DI_0 and DI_4 are not necessarily included in the count value.

Ensure that, in these time ranges, either no signal changes occur at DI_0 and DI_4, or the influence of signal changes occurring in these time ranges on the count value is tolerated by the application.

When using the software gate, the times described in the section "Monitoring and response times" in the programming and operating manual "Industrial Software SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126)" influence the gate control. These times can influence the count value and must be taken into account in the application.

NOTE

After you have closed the gate, the two digital inputs of the counter must have adopted unequal (antivalent) states within the set "Discrepancy time limit" ($DI_0 = 1$, $DI_4 = 0$ or $DI_0 = 0$, $DI_4 = 1$). Otherwise, a diagnostic interrupt "Discrepancy error" can be triggered.

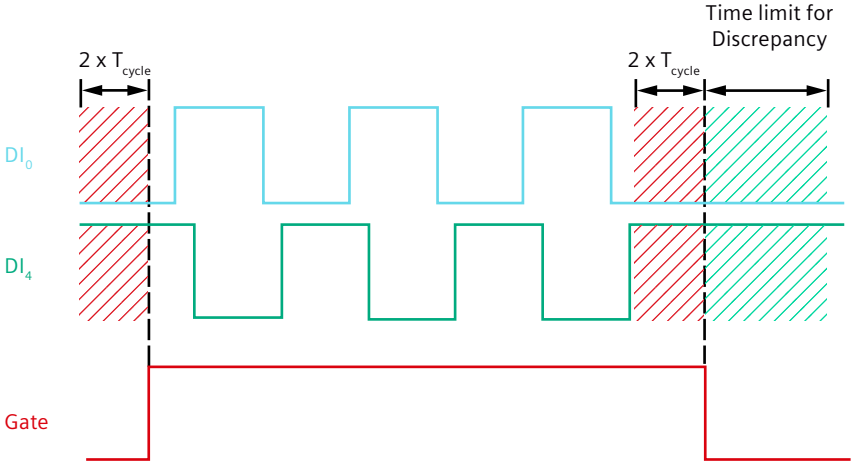


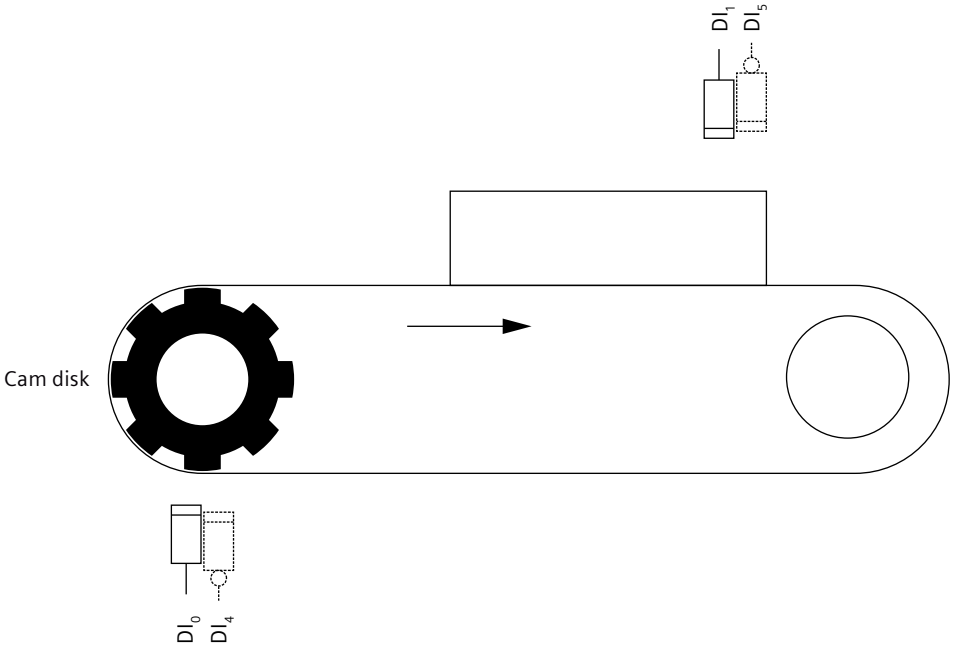
Figure 5-6 Leader and trailer

Counting of continuous pulses

In the illustrated example, the length of the item transported on a conveyor belt is determined.

The object is detected and the gate is controlled via sensors at digital inputs DI_1 and DI_5.

A cam disk is placed on the drive shaft of the conveyor belt. This is detected by sensors connected to DI_0 and DI_4. The length of the object can be inferred from the pulses counted by the sensors.



Counting continuous pulses refers to cases where recurring events are to be counted.

The counting of continuous pulses is defined by the following main characteristics:

- The signal change at the inputs occurs periodically.
- The maximum cycle duration of the pulses applied to the inputs depends on the "Discrepancy time limit" parameter.
- If the counter gate is open, the signal changes at the inputs **cannot** be stopped, paused, or resumed.
- This application example is suitable for applications that allow a tolerance-based count value. (For details, see Rules and restrictions)

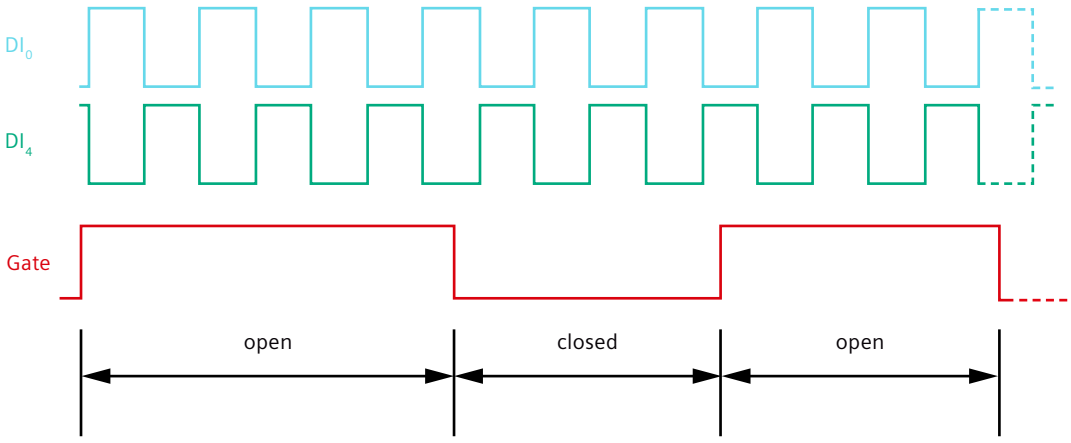


Figure 5-7 Counting of continuous pulses

Rules and restrictions:

- Ensure that the time assigned in the "Discrepancy time limit" parameter is longer than the longest time that the counter inputs are expected to remain unchanged (the longest gap between 2 edges). The figure below shows a continuous pulse pattern that alternates between three cycle durations: P1, P2, P3. The time assigned in the "Discrepancy time limit" parameter must be greater than T1. T1 is the largest distance between 2 edges.

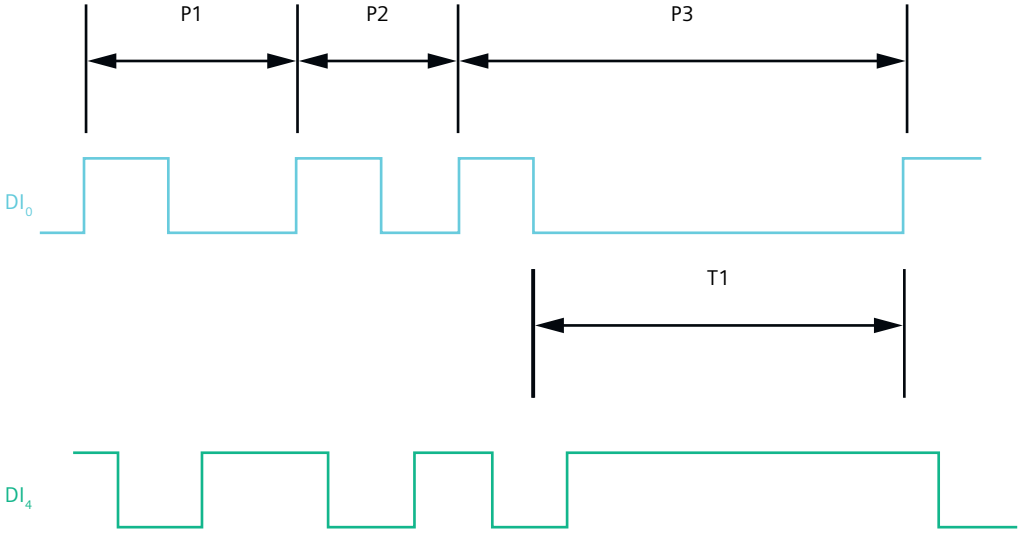


Figure 5-8 Pulse pattern

WARNING

In the time range $2*T_{cycle}$ before the gate opens, signal changes at the inputs DI_0 and DI_4 can be included in the count value.

In the time range $2*T_{cycle}$ before the gate closes, signal changes at the inputs DI_0 and DI_4 are not necessarily included in the count value.

Ensure that, in these time ranges, either no signal changes occur at DI_0 and DI_4, or the influence of signal changes occurring in these time ranges on the count value is tolerated by the application.

When using the software gate, the times described in the section "Monitoring and response times" in the programming and operating manual "Industrial Software SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126)" influence the gate control. These times can influence the count value and must be taken into account in the application.

NOTE

Ensure that the continuous pulse pattern shown in the "Leader and trailer" figure is detected by inputs DI_0 and DI_4 for at least $2*T_{cycle}$ before the gate is opened. Otherwise, a diagnostic interrupt "Discrepancy error" can be triggered.

Ensure that, after the gate is closed, the continuous pulse pattern is detected by inputs DI_0 and DI_4 for at least the configured "Discrepancy time limit". Otherwise, a diagnostic interrupt "Discrepancy error" can be triggered.

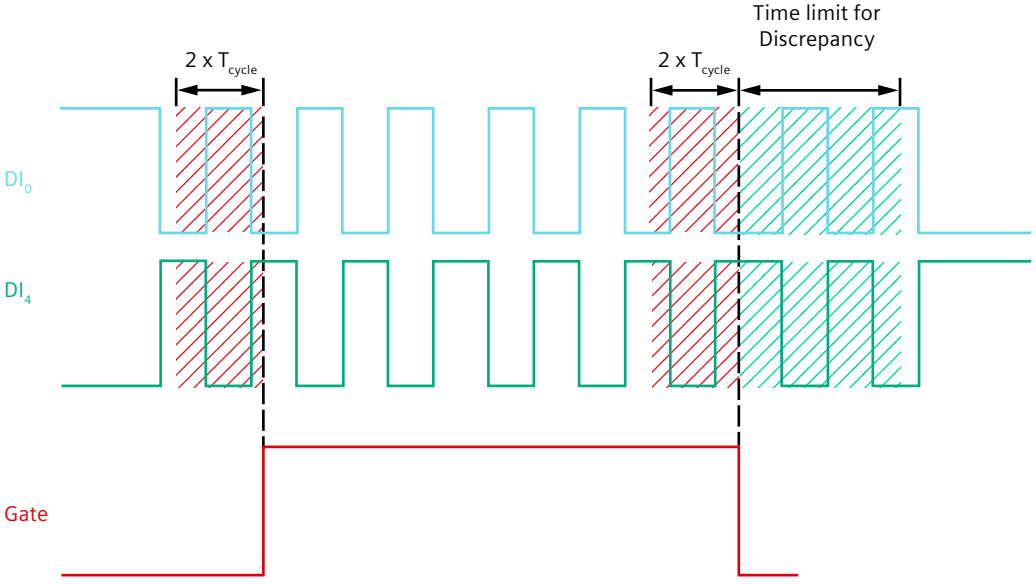


Figure 5-9 Leader and trailer

Standstill and Overspeed monitoring operating mode

6

6.1 Wiring

6.1.1 Pin assignment "Standstill and Overspeed monitoring" operating mode

Pin assignment for the "Standstill and Overspeed monitoring" operating mode

Table 6-1 Pin assignment for the "Standstill and Overspeed monitoring" operating mode

Pin assignment for the "Standstill and Overspeed monitoring" operating mode						
Terminal	**Assignment**	**Terminal**	**Assignment**	**Description**	**BaseUnit**[1]	**Color identification label (terminals 1 to 16)**
1	DI_0	**2**	DI_1	• DI_n: Input signal, channel n • VS_n: Internal sensor supply, channel n	A0	 CC01 6ES7193-6CP01-2MA0
3	DI_2	**4**	DI_3			
5	DI_4	**6**	DI_5			
7	DI_6	**8**	DI_7			
9	VS_0	**10**	VS_1			
11	VS_2	**12**	VS_3			
13	VS_4	**14**	VS_5			
15	VS_6	**16**	VS_7			
L+	DC24V	**M**	M			

[1] Usable BaseUnit types can be identified by the last two digits of their order number. See also *ET 200SP Distributed I/O System* system manual

NOTE

The first BaseUnit of a potential group must be a light-colored BaseUnit.

NOTE

Make sure that you only use digital modules with BaseUnit type A0 during commissioning.

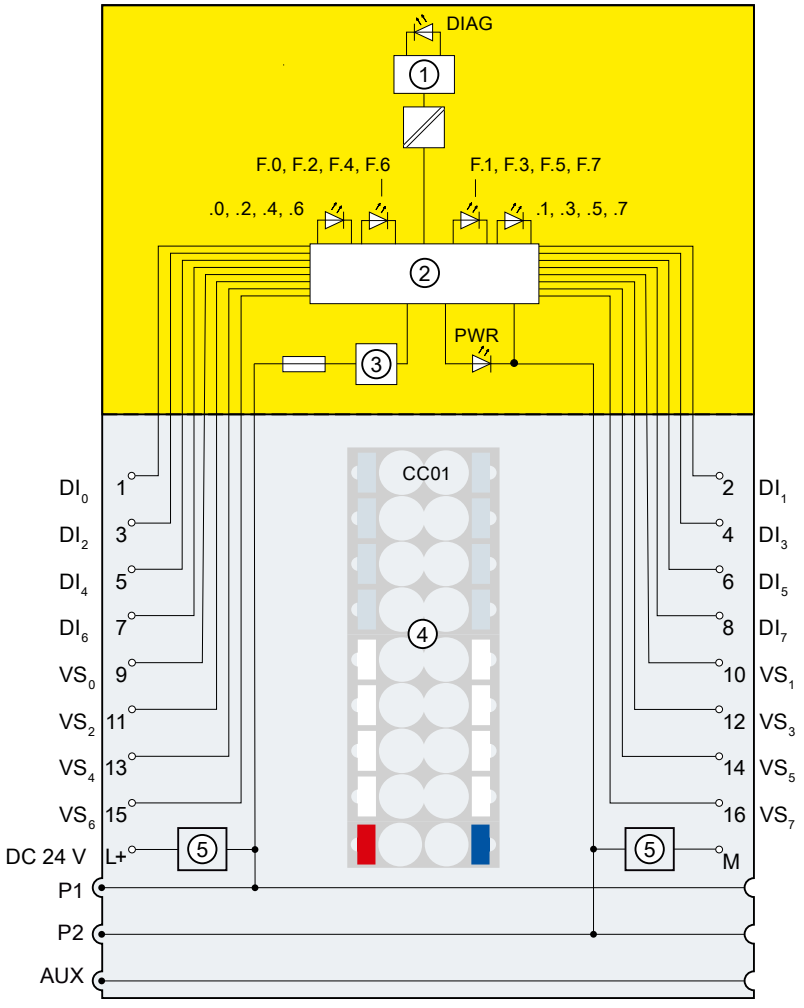
6.1.2 Wiring and block diagram

This section includes the block diagram of the digital input module F-DI 8×24VDC HF with the pin assignment.

You can find more information about wiring the BaseUnit in the Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

Block diagram

The following figure shows the pin assignment of the F-DI 8×24VDC HF digital input module on BaseUnit BU type A0.



①	Backplane bus interface	VS_n	Internal sensor supply, channel n
②	Input electronics	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
③	Reverse polarity protection	DI_n	Input signal, channel n
④	Color identification label with color code CC01 (optional)	DIAG	Error or diagnostics LED (green, red)

⑤	Filter circuit supply voltage (available in light-colored BaseUnit only)	.0 to .7	Channel status LED (green)
L+	24 V DC (infeed only with light-colored BaseUnit)	F.0 to F.7	Channel fault LED (red)
M	Mass supply voltage	PWR	Power LED (green)

Figure 6-1 Block diagram

6.2 Parameters/address space

6.2.1 Standstill and overspeed monitoring

Function

Standstill and overspeed monitoring means the detection of periodically occurring pulse events. The module determines the number of pulses occurring in a defined time window and evaluates them.

Possible applications include:

- Monitoring for excessively high speed during rotation
- Monitoring of the standstill or runout of a rotational movement to its maximum residual speed

The standstill and overspeed monitoring is carried out by means of 1oo2 evaluation of the inputs DI_0 and DI_4. The following figure shows the required pulse pattern.

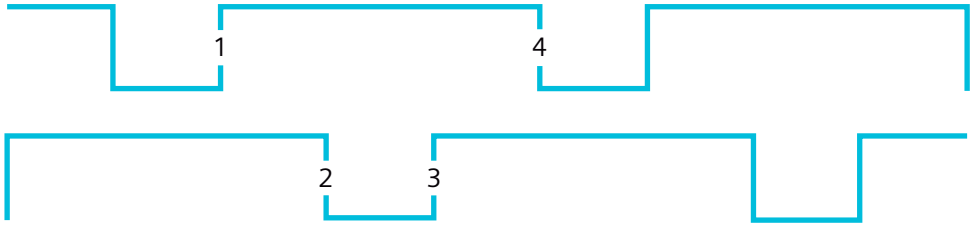
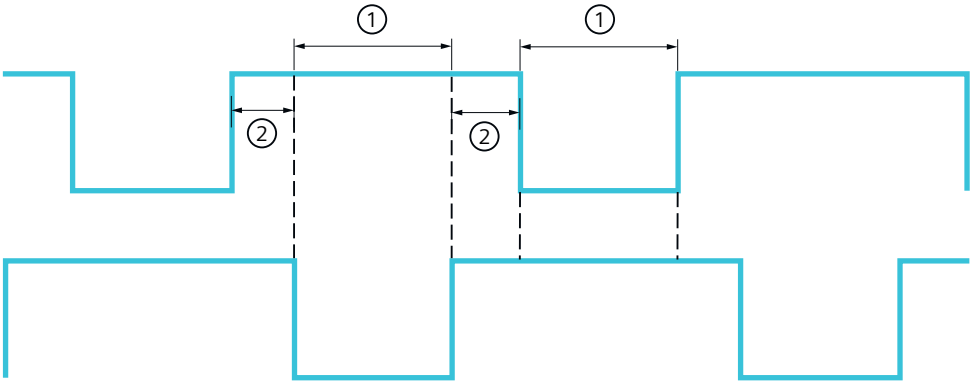


Figure 6-2 Pulse pattern

Between a rising edge (1) and falling edge (4) on the first channel, there must always be a falling edge (2) and a rising edge (3) on the second channel.

In order for a rising or falling edge to be detected, a constant input signal must be present for the minimum pulse duration. See the figure below.



① Minimum pulse duration of the "0" signal

② Minimum duration between edge changes = 330 µs

Figure 6-3 Minimum pulse length

Table 6-2 Numerical values

Input delay	Minimum pulse duration of the "0" signal	Maximum frequency
0.4 ms	0.71 ms	480 Hz
0.8 ms	1.10 ms	350 Hz
3.2 ms	3.60 ms	120 Hz

NOTE

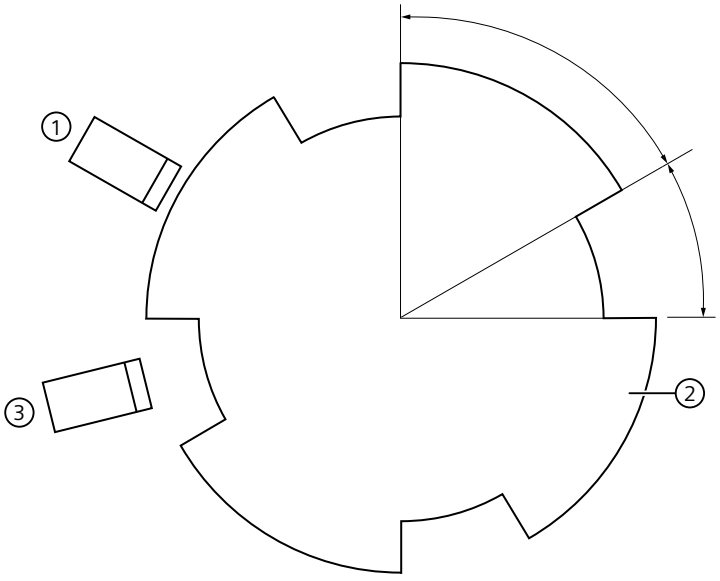
Maximum frequency exceeded

If the maximum frequency is exceeded, a diagnostic message (Frequency too high) may occur, even if the gate is closed.

⚠ WARNING

Input signals shorter than the minimum pulse duration may not be detected. This can lead to a falsification of the standstill and speed detection.

The pulse pattern requirements can be met with applications using a cam disk mounted on a motor shaft. For example, in the following figure in which the sensors are designed as normally open contacts:



① Sensor 1
② Cam disk
③ Sensor 2

Figure 6-4 Example of a pulse detection

With pulse detection, note the following:

- The segment that provides the "1" signal state is larger than the segment that represents the "0" signal state.
- You must position the sensors so that the signals on both sensors do not change at the same time and do not deliver the signal state "0" at the same time.
- After the logic of a sensor switches from 1 to 0, a minimum pulse duration of the "0" signal must be observed. During this entire duration, both sensors must constantly maintain their logic.

  Furthermore, a minimum duration of at least 330 µs must be between the edge changes. This period defines a phase in which both sensors must consistently keep logical 1 at the same time.
- After each logic change on either of the two sensors, a minimum pulse duration should elapse during which the logic on both sensors remains unchanged. See figure "Minimum pulse length" at the beginning of this section.

You define the properties of the standstill and overspeed monitoring with the functions described below.

Standstill monitoring counts the number of relevant edges.

Relevant edges are:

- Rising edges for DI_0
- Rising edges for DI_4 (valid only for tolerant discrepancy evaluation method during standstill)

The standstill monitoring reports the counted number of relevant edges in each monitoring window (at the end of the monitoring window):

- If the tolerant discrepancy evaluation method during standstill is configured, the highest counter reading of DI_0 and DI_4 is reported.
- If the tolerant discrepancy evaluation method during standstill is not configured, the counter reading of DI_0 is reported.

You can find additional information in the section "Use case standstill and overspeed monitoring (Page 104)".

Standstill monitoring

You set the standstill monitoring by selecting a standstill threshold and the duration of a monitoring window. The pulses per monitoring window are counted and compared to the standstill threshold at the end of each monitoring window. A standstill is reported if the number of pulses per monitoring window is less than or equal to the "Standstill threshold" parameter and remains less than or equal for the number of subsequent monitoring windows of "Standstill on-delay" + 1. The standstill is reported by the feedback interface by means of the "Standstill event status" bit. You can find more information under Feedback interface (Page 101).

If the number of input pulses per monitoring window exceeds the "Standstill threshold" parameter, the "Standstill event state" bit is set to "0".

Overspeed monitoring

You set the overspeed monitoring by selecting an overspeed threshold. The pulses per monitoring window are counted and compared to the overspeed threshold at the end of each monitoring window. Overspeed is detected as soon as the number of counted pulses is equal to or greater than the "Overspeed threshold". The overspeed is reported by the feedback interface using the "Overspeed event status" bit. You can find more information under Feedback interface (Page 101).

Reset control

The reset is triggered on the transition from logic 0 to logic 1. A reset clears all standstill and overspeed monitoring faults that are present on the channels. A reset is also necessary if a fault has occurred in the gate input channels. The reset function can only be executed if the standstill and overspeed monitoring is in fault status. If the reset is triggered with the gate open, counting begins immediately after the first monitoring window.

Gate control

Opening the hardware or software gate activates the standstill and overspeed monitoring.

You have two options to control the gate:

- Using the user program
- Via the digital inputs DI_1 and DI_5

You can select one of these two options through parameter assignment. The gate is closed when the control signal is at logic 0 and open when the control signal is at logic 1.

Make sure that a valid pulse pattern is present at digital inputs DI_0 and DI_4 when the gate is opened. See the "Pulse pattern" figure at the beginning of this section.

When the gate is closed, the signal evaluation of the digital inputs DI_0 and DI_4 is not active.

If the reset is triggered with the gate open, counting begins immediately after the first monitoring window. You can find more information under Feedback interface.

NOTE

Automatic closing of the gate

The gate is automatically closed in the following situations:

- If the CPU is in STOP mode
- CRC error in PROFIsafe communication
- In the event of a timeout of the PROFIsafe communication
- In the event of errors in the safety program that lead to a CPU STOP

Discrepancy evaluation method

Standstill and overspeed monitoring allows you to choose by parameter assignment between a strict discrepancy evaluation method and a tolerant discrepancy evaluation method during standstill.

The differences in the discrepancy evaluation method are only applied if the standstill and overspeed monitoring is in the standstill state. This occurs when the number of pulses per monitoring window is lower than the configured "Standstill threshold".

- **Strict discrepancy evaluation method during standstill**

Each detected edge that deviates from the pulse pattern results in a discrepancy error. Use this discrepancy evaluation method to achieve maximum SIL3/Cat.4/PLe.

The parameter "Tolerant discrepancy evaluation method during standstill" is not activated.

- **Tolerant discrepancy evaluation method during standstill**

During standstill, a discrepancy error is only detected if the input signals DI_0 and DI_4 are at logical 0 at the same time. This can help when filtering jitter. To achieve SIL3/Cat.4/PLe, you must use cross-circuit proof wiring. Without cross-circuit proof wiring, you will achieve a maximum of SIL2/ Cat.3/Pld.

The parameter "Tolerant discrepancy evaluation method during standstill" is activated.

6.2.2 Parameters

The "Standstill and Overspeed monitoring" operating mode is only effective if the operating mode selection is configured as "Standstill and Overspeed monitoring".

Parameters for the "Standstill and Overspeed monitoring" operating mode

The following parameters are possible:

Table 6-3 Adjustable parameters

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
Module parameters:				
Operating mode	• Digital inputs • Counter • Standstill and Overspeed monitoring	Digital inputs	No	Module
F-parameters				
Manual assignment of the F-monitoring time	• Disable • Enable	Disable	No	Module
F-monitoring time	1 to 65535 ms	150 ms	No	Module
F-source address	1 to 65534	Depends on the parameter assignment of the F-CPU	No	Module
F-destination address	1 to 65534	Is proposed by the F-system	No	Module
F-parameter signature (without address)	0 to 65535	Is calculated by the F-system	No	Module
Behavior after channel fault	Passivate channel	Passivate channel (unchangeable)	No	Module
Reintegration after channel fault	• Adjustable • All channels automatically	Adjustable	No	Module
F-I/O DB manual number assignment	• Disable • Enable	Disable	No	Module
F-I/O DB number	—	Is proposed by the F-system	No	Module
F-I/O DB name	—	Is proposed by the F-system	No	Module

Table 6-4 Configurable standstill and overspeed monitoring parameters

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
Standstill and Overspeed monitoring - Channel 0, 4				
Input delay	• 0.4 ms • 0.8 ms • 3.2 ms	3.2 ms	No	Channel pair
Channel failure acknowledge	• Manual • Automatic	Manual	No	Channel pair

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
Monitoring window duration	0.1 to 30 s	6 s	No	Channel pair
Overspeed threshold	2 to 14,400	7	No	Channel pair
Overspeed off-delay [number of monitoring windows]	1 to 127	1	No	Channel pair
Standstill threshold	0 to 14,398	2	No	Channel pair
Standstill on-delay [number of monitoring windows]	1 to 127	1	No	Channel pair
Tolerant discrepancy evaluation method during standstill	• Not activated • Activated	Not activated	No	Channel pair
Gate control				
Gate controlled by	• Software • Hardware	Software	No	Module
Gate hardware control - Channel 1, 5				
Sensor evaluation	1oo2 evaluation, non-equivalent	1oo2 evaluation, non-equivalent (unchangeable)	No	Channel pair
Discrepancy behavior	Supply last valid value	Supply last valid value (unchangeable)	No	Channel pair
Reintegration after discrepancy error	Test 0-Signal not necessary	Test 0-Signal not necessary (unchangeable)	No	Channel pair
Discrepancy time	5 ms to 30 s	5 ms	No	Channel pair
Channel failure acknowledge	Automatic	Automatic (unchangeable)	No	Channel pair
Input delay	• 0.4 ms • 0.8 ms • 3.2 ms	3.2 ms	No	Channel pair
Reset control				
Reset controlled by	Software	Software (unchangeable)	No	Module

See also

Standstill and overspeed monitoring use cases (as of firmware version V3.0.0) (Page 104)

6.2.3 Explanation of parameters

6.2.3.1 Module parameters

Operating mode

This parameter is used to specify the desired operating mode.

The digital input module F-DI 8×24VDC HF can be operated in the following operating modes:

- "Digital inputs"
- “Counter"
- "Standstill and Overspeed monitoring"

6.2.3.2 F-parameters

F-parameters

You have to assign the PROFIsafe address (F-destination address together with F-source address) to the F-module before you start operation.

- You specify the F-source address with the "Central F-source address" parameter in the F-CPU.
- The F-destination address is assigned automatically for each F-module CPU-wide. You can change the specified F-destination address in the hardware configuration manually.

Information on the F-parameters for the F-monitoring time, the PROFIsafe addressing (F-source address, F-destination address) and the F-I/O DB can be found in the manual SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

Behavior after channel fault

This parameter is used to specify whether the entire F-module is passivated or just the faulty channel(s) in the event of channel faults. In "Standstill and Overspeed monitoring" mode, the parameter must be set to "Passivate the channel".

Reintegration after channel fault

Use this parameter to select how the channels of the fail-safe module are reintegrated after a fault.

Use on S7-1200/1500 F-CPUs

When using the F-module on F-CPUs S7-1200/1500, set this parameter in the STEP 7 dialog of the F-module:

- "Adjustable"
- "All channels automatically"

The parameter "Behavior after channel fault" is set to "Passivate the channel". You allow the individual configuration of the reintegration type per channel using the "Adjustable" parameter assignment. The reintegration type of the respective channel is specified with the "Channel failure acknowledge" channel parameter.

6.2.3.3 Standstill and overspeed monitoring parameters

Input delay

Input delay applied to the channels. See section Input delay (Page 31).

Channel failure acknowledge

Determines how faults on channels 0 and 4 are acknowledged.

You can select from the following options:

- "Manual"
- "Automatic"

Monitoring window duration

Specifies the monitoring window duration in 0.1 s increments. You can set a range of 0.1 to 30 s. The default setting is 6 s.

Overspeed threshold

Determines the limit for overspeed detection in pulses per monitoring window. You can set a range from 2 to 14,400 pulses. To take the limit into account for normal operation, the set value must be at least 2 greater than the standstill threshold. The default setting is 7.

⚠ WARNING

When configuring the overspeed threshold, you need to consider the monitoring window duration and the input delay.

If the overspeed threshold cannot be reached, speed monitoring will not be performed correctly.

With the following formula, you must determine the maximum reachable value for the overspeed threshold:

*Maximum overspeed threshold = maximum frequency * monitoring window duration*

The value for the maximum frequency can be found in the following "Numerical values" table.

Table 6-5 Numerical values

Input delay	Minimum pulse duration of the "0" signal	Maximum frequency
0.4 ms	0.71 ms	480 Hz
0.8 ms	1.10 ms	350 Hz
3.2 ms	3.60 ms	120 Hz

Overspeed off-delay [number of monitoring windows]

Determines how many consecutive monitoring windows without overspeed must be registered before the "Overspeed event status" bit is reset from 0 to 1. You can set a range from 1 to 127. The default setting is 1. The delay corresponds to the parameterized value + 1 monitoring window.

Standstill threshold

Determines the limit for the standstill detection in pulses per monitoring window. You can set a range from 0 to 14,398 pulses. To take the limit into account for normal operation, the set value must be at least 2 lower than the overspeed limit. The default setting is 2.

⚠ WARNING

When configuring the standstill threshold, you need to consider the monitoring window duration and the input delay.

If the standstill threshold cannot be reached, standstill monitoring will not be performed correctly.

With the following formula, you must determine the maximum reachable value for the standstill threshold:

*Maximum standstill threshold = maximum frequency * monitoring window duration -2*

You must always set the value of the standstill threshold lower than the value of the overspeed threshold.

The value for the maximum frequency can be found in the following "Numerical values" table.

Table 6-6 Numerical values

Input delay	Minimum pulse duration of the "0" signal	Maximum frequency
0.4 ms	0.71 ms	480 Hz
0.8 ms	1.10 ms	350 Hz
3.2 ms	3.60 ms	120 Hz

Standstill on-delay [number of monitoring windows]

Determines how many consecutive monitoring windows must detect a standstill before the standstill event status bit is set. You can set a range from 1 to 127. The default setting is 1. The delay corresponds to the parameterized value + 1 monitoring window.

Tolerant discrepancy evaluation method during standstill

If you select this option, a tolerant discrepancy evaluation method is applied during the standstill. This can help when filtering jitter.

To achieve SIL3/Cat.4/PLe, you must use cross-circuit proof wiring.

6.2.3.4 Parameters for gate and reset control

Gate and reset control

Specifies the source for gate and reset control.

You can choose the following options for the gate control:

- "Software"
- "Hardware"

NOTE

If you select the "Hardware" option, the respective internal sensor supply is automatically enabled. However, their use in the wiring is optional.

You can choose the following options for the reset control:

- "Software"

6.2.3.5 Parameters for gate hardware control

Sensor evaluation

If the hardware control option is selected, the setting is always "1oo2 evaluation, non-equivalent". For more information, see section Sensor evaluation (Page 26).

Discrepancy behavior

If the hardware control option is selected, the setting is always "Supply last valid value". For more information, see section Discrepancy behavior (Page 27).

Reintegration after discrepancy error

If the hardware control option is selected, the setting is always "Test 0-Signal not necessary". For more information, see section Reintegration after discrepancy error (Page 29).

Discrepancy time

For more information, see section Discrepancy time (Page 28).

Channel failure acknowledge

This setting is always "Automatic". For more information, see section Channel failure acknowledge (Page 30).

Input delay

For more information, see section Input delay (Page 31).

6.2.4 Address space

Address assignment of the digital input module F-DI 8×24VDC HF in "Standstill and Overspeed monitoring" operating mode

The digital input module F-DI 8×24VDC HF occupies the following address ranges in the F-CPU:

Table 6-7 Address assignment in the F-CPU

Occupied bytes in the F-CPU:		
F-CPU	**In the input range**	**In the output range**
S7-1200/1500 F-CPUs*	IB x + 0 to x + 14	QB x + 0 to x + 5

*) The standstill and overspeed monitoring only works with F-CPUs that support PROFIsafe version 2.6.1

x = Module start address

Address assignment of the user data and the value status of digital input module F-DI 8×24VDC HF in "Standstill and Overspeed monitoring" operating mode

The user data occupy the following addresses in the F-CPU out of all the assigned addresses of the digital input module F-DI 8×24VDC HF:

Table 6-8 User data address assignment in the input range

Byte in the F-CPU	**Assigned bits in F-CPU per F-module:**							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB x + 0	Reserved						HW gate signal	Reserved
IB x + 1	Standstill event status	Over-speed event status	Reserved			Reset status	Gate status	First mon-itoring window
IB x + 2	Number of pulses per monitoring window							
IB x + 3								
IB x + 4								
IB x + 5								
IB x + 6	Reserved						Value status of HW gate signal	Reserved

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
IB x + 7	Value status of standstill event status	Value status of overspeed event status	Reserved			Value status of reset status	Value status of gate status	Value status of first monitoring window
IB x + 8	Reserved							Value status of the number of pulses per monitoring window
IB x + 9	Reserved					Reset controlled by SW	Gate controlled by SW	Reserved

Table 6-9 User data address assignment in the output range

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
QB x + 0	Reserved					SW reset control	SW gate control	Reserved

6.2.5 Assignment of the standstill and overspeed monitoring control interface

The safety program can influence the behavior of the module in "Standstill and Overspeed monitoring" operating mode via the control interface.

Assignment of the control interface

The following table shows the assignment of the control interface:

Table 6-10 Address assignment in the F-CPU

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
QB x + 0	Reserved					SW reset control	SW gate control	Reserved

Explanations

Table 6-11 Explanations

Byte	Bit	Control bit/value	Explanations
QB x + 0	1	SW gate control	Use this bit to control when the software gate is opened and the standstill and overspeed monitoring is activated. • 0: The SW gate is closed and the standstill and overspeed monitoring is stopped. • 1: The SW gate is open and standstill and overspeed monitoring is enabled.
QB x + 0	2	SW reset control	Use this bit to clear all error statuses in the standstill and overspeed monitoring. • 0: No action • 1: Sets the number of pulses per monitoring window to 0 and clears all error states in the standstill monitoring that are present on the channels. The "SW reset" action is always initiated when this bit transitions from 0 to 1. The current number of pulses per monitoring window is set to 0 and any error status that is present on the channels of the standstill and overspeed monitoring is cleared.

6.2.6 Assignment of the standstill and overspeed monitoring feedback interface

The safety program can receive actual values and status information in "Standstill and Overspeed monitoring" operating mode via the feedback interface.

Feedback interface

The following table shows the assignment of the feedback interface:

Table 6-12 Assignment of the feedback interface

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB x + 0	Reserved						HW gate signal	Reserved
IB x + 1	Standstill event status	Overspeed event status	Reserved			Reset status	Gate status	First monitoring window
IB x + 2	Number of pulses per monitoring window							
IB x + 3								
IB x + 4								
IB x + 5								
IB x + 6	Reserved						Value status of HW gate signal	Reserved

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB x + 7	Value status of standstill event status	Value status of over-speed event status	Reserved			Value status of reset status	Value status of gate status	Value status of first monitoring window
IB x + 8	Reserved							Value status of the number of pulses per monitoring window
IB x + 9	Reserved					Reset controlled by SW	Gate controlled by SW	Reserved

Explanations

Table 6-13 Explanations

Byte	Bit	Feedback bit/value	Description
IB x + 0	1	HW gate signal	Only valid if the HW control is configured for the gate. The signal value is formed via a 1oo2 evaluation, non-equivalent of the digital inputs DI_1 and DI_5.
IB x + 1	0	First monitoring window	The "First monitoring window" bit indicates whether the current monitoring window is the first after a new gate open command was received. • 0: The current monitoring window is not the first after a gate open command. Therefore, normal measured data can be expected. This bit enables the control system to identify the first monitoring window after gate opening. In this first window, the data may not be valid yet. In this way, the control system can distinguish the first window with an error from the subsequent regular monitoring windows. This allows you to distinguish between an actual error and the expected initial state during the first monitoring window. The first monitoring window should be handled by the user program accordingly before the actual measured values can be received. • 1: The current monitoring window is the first after a new gate open command. In the sampling phase, the standstill value status during the first monitoring window is 0 because there is no valid measurement data available to report.
IB x + 1	1	Gate status	The "Gate status" bit indicates that the module has received and responded to the gate control from either the SW control interface or the HW control: • 1: Gate opened. Standstill and overspeed monitoring active. • 0: Gate closed Changes to the counting channel pair for standstill and overspeed monitoring are ignored.

Byte	Bit	Feedback bit/value	Description
IB x + 1	2	Reset status	The "Reset status" bit indicates that the module has received the "Reset" from the control interface and responded as follows: • If the reset control transitions from 0 to 1, the "Reset status" bit is set to 1 and the module deletes the error states for standstill and overspeed monitoring. • If the reset control is set to 0, the "Reset status" bit is also set to 0.
IB x + 1	6	Overspeed event status	The "Overspeed event status" bit indicates the status of an overspeed detection. • 0: Overspeed detected • 1: No overspeed The bit is set to "0" if the pulse count within a monitoring window is greater than or equal to the configured "Overspeed threshold". The bit is automatically reset to "1" when both of the following conditions are met: • The number of pulses is below the "Overspeed threshold". • This state is detected in the number of consecutive monitoring windows defined by the "Overspeed off-delay".
IB x + 1	7	Standstill event status	The "Standstill event status" bit indicates the status of a detected standstill. • 0: No standstill detected • 1: Standstill detected The bit is set to "1" if both of the following conditions are met: • The pulse count within a monitoring window is less than or equal to the configured "Standstill threshold". • This state is detected in the number of consecutive monitoring windows defined by the "Standstill on-delay". The bit is automatically reset to "0" as soon as the pulse count exceeds the defined "Standstill threshold".
IB x + 2 **IB x + 3** **IB x + 4** **IB x + 5**	0-7	Number of pulses per monitoring window	Contains the value status of the number of pulses per monitoring window
IB x + 6	1	Value status of HW gate signal	Contains the value status of the hardware control channel pair in the event that the gate is controlled by the hardware.
IB x + 7	0	Value status of first monitoring window	Contains the value status of first monitoring window
IB x + 7	1	Value status of gate status	Contains the value status of gate status
IB x + 7	2	Value status of reset status	Contains the value status of reset status
IB x + 7	6	Value status of overspeed event status	Contains the value status of overspeed event status
IB x + 7	7	Value status of standstill event status	Contains the value status of standstill event status
IB x + 8	0	Value status of the number of pulses per monitoring window	Contains the value status of the number of pulses per monitoring window
IB x + 9	1	Gate controlled by SW	Contains bit that indicates whether gate is software-controlled.*
IB x + 9	2	Reset controlled by SW	Contains bit that indicates whether reset is software-controlled.*

*) This can only be changed by parameter assignment.

A detailed bit assignment of the bytes IB x + 6 to IB x + 9 can be found in the above table "Assignment of the feedback interface".

6.3 Standstill and overspeed monitoring use cases (as of firmware version V3.0.0)

⚠ WARNING

When the "Tolerant discrepancy evaluation method during standstill" parameter is activated

To achieve SIL3/Cat.4/PLe when the parameter is activated, the cables used for standstill and overspeed monitoring must be installed in a cross-circuit proof manner.

⚠ WARNING

Make sure that the highest possible frequency does not exceed 480 Hz in the application.

Conditions for achieving SIL/Cat./PL

The table below lists the conditions which have to be met for achieving at least the corresponding safety requirements.

Table 6-14 Conditions for achieving SIL/Cat./PL

Discrepancy evaluation	Wiring requirements	Achievable SIL/Cat./PL
Standstill and overspeed monitoring (tolerant discrepancy evaluation method during standstill deactivated)	None	3 / 4 / e
	Cross-circuit proof wiring	3 / 4 / e
Standstill and overspeed monitoring (tolerant discrepancy evaluation method during standstill activated)	None	2 / 3 / d
	Cross-circuit proof wiring	3 / 4 / e

Inputs for standstill and overspeed monitoring

The digital input module F-DI 8x24VDC HF has 8 fail-safe inputs, DI_0 to DI_7.

The inputs are paired in 1oo2 equivalent logic for the standstill and overspeed monitoring counter channels and in 1oo2 non-equivalent logic for the hardware gate control channels:

- DI_0 and DI_4 are used as channels for the standstill and overspeed monitoring.
- DI_1 and DI_5 are used optionally for HW gate control.

The process signal for the hardware control is provided via channel DI_1.

Strict discrepancy evaluation method during standstill

If the strict discrepancy evaluation method is used during standstill, only input DI_0 counts.

If the speed or overspeed is detected, only input DI_0 counts.

Tolerant discrepancy evaluation method during standstill

If the tolerant discrepancy evaluation method during standstill is used, both DI_0 and DI_4 count, and the highest value of both (DI_0, DI_4) is used.

The tolerant discrepancy evaluation method for normal speed and overspeed is identical to the strict discrepancy evaluation method, which means that only DI_0 is counted.

Relevant edges are:

- Rising edges for DI_0
- Rising edges for DI_4 (valid only for tolerant discrepancy evaluation method during standstill)

The standstill monitoring reports the counted number of pulses in each monitoring window (at the end of the monitoring window).

Wiring

The wiring is performed on a suitable BaseUnit.

Sensor supply

In "Standstill and Overspeed monitoring" mode, the internal sensor supplies are permanently switched on, permanently assigned to the inputs, and cannot be changed.

- VS_0 to DI_0 and VS_4 to DI_4 (always activated)
- VS_1 to DI_1 and VS_5 to DI_5 (activated if the HW gate control is configured)
- The short-circuit tests of the sensor supplies are permanently deactivated.

NOTE

The use of the internal sensor supply in the wiring is optional.

NOTE

Avoidance of interference due to high-energy surge voltages

To avoid interference due to high-energy surge voltages, you need to consider the following restrictions in "Standstill and Overspeed monitoring" operating mode:

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 3.2 ms:

No additional restrictions apply.

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 0.8 ms:

For the DI_0 and DI_4 inputs, you need to use either shielded cables with a maximum length according to the technical specifications (Page 123) or unshielded cables with a maximum length of 30 m. When unshielded cables are used, they can only be installed inside a building.

The following applications are not supported:

- Applications according to NAMUR recommendation NE 21
- Applications according to EN 298
- Shipbuilding applications

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 0.4 ms:

For the DI_0 and DI_4 inputs, you need to use either shielded cables with a maximum length according to the technical specifications (Page 123) or unshielded cables with a maximum length of 30 m. When unshielded cables are used, they can only be installed inside a building.

The following applications are not supported:

- Applications according to NAMUR recommendation NE 21
- Applications according to EN 298
- Shipbuilding applications

The length of the cable between the power supply unit and the F-module cannot be greater than 30 m. The cable can only be installed inside a building.

NOTE

Interruptions of the supply voltage according to IEC 61131-2 are not buffered by the F-module and thus influence the internal sensor supplies. This can lead to the occurrence of diagnostics and passivation of the F-module in "Standstill and Overspeed monitoring" operating mode. To ensure problem-free functioning of the F-module and the sensors, we recommend the following:

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 3.2 ms:

No additional measures necessary.

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 0.8 ms or 0.4 ms:

For the power supply, use a separate power supply unit that only supplies voltage in "Standstill and Overspeed monitoring" operating mode to F-DI 8x24VDC HF digital input modules and their associated sensors.

⚠ WARNING

When selecting the sensors, take into account that test pulses at the output of the sensor may influence the number of pulses per monitoring window.

Wiring diagram - Use case with external sensor supply

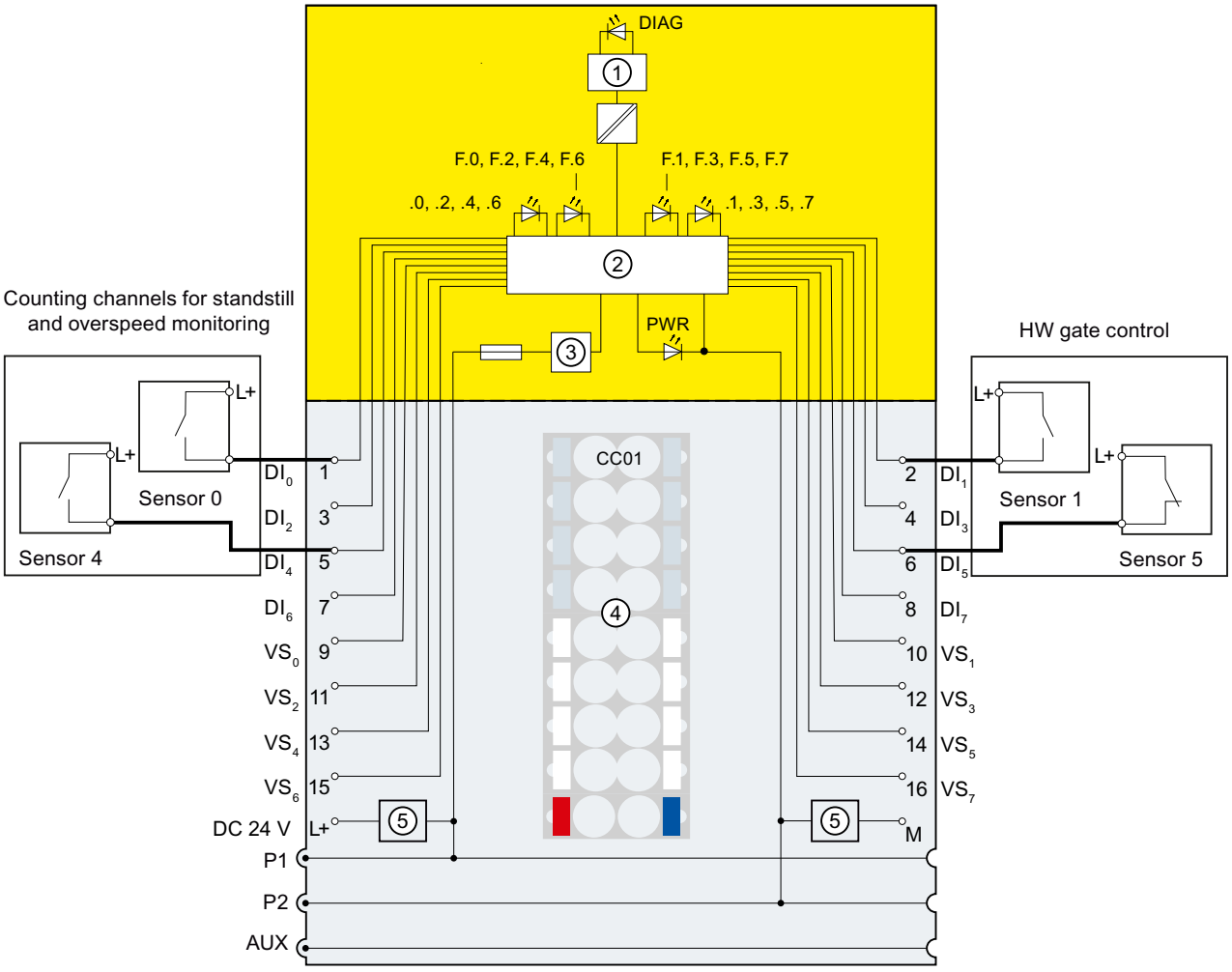


Figure 6-5 Use case with external sensor supply

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

WARNING

When the "Tolerant discrepancy evaluation method during standstill" parameter is activated

To achieve SIL3/Cat.4/PLe when the parameter is activated, the cables used for standstill and overspeed monitoring must be installed in a cross-circuit proof manner.

Wiring diagram - Use case with internal sensor supply

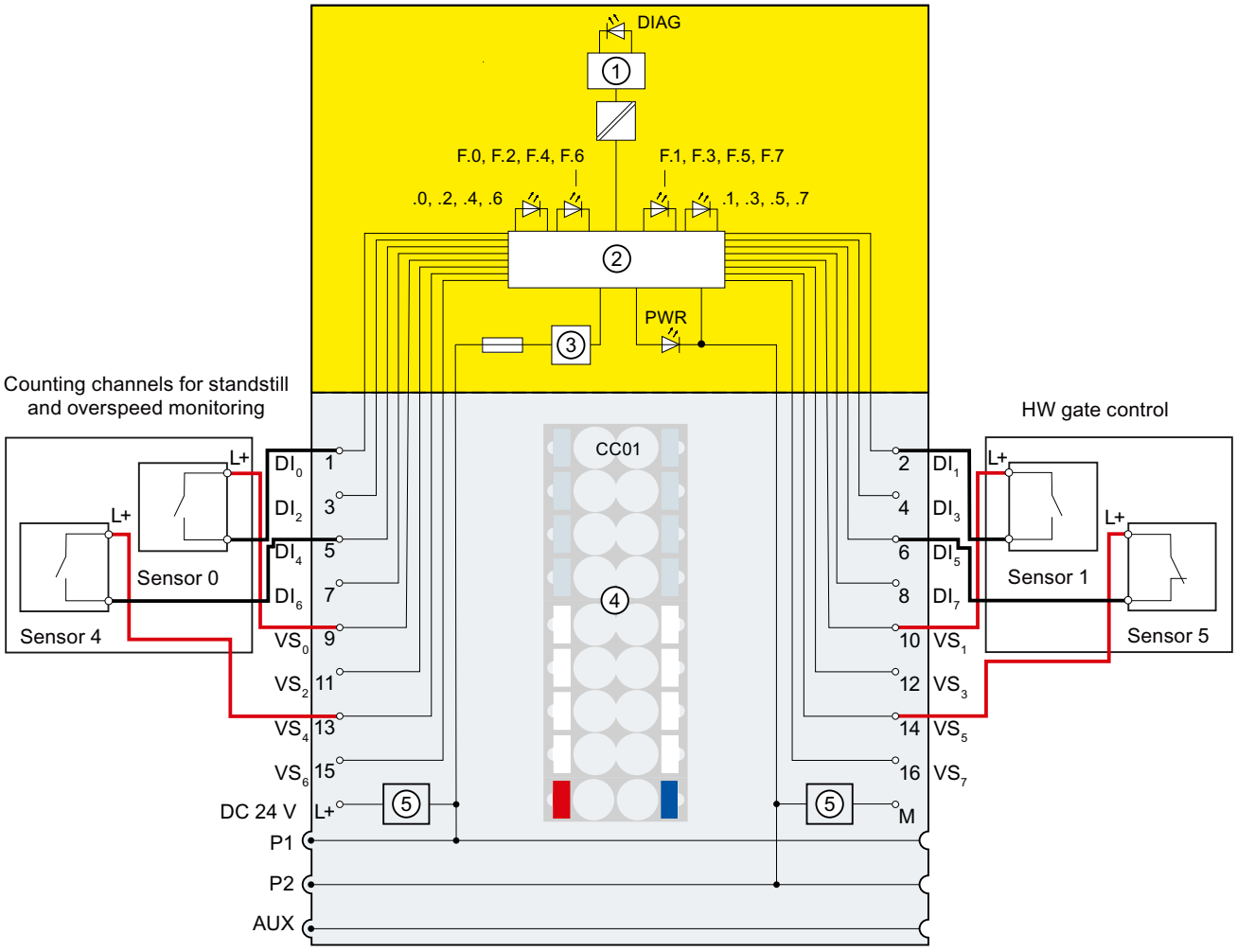


Figure 6-6 Use case with internal sensor supply

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

WARNING

When the "Tolerant discrepancy evaluation method during standstill" parameter is activated

To achieve SIL3/Cat.4/PLe when the parameter is activated, the cables used for standstill and overspeed monitoring must be installed in a cross-circuit proof manner.

Fault detection

The following tables show the fault detection depending on the sensor supply:

Table 6-15 Fault detection at standstill and overspeed monitoring inputs (DI_0 and DI_4)

Tolerant discrepancy evaluation method during standstill disabled		
Faults	**Fault detection at standstill and overspeed monitoring inputs**	
	Internal sensor supply	**External sensor supply**
Short-circuit within the channel pair	Yes	Yes
Short-circuit with other channel pairs or with other sensor supplies	Yes*	Yes*
Short-circuit with L+ to DI_0 or DI_4	Yes*	Yes*
Short-circuit with M to DI_0 or DI_4	Yes*	Yes*
Short-circuit with L+ to SV_n	No	-
Short-circuit with M to SV_n or defective	Yes	-
Discrepancy error	Yes	Yes
Wire break	Yes**	Yes**

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

**) A single fault (wire break on one channel) may not be detected immediately, but only when the next pulse signals are generated during rotation. A double fault (wire break on both channels DI_0 and DI_4) is detected.

Table 6-16 Fault detection at HW control inputs (DI_1 and DI_5)

Tolerant discrepancy evaluation method during standstill disabled		
Faults	**Fault detection at HW control inputs**	
	Internal sensor supply	**External sensor supply**
Short-circuit within the channel pair	Yes	Yes
Short-circuit with other channel pairs or with other sensor supplies	Yes*	Yes*
Short-circuit with L+ to DI_n	Yes*	Yes*
Short-circuit with M to DI_n	Yes*	Yes*
Discrepancy error	Yes	Yes
Short-circuit with L+ to SV_n	No	-
Short-circuit with M to SV_n or defective	Yes	-

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

Fault detection

Table 6-17 Fault detection at standstill and overspeed monitoring inputs (DI_0 and DI_4)

Tolerant discrepancy evaluation method during standstill enabled		
Faults	**Fault detection at standstill and overspeed monitoring inputs**	
	Internal sensor supply	**External sensor supply**
Short-circuit within the channel pair	No	No
Short-circuit with other channel pairs or with other sensor supplies	No	No
Short-circuit with L+ to DI_0 or DI_4	No	No
Short-circuit with M to DI_0 or DI_4	Yes*	Yes*
Short-circuit with L+ to SV_n	No	-
Short-circuit with M to SV_n or defective	Yes	-
Discrepancy error	Yes	Yes
Wire break	Yes**	Yes**

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

**) A single fault (wire break on one channel) may not be detected immediately, but only when the next pulse signals are generated during rotation. A double fault (wire break on both channels DI_0 and DI_4) is detected.

Table 6-18 Fault detection at HW control inputs (DI_1 and DI_5)

Tolerant discrepancy evaluation method during standstill enabled		
Faults	**Fault detection at HW control inputs**	
	Internal sensor supply	**External sensor supply**
Short-circuit within the channel pair	Yes	Yes
Short-circuit with other channel pairs or with other sensor supplies	Yes*	Yes*
Short-circuit with L+ to DI_n	Yes*	Yes*
Short-circuit with M to DI_n	Yes*	Yes*
Discrepancy error	Yes	Yes
Short-circuit with L+ to SV_n	No	-
Short-circuit with M to SV_n or defective	Yes	-

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

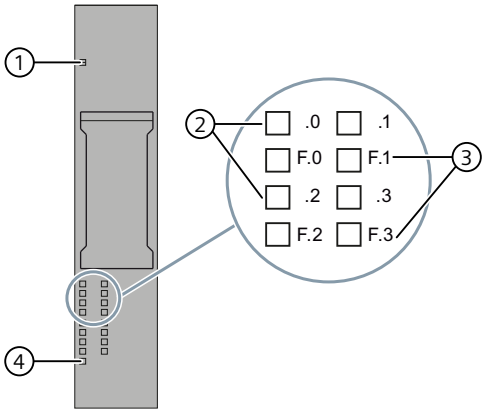
Interrupts/diagnostic messages

7

7.1 Status and error display

LED display

The following figure shows you the LED display of the F-DI 8x24VDC HF.



① DIAG (green/red)
② Channel status (green)
③ Channel error (red)
④ PWR (green)

Figure 7-1 LED display

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedies for diagnostic messages can be found in section Diagnostic messages (Page 116).

WARNING

The DIAG LED and the channel status and channel fault LEDs of the inputs are not designed as safety-related LEDs and therefore may not be evaluated for safety-related activities.

DIAG LED

Table 7-1 DIAG LED fault display

DIAG	Meaning
□ Off	Backplane bus supply of the ET 200SP not okay
☼ Flashing	Module parameters not configured
■ On	Module parameters configured and no module diagnostics
☼ Flashing	• Module parameters configured and module diagnostics • Operation at F-CPUs S7-1200/1500: At least one channel waits for a user acknowledgement.
☼ Flashing	• Operation at F-CPUs S7-1200/1500: After a module fault, the F-module waits for a user acknowledgement. • Operation at F-CPUs S7-300/400: The F-module waits for a user acknowledgement.

Channel status/channel fault LED

Table 7-2 Status display of the LED channel status/channel fault

Channel status	Channel fault	Meaning
□ Off	□ Off	Process signal = 0 and no channel diagnostics
■ On	□ Off	Process signal = 1 and no channel diagnostics
□ Off	■ On	Process signal = 0 and channel diagnostics
☼/ Alternately flashing		At least one channel waits for a user acknowledgement.

Channel status/DIAG/channel fault LED

Table 7-3 Status display of the LED channel status/DIAG/channel fault

Channel status	DIAG	Channel fault	Meaning
□ Off	☼ Flashing	■ All On	The PROFIsafe address does not match the PROFIsafe address of the configuration or there is a module-wide error. See section Interrupts (Page 114)
☼ Flashing	☼ Flashing	□ Off	Identification of the F-module when assigning the PROFIsafe address

PWR LED

Table 7-4 Status display of the PWR LED

PWR	Meaning
□ Off	Supply voltage L+ not present
■ On	Supply voltage L+ present

7.2 Interrupts

Introduction

The fail-safe digital input module F-DI 8×24VDC HF supports diagnostic interrupts.

Diagnostic interrupt

The F-module generates a diagnostic interrupt for each diagnostic message described in section Diagnostic messages (Page 116).

The following list provides you with an overview of the diagnostic interrupts of the F-module. The diagnostic interrupts are assigned either to one channel or the entire F-module.

⚠ WARNING

Before acknowledgment of a diagnostic message, eliminate the respective error and validate your safety function. Proceed as described in section Diagnostic messages (Page 116) to eliminate the error.

Module-wide diagnostic interrupts:

- Overtemperature
- Parameter error
- Supply voltage missing
- Communication fault
- Mismatch of safety destination address (F_Dest_Add)
- Safety destination address not valid (F_Dest_Add)
- Safety source address not valid (F_Source_Add)
- Safety watchdog time value is 0 ms (F_WD_Time)
- Parameter F_SIL exceeds SIL from specific device application
- Parameter F_CRC_Length does not match the generated values
- Version of F parameter set incorrect
- CRC1 fault

- Device-specific diagnostics information, see manual
- Inconsistent iParameter (iParCRC error)
- F_Block_ID not supported
- Transmission error: Inconsistent data (CRC error)
- Transmission error: Timeout (watchdog time 1 or 2 expired)
- Acknowledge required to enable channel(s) - as channel error(s) are remedied.
- Watchdog tripped
- Invalid/inconsistent firmware present
- Diagnostic queue overflow
- F-address memory not accessible
- No valid F-address available
- Undertemperature
- Supply voltage too high
- Supply voltage too low
- F-module error (0x032F)

Channel-wide diagnostic interrupts

- Wire break
- Discrepancy failure, channel status 0/0
- Discrepancy failure, channel status 0/1
- Discrepancy failure, channel status 1/0
- Discrepancy failure, channel status 1/1
- Input signal not recorded unique
- Internal sensor supply short-circuit to P
- Overload or internal sensor supply short-circuit to ground
- Sensor signal flutters
- Frequency too high
- Discrepancy error
- Input shorted to P
- Channel passivated
- Counter discrepancy limit exceeded

7.3 Diagnostic messages

Diagnostic messages

Module faults are indicated as diagnostics (module status).

Once the fault is eliminated, the F-module must be reintegrated in the safety program. For additional information on passivation and reintegration of F-I/O, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

NOTE

If you are using a GSDML file for configuring the F-module, other error codes will be supplied. In this case you must multiply the listed error numbers by 0x40 (e.g. 0x05 * 0x40 = 0x140). However, the text in the CPU diagnostic buffer corresponds to the text of the diagnostic interrupt as listed in the table below.

Table 7-5 Diagnostic messages of the F-DI 8x24VDC HF

Diagnostic message	Fault code	Meaning	Remedy
Overtemperature	5_H	An excessively high temperature was measured in the F-module.	Operate the F-module within the specified temperature range. (See Technical specifications (Page 123)) Once the fault has been eliminated, the F-module must be removed and inserted or the power switched OFF and ON
Wire break	6_H	Possible causes: • There is an interrupted cable between the module and sensor. • The channel is not connected (open).	Establish a cable connection.
Parameter error	10_H	Parameter assignment errors include: • The F-module cannot use the parameters (unknown, invalid combination, etc.). • The F-module parameters have not been configured.	• Correct the parameter assignment. • Check whether a coding element is available.
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check supply voltage L+ at the BaseUnit • Check BaseUnit type
Communication fault	13_H	Possible causes: • An impermissibly high electromagnetic interference is present. • The F-module has detected an internal error and reacted to it in a safety-oriented manner.	• Correct the fault. The module must then be pulled and plugged, or the power switched OFF and ON. • If the F-module cannot be put into operation anymore, consider a replacement.
Mismatch of safety destination address (F_Dest_Add)	40_H	The PROFIsafe driver has detected a different F-destination address.	Check the parameter assignment of the PROFIsafe driver and the address setting of the F-module.
Safety destination address not valid (F_Dest_Add)	41_H	The PROFIsafe driver has detected an invalid F-destination address.	Check the parameter assignment of the PROFIsafe driver.

Diagnostic message	Fault code	Meaning	Remedy
Safety source address not valid (F_Source_Add)	42_H	The PROFIsafe driver has detected an invalid F-source address.	
Safety watchdog time value is 0 ms (F_WD_Time)	43_H	The PROFIsafe driver has detected an invalid watchdog time.	
Parameter F_SIL exceeds SIL from specific device application	44_H	The PROFIsafe driver has detected a discrepancy between the SIL setting of the communication and the application.	
Parameter F_CRC_Length does not match the generated values	45_H	The PROFIsafe driver has detected a discrepancy in the CRC length.	
Version of F parameter set incorrect	46_H	The PROFIsafe driver has detected an incorrect version of the F-parameters or an invalid F_Block_ID.	
CRC1 fault	47_H	The PROFIsafe driver has detected inconsistent F-parameters.	
Device-specific diagnostics information, see manual	48_H	The PROFIsafe driver has received inconsistent fail-safe parameters.	
Inconsistent iParameter (iParCRC error)	$4B_H$	The PROFIsafe driver has detected inconsistent iParameters.	Check the parameter assignment of the PROFIsafe driver.
F_Block_ID not supported	$4C_H$	The PROFIsafe driver has detected an incorrect Block ID.	Check the parameter assignment of the PROFIsafe driver.
Transmission error: Inconsistent data (CRC error)	$4D_H$	The PROFIsafe driver has detected a CRC error. Possible causes: • The communication between F-CPU and F-module is interrupted. • Impermissibly high electromagnetic interference is present. • An error has occurred during the sign-of-life monitoring.	• Check the communication link between the F-module and the F-CPU. • Eliminate the cause of the electromagnetic interference.
Transmission error: Timeout (watchdog time 1 or 2 expired)	$4E_H$	The PROFIsafe driver has detected a timeout. Possible causes: • The F-monitoring time is set incorrectly. • A bus fault is present.	• Check the parameter assignment. • Make sure that your communication is operating correctly.
Acknowledge required to enable channel(s) - as channel error(s) are remedied.	$4F_H$	A channel fault was detected. A confirmation is required to enable the channel.	Confirm the channel fault.
Watchdog tripped	103_H	Possible causes: • An impermissibly high electromagnetic interference is present. • The F-module has detected an internal error and reacted to it in a safety-oriented manner.	• Correct the fault. The module must then be pulled and plugged, or the power switched OFF and ON. • If the F-module cannot be put into operation anymore, consider a replacement.

Diagnostic message	Fault code	Meaning	Remedy
Invalid/inconsistent firmware present	$11B_H$	The firmware is incomplete and/or firmware added to the F-module is incompatible. This leads to errors or functional limitations when operating the F-module.	• Perform a firmware update for all parts of the F-module and note any error messages. • Use only firmware versions released for this F-module.
Diagnostic queue overflow	$13E_H$	Overflow of the diagnostic memory. Not all pending diagnostics could be sent. This error can result in deactivation of the module up to switching on/off of the power supply.	Eliminate the previously reported error.
Discrepancy failure, channel status 0/0	300_H	The discrepancy time set for 1oo2 evaluation was exceeded. Possible causes: • The process signal is faulty. • The sensor is defective. • The configured discrepancy time is too low. • There is a short-circuit between an unconnected sensor cable and the sensor supply cable. • Wire break in connected sensor cable or the sensor supply cable • An error occurred during the discrepancy check.	• Check the process signal. • Replace the sensor. • Check the parameter assignment of the discrepancy time. • Check the process wiring. You must eliminate the occurred error within 100 hours if no short-circuit test has been configured for the corresponding sensor supply.
Discrepancy failure, channel status 0/1	301_H		
Discrepancy failure, channel status 1/0	302_H		
Discrepancy failure, channel status 1/1	303_H		
Input signal not recorded unique	305_H	An error occurred during the plausibility check of the input signal between the processors. Possible causes: • The input signal is faulty. For example, through an impermissibly high electromagnetic interference. • There is a high-frequency input signal. For example, through reciprocal interference of the sensors, or the signal lies above the sampling frequency of the input signal. • A momentary interruption/short-circuit of the sensor cable (loose contact) is present. • The sensor/switch bounces.	• Use shielded cables to reduce the EMC effects. • Reduce the input frequency. • Check the wiring of the sensor.
Internal sensor supply short-circuit to P	306_H	Possible causes: • There is a short-circuit of the internal sensor supply with L+. • There is a short-circuit of two sensor supplies. • The capacitance of the connected sensor for the configured test time is too high. • The sensor is defective.	• Eliminate the short-circuit in the process wiring. • Check the configured test time and the process wiring. • Replace the sensor.

Diagnostic message	Fault code	Meaning	Remedy
Overload or internal sensor supply short-circuit to ground	307_H	Possible causes: • The internal sensor supply is short-circuited to ground. • Impermissibly high electromagnetic interference is present.	• Eliminate the overload. • Eliminate the short-circuit in the process wiring. • Check the "Sensor supply" parameter. • Eliminate/reduce the electromagnetic interference.
F-address memory not accessible	$30D_H$	F-source address placed in the electronic coding element and F-destination address cannot be accessed.	Check whether the coding element is available. Replace the coding element, if necessary.
No valid F-address available	$30E_H$	No valid PROFIsafe address is stored in the retentive memory. Possible causes: • Initial commissioning • Deliberate parameter change of the PROFIsafe address • Deviation between setpoint and actual configuration of the plant	• Perform the assignment of the PROFIsafe address during initial commissioning or deliberate parameter changes. • Check the consistency between the setpoint and actual configuration.
Sensor signal flutters	310_H	Too many signal changes have occurred within the time configured with the "Monitoring window" parameter. • The "Monitoring window" parameter setting is too high. • The "Number of signal changes" parameter setting is too low. • A momentary interruption/short-circuit of the sensor cable (loose contact) is present. • Impermissibly high electromagnetic interference is present. • The sensor/switch is bouncing. • The sensor is defective.	• Check the "Monitoring window" parameter. • Check the "Number of signal changes" parameter. • Check the process wiring. • Eliminate/reduce the electromagnetic interference. • Replace the sensor.
Frequency too high	311_H	The switching frequency of the sensor is too high. For counter as well as standstill and overspeed monitoring: This error can be detected even when the gate signal is closed.	Reduce the switching frequency of the sensor.
Undertemperature	312_H	The minimum permissible temperature limit has been violated.	Operate the F-module within the specified temperature range. (See Technical specifications (Page 123))
Discrepancy error	314_H	The discrepancy time set for 1oo2 evaluation was exceeded. The error message is output for channel n+4. Additional information: see error codes 300_H ... 303_H. For counter as well as standstill and overspeed monitoring:	Additional information: see error codes 300_H ... 303_H. For counter as well as standstill and overspeed monitoring: Determine and resolve the cause for the discrepancy error and then reset the counter or standstill and overspeed monitoring with the reset control.

Diagnostic message	Fault code	Meaning	Remedy
		This error indicates that the edges on the two channels do not match: • For counter, the edges were not matched within the configured discrepancy time. • For counter, a gate start was triggered while an unmatched edge was unresolved. • During standstill and overspeed monitoring, an out-of-sequence edge was detected using the strict discrepancy evaluation method during standstill. • During standstill and overspeed monitoring with either of the two discrepancy evaluation methods, both signals are logical 0 at the same time.	
Input shorted to P	$31C_H$	The input signal is short-circuited to L+.	Eliminate the short-circuit.
Supply voltage too high	321_H	The supply voltage is too high.	Check the supply voltage.
Supply voltage too low	322_H	Possible causes: • The supply voltage is too low. • Wrong BaseUnit	• Check the supply voltage. • Use a BaseUnit of the type A0.
Channel passivated	$32B_H$	Possible causes: • The high or low counting limit of the counter was violated twice without acknowledgment. • An error occurred on a hardware control channel pair.	Check the diagnostic buffer for errors that may have occurred in the hardware control channels. Resolve all existing errors and then reset the counter or the standstill monitoring with the reset control.
F-module error (0x032F)	$32F_H$	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module is defective.	• The internal diagnostics has detected an error. Removing and inserting the module or POWER OFF – POWER ON necessary. • If the F-module cannot be put into operation anymore, consider a replacement.
Counter discrepancy limit exceeded	334_H	The counter discrepancy limit between the two channels of the counter has exceeded the permissible limit of 1.	Determine and resolve the cause for the discrepancy error and then reset the counter with the reset control.

Supply voltage outside the nominal range

If the supply voltage L+ is outside the specified value range, the DIAG LED flashes and the module is passivated.

With subsequent voltage recovery (level must be within the specified value range for at least 1 minute (see Technical specifications (Page 123): Voltages, Currents, Potentials)), the DIAG LED stops flashing. The module remains passivated.

Behavior in case of cross circuit/short-circuit to the sensor supply

When internal sensor supply is configured and short-circuit test is deactivated, short-circuits to ground at the sensor supplies are detected. Channels for which the relevant sensor supply is configured will be passivated.

When internal sensor supply is configured and short-circuit test is enabled, short-circuits to ground and potential at the sensor supply are detected. Channels for which the relevant sensor supply is configured will be passivated.

Behavior of the safety mat evaluation in case of cross circuit/short-circuit to the sensor supply or the digital input

With configured safety mat evaluation, short-circuits with L+, short-circuits with M and cross circuits to another channel are detected with configured safety mat evaluation. Both channels assigned to the affected safety mat evaluation are passivated.

To make it easier to determine the cause of the error, the red channel LED of the input affected by the short-circuit/cross circuit lights up.

Behavior of the safety mat evaluation after wire break of the sensor supply cable or the cable of the digital input

With configured safety mat evaluation, the wire break is detected on all cables used for the connection of the safety mat evaluation. Both channels assigned to the affected safety mat evaluation are passivated.

To make it easier to determine the cause of the error, the red channel LED of the input affected by the wire break lights up.

Special features for fault detection

The detection of certain faults (short-circuits or discrepancy errors, for example) depends on the application, the wiring, and the parameter assignment of the short-circuit test and the sensor power supply. For this reason, tables on fault detection for the applications are presented under:

Applications for inputs (Page 35)

Use cases for Counter (as of firmware version V3.0.0) (Page 73)

Standstill and overspeed monitoring use cases (as of firmware version V3.0.0) (Page 104)

Detection of a cross circuit is not ensured in mixed operation between a channel with safety mat and a channel with 1oo1 or 1oo2 configuration.

Generally applicable information on diagnostics

For information on diagnostics which apply to all F-modules (e.g. reading out the diagnostic functions, passivation of channels), refer to the SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

See also

S7 Distributed Safety - Configuring and Programming
(https://support.industry.siemens.com/cs/ww/en/view/22099875)

7.4 Value status

Properties

In addition to the diagnostic messages and the status and error display, the F-module makes available information about the validity of each input and output signal – the value status. The value status is entered in the process image along with the input signal.

Value status for digital input and output modules

The value status is additional binary information of a digital input or output signal. It is entered in the process image of the inputs (PII) at the same time as the process signal. It provides information about the validity of the input or output signal.

The value status is influenced by all errors.

- 1_B: A valid process value is output for the channel.
- 0_B: A fail-safe value is output for the channel, or the channel is deactivated.

Assignment of inputs and outputs for the value status in the PII

Each channel of the F-module is assigned a value status in the process image of the inputs. You can find the assignment in the following sections:

Address space (Page 33) of the "Digital inputs" operating mode

Address space (Page 68) of the "Counter" operating mode

Address space (Page 99) of the "Standstill and Overspeed monitoring" operating mode

Reference

A detailed description of the evaluation and processing of the value status can be found in the SIMATIC Safety – Configuring and Programming
(https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

Technical specifications

8

Technical specifications of F-DI 8×24VDC HF

The following table lists the technical specifications as of the issue date. You can find a data sheet including updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7136-6BA01-0CA0/td?dl=en).

Article number	6ES7136-6BA01-0CA0
General information	
Product type designation	F-DI 8x24VDC HF
Firmware version	V3.0
• FW update possible	Yes
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC01
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	SIMATIC Safety V20 or higher with HSP 0484
• STEP 7 configurable/integrated from version	as 6ES7136-6BA00-0CA0
• PROFINET from GSD version/GSD revision	GSDML V2.45
Operating mode	
• DI	Yes
• Counter	Yes; pulse counting, standstill and speed monitoring
CiR - Configuration in RUN	
Reparameterization possible in RUN	No
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
power supply according to NEC Class 2 required	No
Input current	
Current consumption, max.	40 mA; without load
Encoder supply	
Number of outputs	8

Article number	6ES7136-6BA01-0CA0
24 V encoder supply	
• 24 V	Yes; min. L+ (-1.5 V)
• Short-circuit protection	Yes; Electronic (response threshold 0.7 A to 1.8 A)
• Output current per channel, max.	300 mA
• Output current per module, max.	800 mA; Total current of all encoders
Power loss	
Power loss, typ.	2 W
Address area	
Address space per module	
• Inputs	7 byte; S7-300/400F CPU, 6 byte
• Outputs	5 byte; S7-300/400F CPU, 4 byte
Hardware configuration	
Automatic encoding	Yes
• Electronic coding element type F	Yes
Digital inputs	
Number of digital inputs	8
Digital inputs, parameterizable	Yes
Source/sink input	Yes; P-reading
Input characteristic curve in accordance with IEC 61131, type 1	Yes
Digital input functions, parameterizable	
• Counter	Yes
– Number, max.	1
– Counting frequency, max.	500 Hz
– Counting direction up/down	Yes
Input voltage	
• Rated value (DC)	24 V
• for signal "0"	-30 to +5 V
• for signal "1"	+15 to +30 V
Input current	
• for signal "1", typ.	3.7 mA
Input delay (for rated value of input voltage)	
for standard inputs	
– parameterizable	Yes
– at "0" to "1", min.	0.4 ms
– at "0" to "1", max.	20 ms
– at "1" to "0", min.	0.4 ms
– at "1" to "0", max.	20 ms

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for technological functions	
– parameterizable	No
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	500 m
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
• Hardware interrupt	No
Diagnostics indication LED	
• RUN LED	Yes; green LED
• ERROR LED	Yes; red LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Suitable for safety functions	Yes
Highest safety class achievable in safety mode	
• Performance level according to ISO 13849-1	PLe
• Category according to ISO 13849-1	Cat. 4
• SIL acc. to IEC 61508	SIL 3
Probability of failure (for service life of 20 years and repair time of 100 hours)	
– Low demand mode: PFDavg in accordance with SIL3	< 2.00E-05
– High demand/continuous mode: PFH in accordance with SIL3	< 1.00E-09 1/h
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	0 °C

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• horizontal installation, max.	60 °C
• vertical installation, max.	0 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	4 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	29 g

Dimension drawing

See the Equipment Manual ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521).

Response times

A

Introduction

The next section shows the response times of the digital input module F-DI 8×24VDC HF. The response times of the digital input module F-DI 8×24VDC HF are included in the calculation of the response time of the F-system. To do this, use the SIMATIC STEP7 response time table (https://support.industry.siemens.com/cs/ww/en/view/93839056).

WARNING

If you have configured the digital input module F-DI 8x24VDC HF (6ES7136-6BA00-0CA0) in a plant, but have inserted the digital input module F-DI 8x24VDC HF (6ES7136-6BA01-0CA0) instead, the information from the manual of the digital input module F-DI 8x24VDC HF (6ES7136-6BA00-0CA0) still applies.

Definition of response time for fail-safe digital inputs

The response time represents the interval between a signal change at the digital input and reliable availability of the safety frame on the backplane bus.

Times required for the calculation

- Maximum cycle time: T_{cycle} = 8.0 ms
- Max. acknowledgement time (device acknowledgement time): T_{DAT} = 16 ms

Maximum response time in an error-free scenario (worst case delay time, WCDT) for 1oo1 evaluation.

The following formula applies to a sensor supply without short-circuit test:

Maximum response time (T_{WCDT}) = 2 * T_{cycle} + Input delay

The following formula applies to a sensor supply with short-circuit test:

Maximum response time (T_{WCDT}) = 2 * T_{cycle} + Input delay + T1 + T2

T1 = Time for short-circuit test

T2 = Startup time of sensor after short-circuit test

Maximum response time in an error-free scenario (worst case delay time, WCDT) for 1oo2 evaluation.

The following formula applies to a sensor supply without short-circuit test:

Maximum response time (T_{WCDT}) = 2 * T_{cycle} + Input delay+ Discrepancy time*

The following formula applies to a sensor supply with short-circuit test:

Maximum response time (T_{WCDT}) = 2 * T_{cycle} + Input delay + max (T1p + T2p, T1s + T2s) + Discrepancy time*

*) Is omitted for discrepancy behavior "Supply value 0"

T1p = Time for short-circuit test (sensor 1)

T2p = Startup time of sensor after short-circuit test (sensor 1)

T1s = Time for short-circuit test (sensor 2)

T2s = Startup time of sensor after short-circuit test (sensor 2)

The discrepancy time is included in the calculation of the maximum response time (T_{WCDT}) and can therefore be set to 0 in the SIMATIC STEP7 response time table.

Maximum response time to external short-circuits (one fault delay time, OFDT)

Maximum response time (T_{OFDT}) = Input delay + T_{cycle} + (n * T_{cycle}) + Sum[x=0...7](Tsx)

Tsx summation term:

(T1x + T2x) < T_{cycle} → Tsx = T_{cycle}

(T1x + T2x) >= T_{cycle} → Tsx = max (T1x, T_{cycle}) + T2x

For deactivated sensor supplies or sensor supplies with deactivated short-circuit test, the value 0 has to be used in the formula for Tsx.

x = Sensor supply

T1x = Time for short-circuit test

T2x = Startup time of sensor after short-circuit test

n = Number of sensor supplies with activated short-circuit test

Below you will find two examples for calculating the maximum response time to external short-circuits on a F-DI 8×24VDC HF depending on the parameter assignment.

Channel	Input delay (ms)	Short-circuit test	T1 (ms)	T2 (ms)	T_{cycle} (ms)	T1 + T2 < T_{cycle}	Ts (ms)	Max. response time to external short-circuits (ms)
0	3.2	Enable	4.2	4.2	8.0	NO	12.2	172.8
1	3.2	Enable	4.2	4.2	8.0	NO	12.2	172.8
2	3.2	Enable	4.2	4.2	8.0	NO	12.2	172.8

Channel	Input delay (ms)	Short-circuit test	T1 (ms)	T2 (ms)	T_{cycle} (ms)	T1 + T2 < T_{cycle}	Ts (ms)	Max. response time to external short-circuits (ms)
3	3.2	Enable	4.2	4.2	8.0	NO	12.2	172.8
4	3.2	Enable	4.2	4.2	8.0	NO	12.2	172.8
5	3.2	Enable	4.2	4.2	8.0	NO	12.2	172.8
6	3.2	Enable	4.2	4.2	8.0	NO	12.2	172.8
7	3.2	Enable	4.2	4.2	8.0	NO	12.2	172.8

Example calculation: (4.2 ms + 4.2 ms) >= 8.0 ms→ Ts = max (4.2 ms, 8.0 ms) + 4.2 ms = 12.2 ms

Channel	Input delay (ms)	Short-circuit test	T1 (ms)	T2 (ms)	T_{cycle} (ms)	T1 + T2 < T_{cycle}	Ts (ms)	Max. response time to external short-circuits (ms)
0	0.4	Enable	0.5	0.5	8.0	YES	8.0	5334.8
1	0.8	Enable	4.2	10	8.0	NO	18.0	5335.2
2	1.6	Enable	20	4.2	8.0	NO	24.2	5336.0
3	3.2	Enable	100	100	8.0	NO	200	5337.6
4	0.4	Disable	-	-	8.0	-	-	- *)
5	0.8	Enable	4.2	4.2	8.0	NO	12.2	5335.2
6	1.6	Enable	500	500	8.0	NO	1000	5336.0
7	3.2	Enable	2000	2000	8.0	NO	4000	5337.6

*) External short-circuits are not detected with a deactivated short-circuit test.

Example calculation channel 1: (4.2 ms +10 ms) >= 8.0 ms → Ts = max(4.2 ms, 8.0 ms) + 10 ms = 18.0 ms

Maximum response time for discrepancy error for 1oo2 evaluation (one fault delay time, OFDT)

Maximum response time (T_{OFDT}) = 2 * T_{cycle} + Input delay + 2 * max (T1p + T2p, T1s + T2s) + Discrepancy time

T1p = Time for short-circuit test (sensor 1)

T2p = Startup time of sensor after short-circuit test (sensor 1)

T1s = Time for short-circuit test (sensor 2)

T2s = Startup time of sensor after short-circuit test (sensor 2)

Maximum response time with no faults (Worst Case Delay Time, WCDT) for safety mat evaluation

When the safety mat is activated (the contact is closed), the maximum response time is 17.6 ms.

Maximum response time in the case of fault (One Fault Delay Time, OFDT) for safety mat evaluation

If a safety mat evaluation is only configured on one channel pair, the maximum response time in case of a fault is 25.6 ms.

If a safety mat evaluation is configured on 2 to 4 channel pairs, the maximum response time in case of a fault is 33.6 ms.

Maximum response time with no faults (Worst Case Delay Time, WCDT) for counter

Maximum response time (T_{WCDT}) = 2 * T_{cycle} + Input delay

Maximum response time to discrepancy error for counter (One Fault Delay Time, OFDT)

Maximum response time (T_{OFDT}) = 3 * T_{cycle} + Input delay + T1w

T1w = Discrepancy time limit (maximum permissible value is 30,000 ms).

Maximum response time with no faults (Worst Case Delay Time, WCDT) for standstill and overspeed monitoring

Maximum response time (T_{WCDT}) = 2 * T_{cycle} + Input delay + T2w * 1.002

T2w = Monitoring window duration (maximum permissible value is 30,000 ms).

Maximum response time to discrepancy error for standstill and overspeed monitoring (One Fault Delay Time, OFDT)

To define the worst case failure response time for standstill and overspeed monitoring, the following assumptions need to be made:

- An event must occur that makes the failure noticeable. This implies a deviation from the expected pulse sequence. This event is defined as failure event.
- A type of motion must activate the sensor to trigger an event.

The failure reaction indicates the time between the occurrence of the failure event and the occurrence of a discrepancy on the backplane bus. To detect the discrepancy and pass it on to the backplane bus, 2 * T_{cycle} + Input delay are required.