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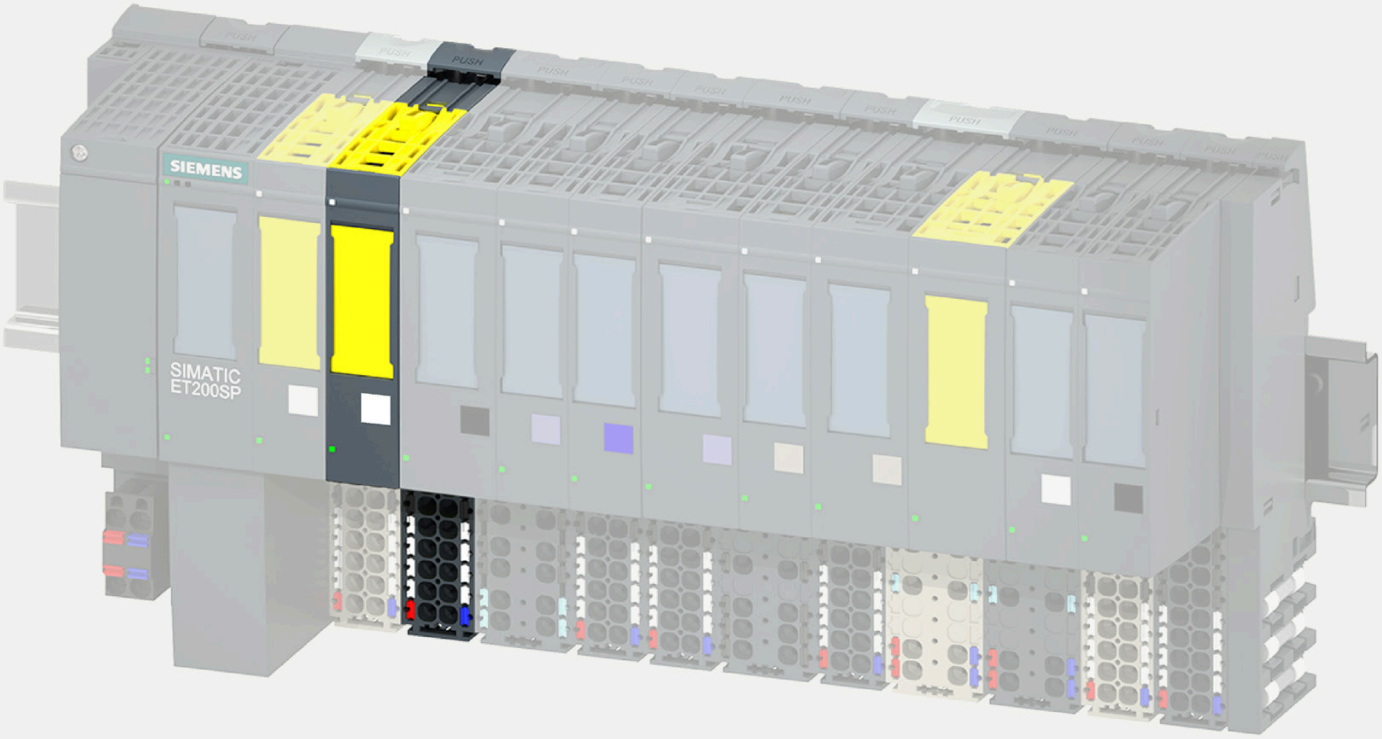

Edition 04/2022

EQUIPMENT MANUAL

SIMATIC

ET 200SP

Digital input module F-DI 8x24VDC HF
6ES7136-6BA01-0CA0

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SIMATIC

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

Equipment Manual

Original operating instructions

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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.

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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 personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

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Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. 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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Preface

Purpose of the documentation

This Equipment Manual supplements the System Manual ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Functions that generally relate to the system are described in the System Manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

You can find the description of the F-system SIMATIC Safety in the SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) programming and operating manual.

Conventions

CPU: When the term "CPU" is used below, it refers to both the central modules of the S7-1200/1500 automation system and of the S7-300/S7-400 automation systems of the previous generation, as well as the CPUs of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

PII: Process image input.

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.

Standards

You can find a dated reference to the respective standards in the certificate (https://support.industry.siemens.com/cs/ww/en/view/57141281) or in the EC Declaration of Conformity (https://support.industry.siemens.com/cs/ww/en/view/71764057) on the F-module.

Certified versions

The certified product and firmware versions are specified in Annex 1 of the report on the TÜV certificate (https://support.industry.siemens.com/cs/ww/en/view/57141289).

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Important note for maintaining the operational safety of your system

WARNING

The operators of systems with safety-related characteristics must adhere to specific operational safety requirements. The supplier is also obliged to comply with special product monitoring measures. Siemens informs system operators in the form of personal notifications about product developments and properties which may be or become important issues in terms of operational safety.

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 on to 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/products?pnid=13751&lc=en-WW)
- SIMATIC S7-400/S7-400H/S7-400F/FH (https://support.industry.siemens.com/cs/products?pnid=13828&lc=en-WW)
- S7-1500 Software Controller (https://support.industry.siemens.com/cs/us/en/ps/13912)
- SIMATIC S7-1500/SIMATIC S7-1500F (https://support.industry.siemens.com/cs/products?pnid=13716&lc=en-WW)
- SIMATIC S7-1200/SIMATIC S7-1200F (https://support.industry.siemens.com/cs/products?pnid=13683&lc=en-WW)
- Distributed I/O (https://support.industry.siemens.com/cs/products?pnid=14029&lc=en-WW)
- STEP 7 (TIA Portal) (https://support.industry.siemens.com/cs/products?pnid=14340&lc=en-WW)

Siemens provides products and solutions with industrial security 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 security 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.

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To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/industrialsecurity).

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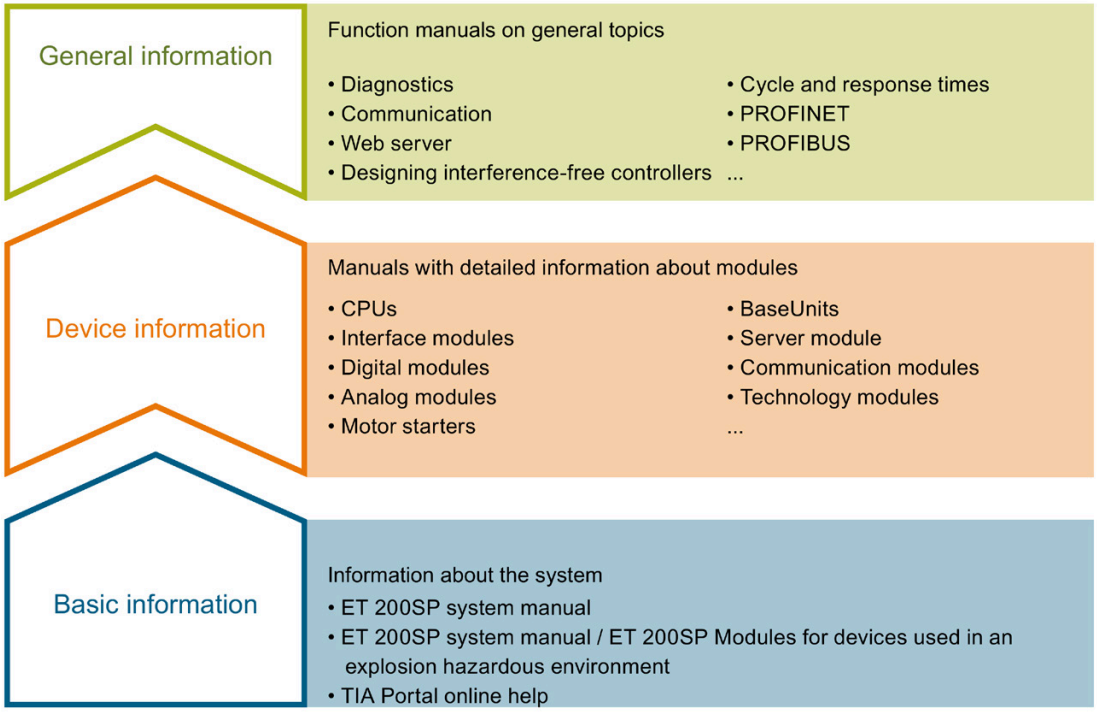
Documentation guide

1

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.



Basic information

The System Manual and Getting Started describe 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.

Device information

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

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

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

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/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.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

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

"mySupport" - Documentation

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

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

"mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- 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" - CAx data on the Internet (https://support.industry.siemens.com/my/ww/en/CAxOnline).

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

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one 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 simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station 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 by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics 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) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant, incl. fail-safe inputs and outputs.

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

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://www.siemens.com/sinetplan).

Product overview

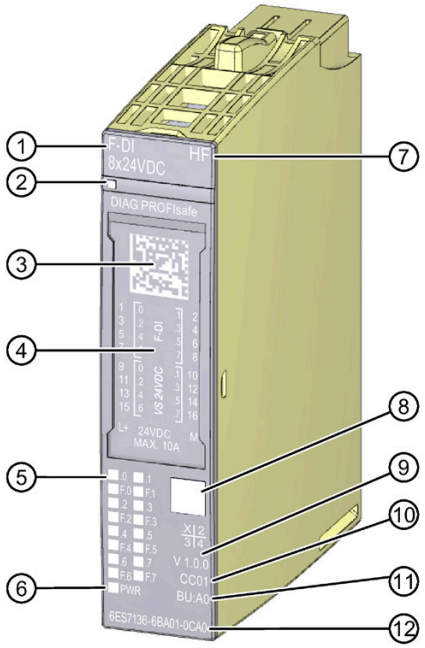
2

2.1 Properties

Article number

6ES7136-6BA01-0CA0

View of the module



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

Figure 2-1 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
- Safety mat evaluation (firmware V2.0.0 or higher)
- Supply voltage L+
- Sink input (P-reading)
- Suitable for the connection of 3-/4-wire sensors according to IEC 61131, Type 1
- 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
- Channel-specific assignable input delay 0.4 ms to 20 ms
- Internal short-circuit-proof sensor supplies for each input
- External sensor supply possible
- 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-based
  - e.g. load voltage missing, module-based
- 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 a repair within 100 hours is not possible, remove the respective module from the BaseUnit or switch off its supply voltage before 100 hours expires.

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).

Connecting

3

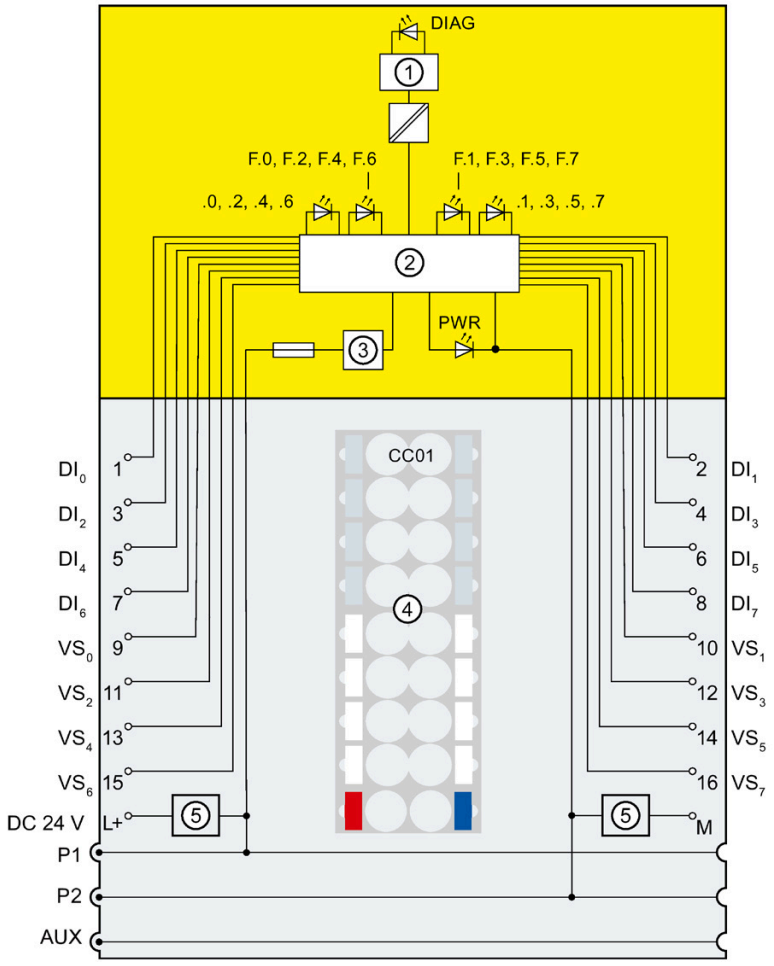
3.1 Wiring and block diagram

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 3-1 Block diagram

Parameters/address space

4

4.1 Parameters

Parameter for F-DI 8x24VDC HF

WARNING

Diagnostics functions should be activated or deactivated in accordance with the application, see section Applications of the F-I/O module (Page 37).

The following parameters are possible:

Table 4- 1 Adjustable parameters

Parameter	Value range	Default	Parameter reassignment in RUN	Scope
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 faults	• Passivate the entire module • Passivate channel	Passivate channel	No	Module
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

Parameter	Value range	Default	Parameter reassignment in RUN	Scope
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	• Manually • Automatically The value range offered depends on the F-CPU used and the parameter assignment of the F-parameter "Reintegration after channel fault".	(S7-300/400) Parameter is not supported (S7-1200/1500) Manually	No	Channel

Parameter	Value range	Default	Parameter reassignment in RUN	Scope
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 Explanation of parameters

4.2.1 F-parameters

4.2.1.1 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)

4.2.1.2 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"

4.2.1.3 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.

4.2.2 Parameters of the sensor supply

4.2.2.1 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.

4.2.2.2 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.

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.

4.2.2.3 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.

4.2.3 Parameters of the channel pairs

4.2.3.1 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.

4.2.3.2 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.

4.2.3.3 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.

4.2.3.4 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.

4.2.4 Parameters of the channels

4.2.4.1 Activated

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

4.2.4.2 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.

4.2.4.3 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.

During 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 during safety mat evaluation

During 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 24)

4.2.4.4 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 71)

Technical specifications (Page 68)

4.2.4.5 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.

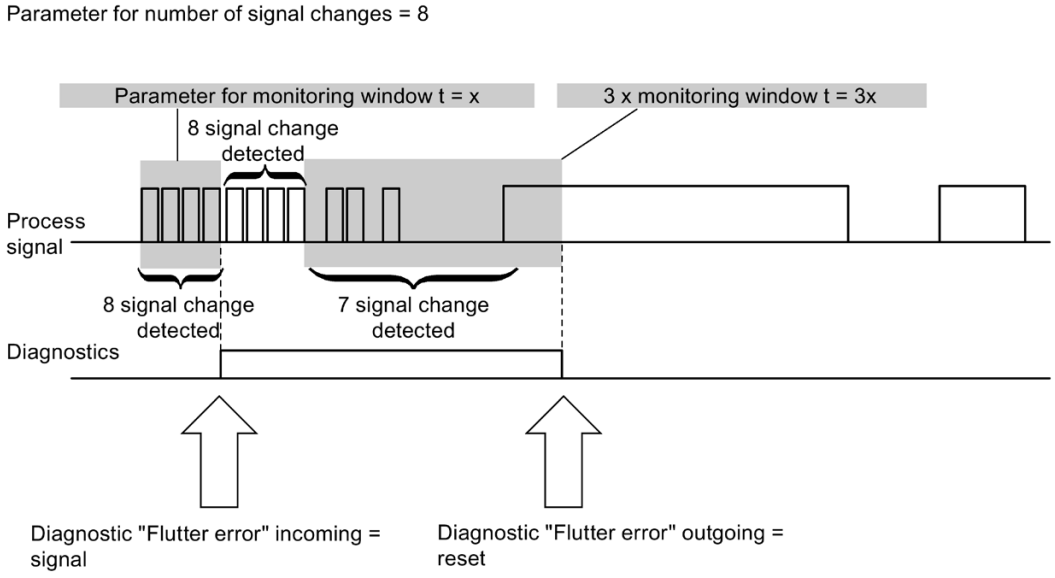


Figure 4-1 Figure chatter monitoring

4.2.4.6 Number of signal changes

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

4.2.4.7 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.

4.3 Address space

Address assignment of the digital input module F-DI 8×24VDC HF

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

Table 4- 2 Address assignment in the F-CPU

Occupied bytes in the F-CPU:		
F-CPU	**In input range**	**In 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 the digital input module F-DI 8×24VDC HF

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- 3 Address assignment through user data

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.

Additional 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)

Applications of the F-I/O module

5

5.1 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.

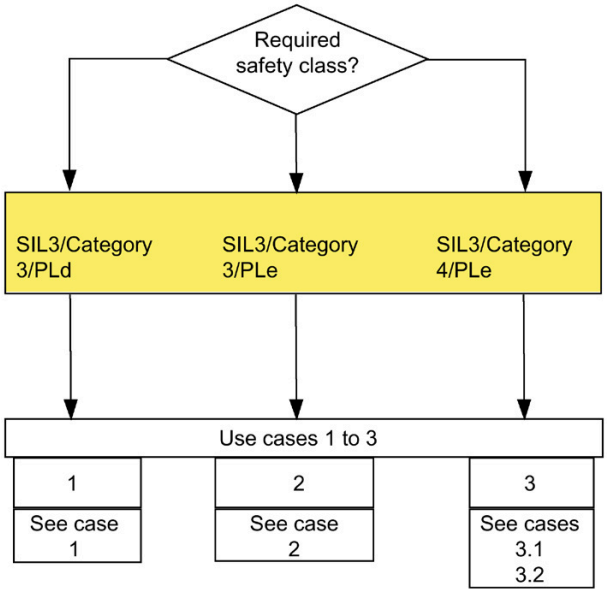


Figure 5-1 Selecting the application – digital input module F-DI 8×24VDC HF

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 5- 1 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	
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).

5.1.1 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.

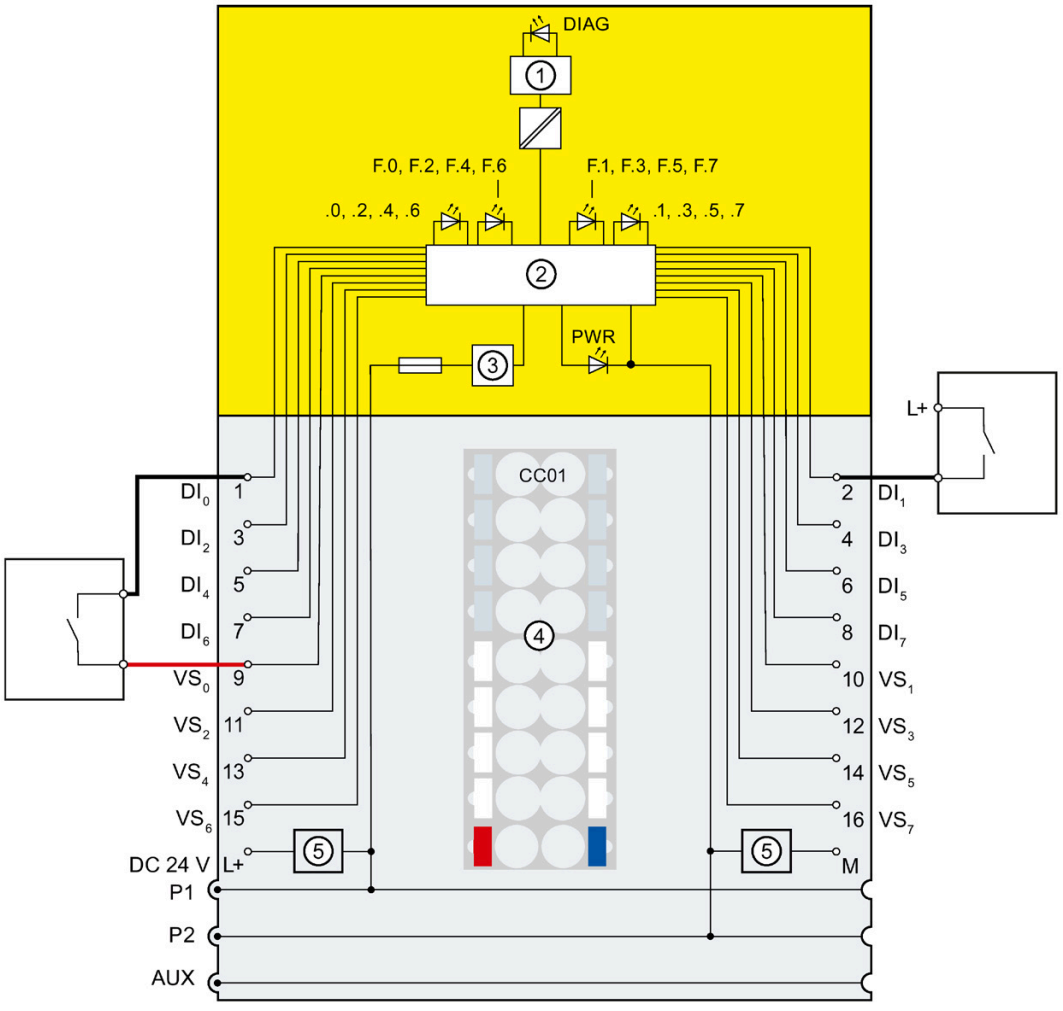


Figure 5-2 One sensor connected via one channel, internal and external sensor supply

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 5- 2 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 5- 3 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	—	—	—

Fault	Fault detection		
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.

5.1.2 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.

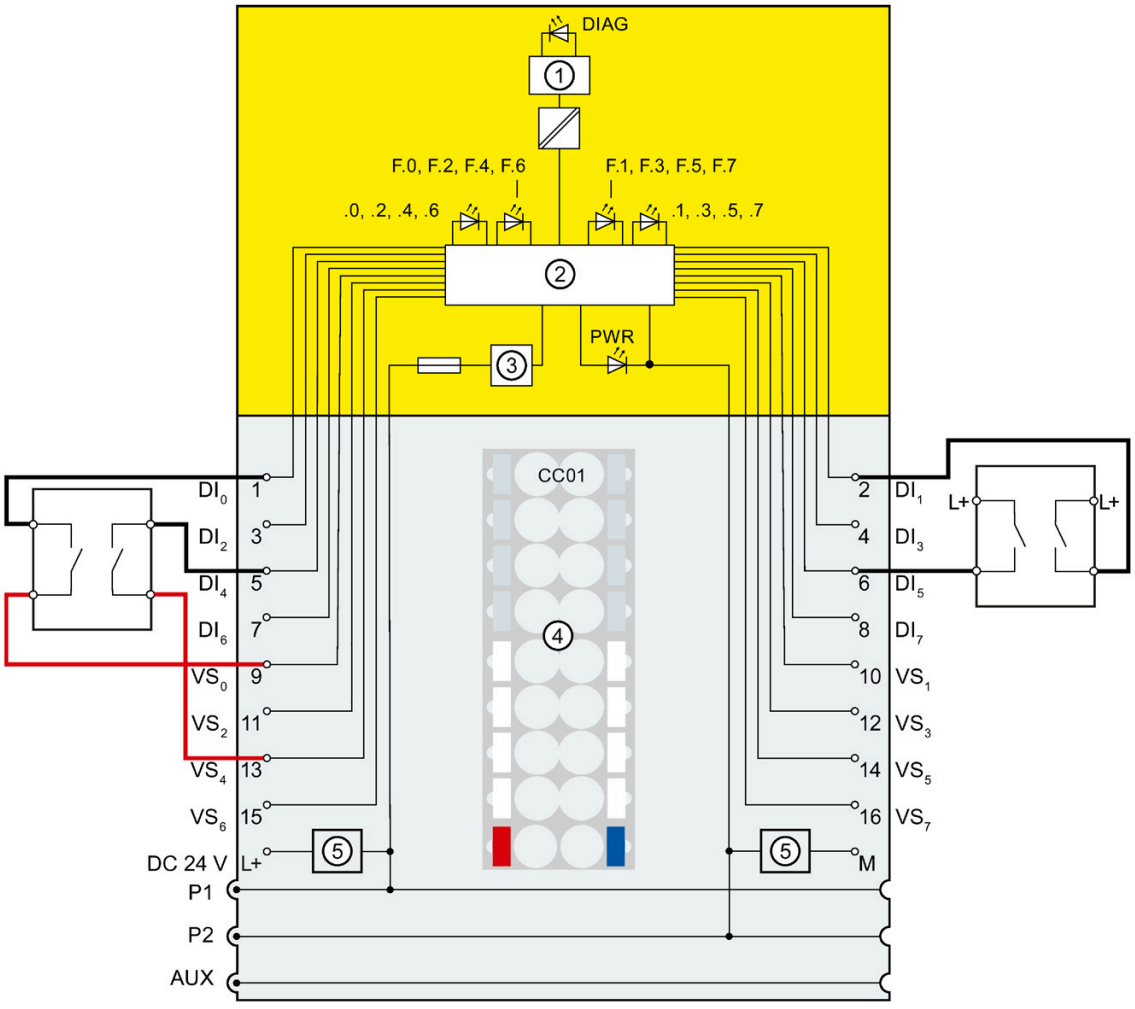


Figure 5-3 A two-channel sensor connected via two channels, internal and external sensor supply

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.

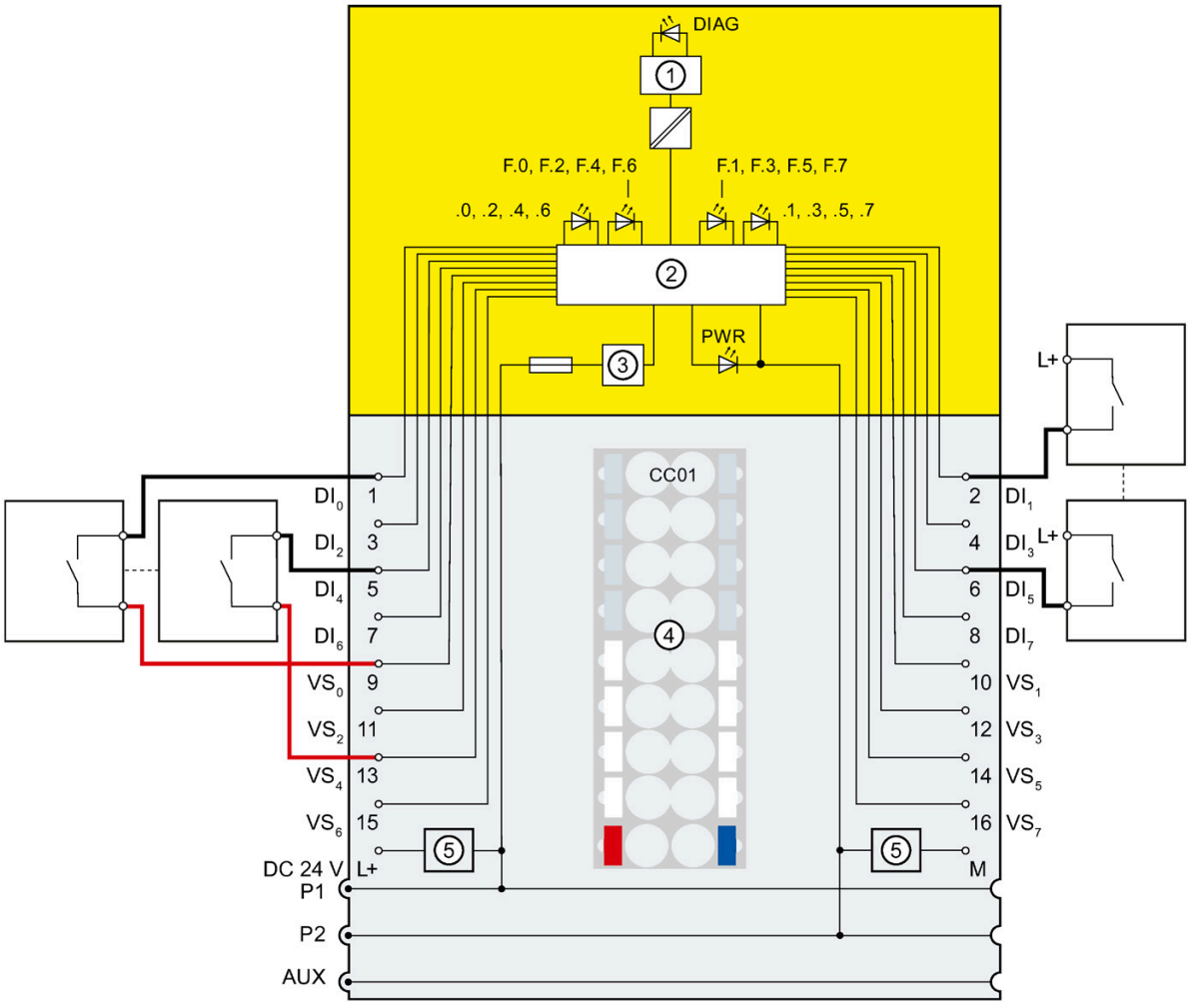


Figure 5-4 Two one-channel sensors connected via two channels, internal and external sensor supply

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 5- 4 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 5- 5 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.

5.1.3 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.

5.1.3.1 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.

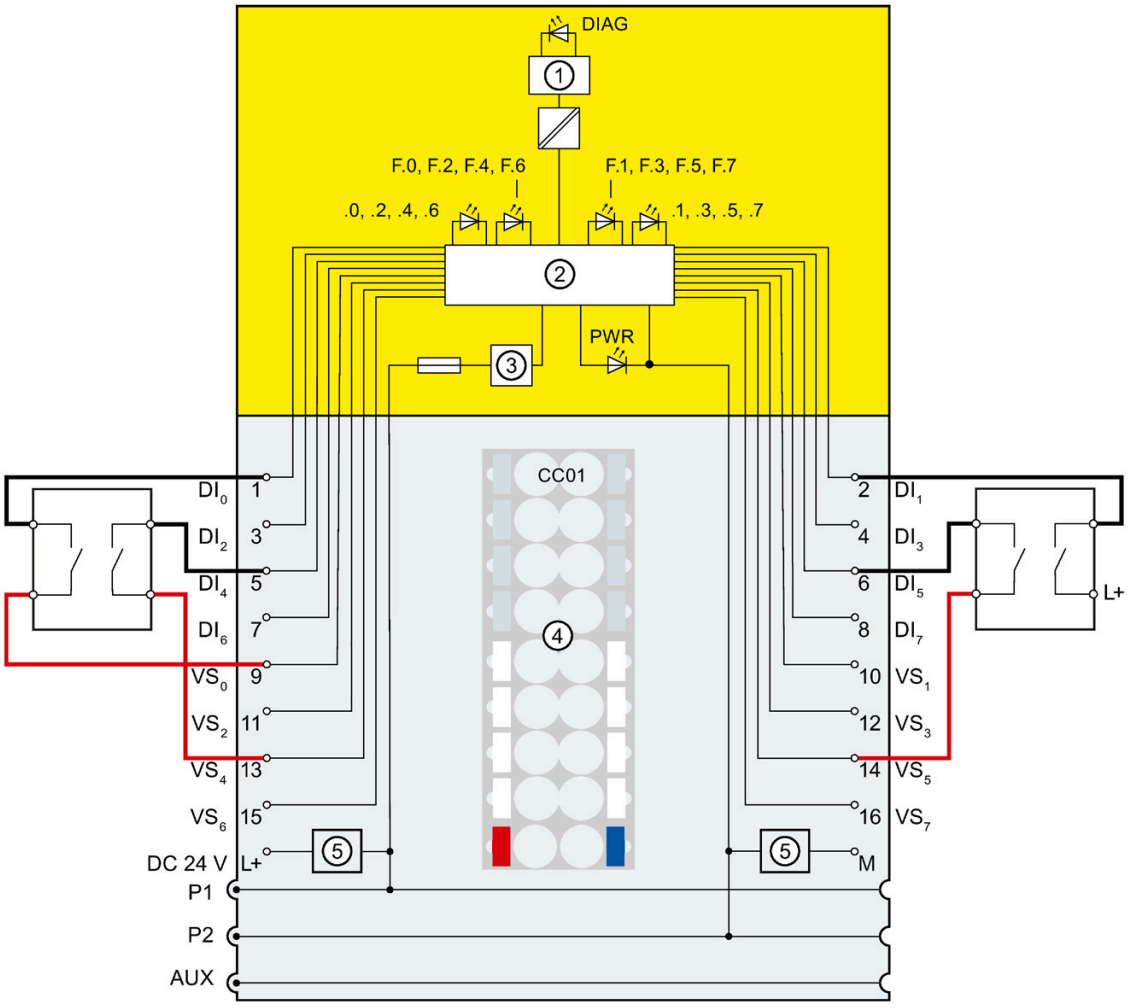


Figure 5-5 A two-channel sensor connected via two channels, internal sensor supply and a two-channel sensor connected via two channels, internal and external sensor supply

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.

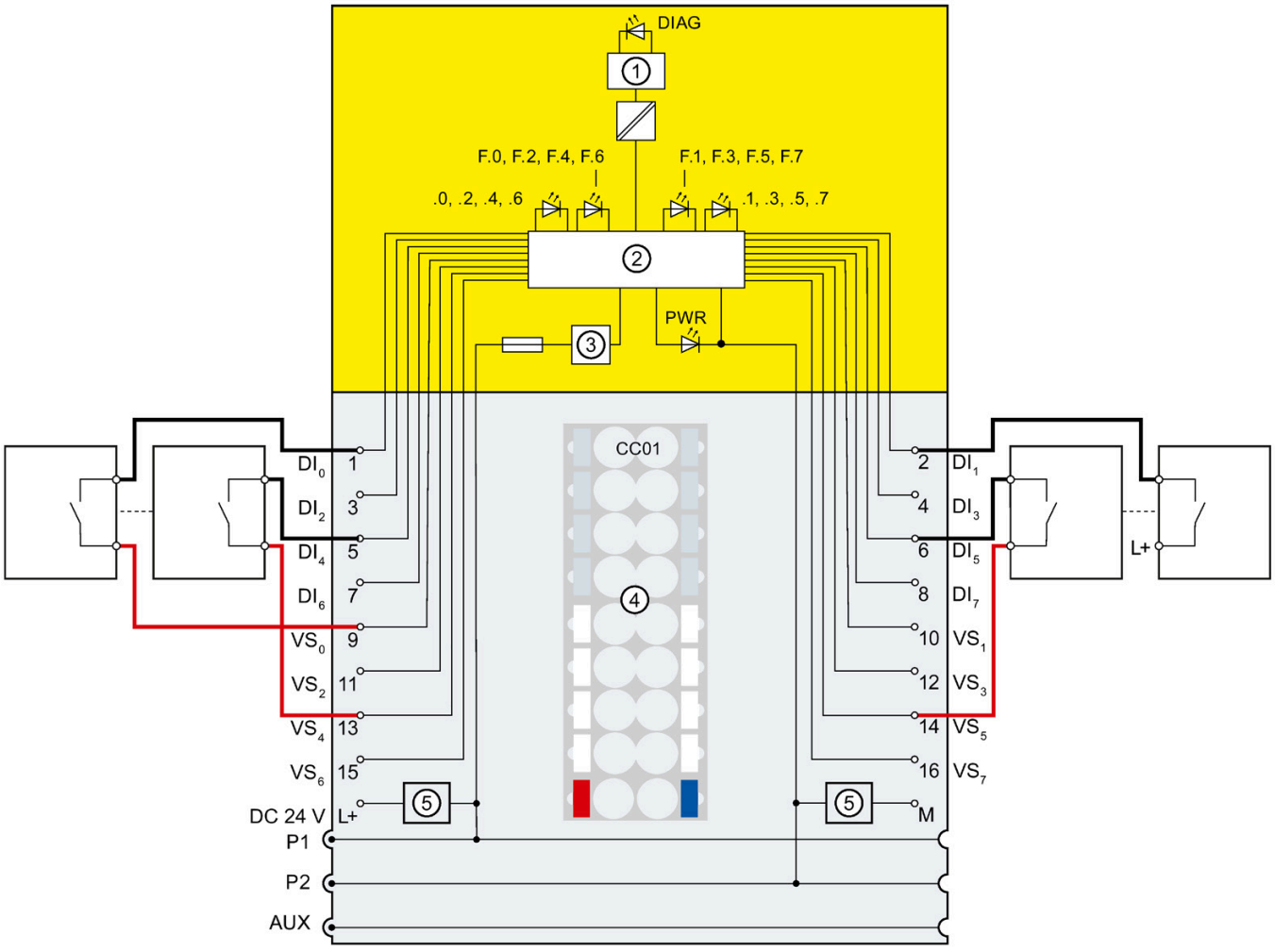


Figure 5-6 Two one-channel sensors connected via two channels, internal sensor supply and two one-channel sensors connected via two channels, internal and external sensor supply.

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 5- 6 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 5- 7 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.

5.1.3.2 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.

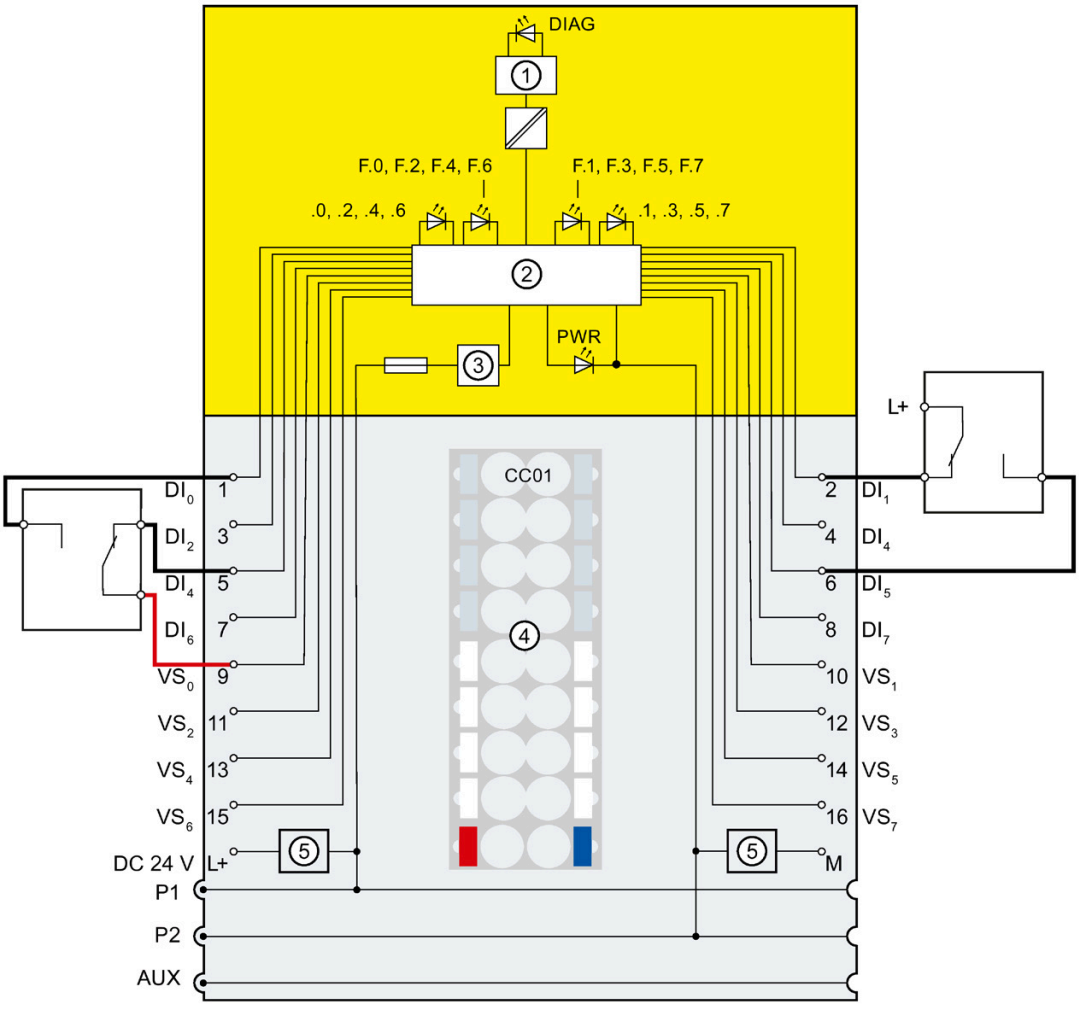


Figure 5-7 One non-equivalent sensor connected, internal sensor supply and one non-equivalent sensor connected, external sensor supply

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.

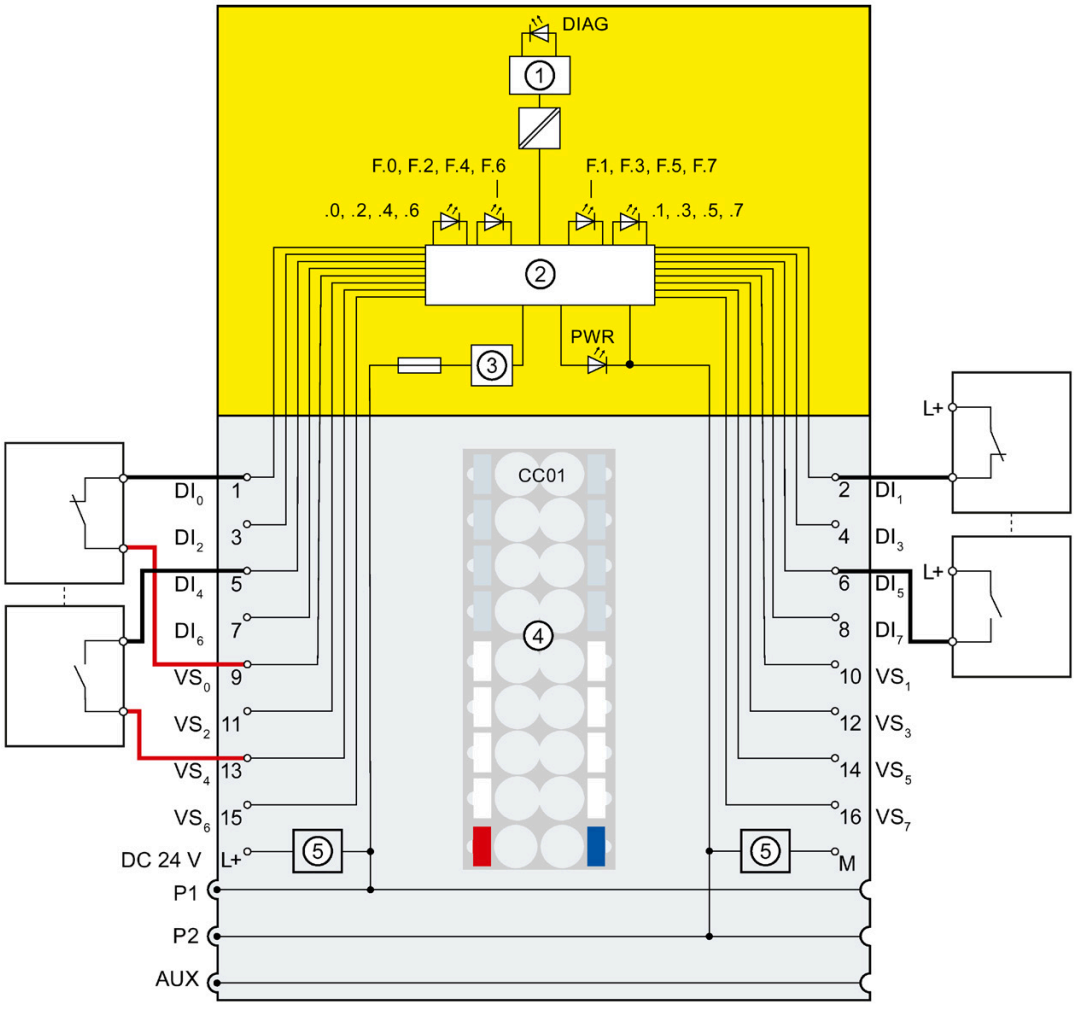


Figure 5-8 Two one-channel sensors connected via two channels non-equivalent, internal sensor supply and two one-channel sensors connected via two channels non-equivalent, external sensor supply.

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 5- 8 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 5- 9 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.

5.2 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.

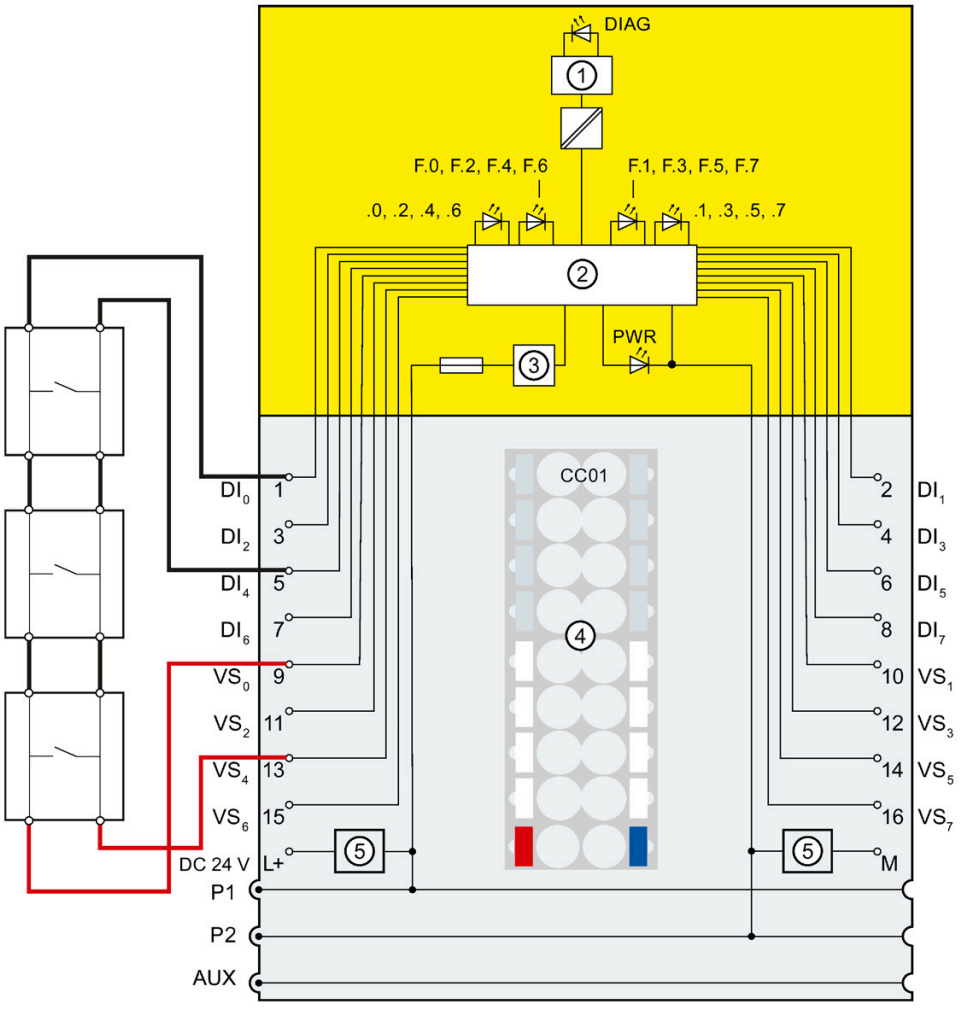


Figure 5-9 Safety mats connected via two channels to two internal sensor supplies

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 37).

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 5- 10 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)
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 5- 11 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.

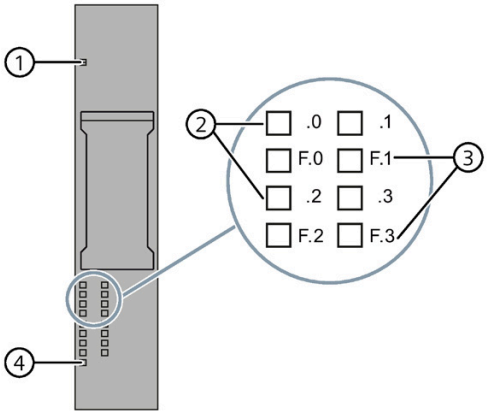
Interrupts/diagnostic messages

6

6.1 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 6-1 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 61).

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 6- 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 6- 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 6- 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 59)
Flashing	Flashing	Off	Identification of the F-module when assigning the PROFIsafe address

PWR LED

Table 6- 4 Status display of the PWR LED

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

6.2 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 61).

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 61) to eliminate the error.

Module-wide diagnostic interrupts:

- Overtemperature
- Wire break
- 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
- Undertemperature
- Supply voltage too high
- Supply voltage too low
- F-module error (0x032F)

Channel-wide diagnostic interrupts

- 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
- F-address memory not accessible
- No valid F-address available
- Sensor signal flutters
- Frequency too high
- Discrepancy failure
- Input shorted to P

6.3 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 6- 5 Diagnostic messages of the F-DI 8x24VDC HF

Diagnostic message	Fault code	Meaning	Remedy
Overtemperature	5H	An excessively high temperature was measured in the F-module.	Operate the F-module within the specified temperature range. (See Technical specifications (Page 68)) Once the fault has been eliminated, the F-module must be removed and inserted or the power switched OFF and ON
Wire break	6H	Possible causes: • There is an interrupted cable between the module and sensor. • The channel is not connected (open).	Establish a cable connection.
Parameter error	10H	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	11H	Missing or insufficient supply voltage L+	• Check supply voltage L+ at the BaseUnit • Check BaseUnit type

Diagnostic message	Fault code	Meaning	Remedy
Communication fault	13H	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)	40H	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)	41H	The PROFIsafe driver has detected an invalid F-destination address.	Check the parameter assignment of the PROFIsafe driver.
Safety source address not valid (F_Source_Add)	42H	The PROFIsafe driver has detected an invalid F-source address.	
Safety watchdog time value is 0 ms (F_WD_Time)	43H	The PROFIsafe driver has detected an invalid watchdog time.	
Parameter F_SIL exceeds SIL from specific device application	44H	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	45H	The PROFIsafe driver has detected a discrepancy in the CRC length.	
Version of F parameter set incorrect	46H	The PROFIsafe driver has detected an incorrect version of the F-parameters or an invalid F_Block_ID.	
CRC1 fault	47H	The PROFIsafe driver has detected inconsistent F-parameters.	
Device-specific diagnostics information, see manual	48H	The PROFIsafe driver has received inconsistent fail-safe parameters.	
Inconsistent iParameter (iParCRC error)	4BH	The PROFIsafe driver has detected inconsistent iParameters.	Check the parameter assignment of the PROFIsafe driver.
F_Block_ID not supported	4CH	The PROFIsafe driver has detected an incorrect Block ID.	Check the parameter assignment of the PROFIsafe driver.
Transmission error: Inconsistent data (CRC error)	4DH	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)	4EH	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.

Diagnostic message	Fault code	Meaning	Remedy
Acknowledge required to enable channel(s) - as channel error(s) are remedied.	4FH	A channel fault was detected. A confirmation is required to enable the channel.	Confirm the channel fault.
Watchdog tripped	103H	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.
Invalid/inconsistent firmware present	11BH	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	13EH	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	300H	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	301H		
Discrepancy failure, channel status 1/0	302H		
Discrepancy failure, channel status 1/1	303H		

Diagnostic message	Fault code	Meaning	Remedy
Input signal not recorded unique	305H	An error has 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	306H	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.
Overload or internal sensor supply short-circuit to ground	307H	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	30DH	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	30EH	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.

Diagnostic message	Fault code	Meaning	Remedy
Sensor signal flutters	310H	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	311H	The switching frequency of the sensor is too high.	Reduce the switching frequency of the sensor.
Undertemperature	312H	The minimum permissible temperature limit has been violated.	Operate the F-module within the specified temperature range. (See Technical specifications (Page 68))
Discrepancy error	314H	The discrepancy time set for 1oo2 evaluation was exceeded. The error message is output for channel n+4. Additional information: see error codes 300H ... 303H.	Additional information: see error codes 300H ... 303H.
Input shorted to P	31CH	The input signal is short-circuited to L+.	Eliminate the short-circuit.
Supply voltage too high	321H	The supply voltage is too high.	Check the supply voltage.
Supply voltage too low	322H	Possible causes: • The supply voltage is too low. • Wrong BaseUnit	• Check the supply voltage. • Use a BaseUnit of the type A0.
F-module error (0x032F)	32FH	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.

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 68): 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. The corresponding tables for error detection can therefore be found in the applications under Applications of the F-I/O module (Page 37).

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)

6.4 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 section Address space (Page 35).

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

7

Technical specifications of F-DI 8×24VDC HF

The following table shows the technical specifications as of 10/2021. 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	
• 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	up to and incl. V17 as 6ES7136-6BA00-0CA0
• PROFINET from GSD version/GSD revision	GSDML V2.35
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
Input current	
Current consumption, max.	40 mA; without load
Encoder supply	
Number of outputs	8
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

Article number	6ES7136-6BA01-0CA0
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
Source/sink input	Yes; P-reading
Input characteristic curve in accordance with IEC 61131, type 1	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
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

Article number	6ES7136-6BA01-0CA0
• 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
• horizontal installation, max.	60 °C
• vertical installation, min.	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)

In case of a 1oo2 evaluation, the discrepancy time in the SIMATIC STEP7 response time table must be set to 0.

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

The following section provides two examples for the calculation of the maximum response time to external short-circuits at an 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
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.