SIEMENS

SIMATIC

S7-1500 / ET 200MP

Digital input module F-DI 16x24VDC (6ES7526-1BH00-0AB0)

Manual

Translation of original operating instructions

Edition | 01/2016

Answers for industry.

SIEMENS

SIMATIC

ET 200MP
Digital input module
F-DI 16x24VDC
(6ES7526-1BH00-0AB0)

Manual

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 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:

> ⚠️ **WARNING**
>
> 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.

Trademarks

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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.

Preface

Purpose of the documentation

This manual supplements the system manual S7-1500 Automation System. You can find information on the functions that apply generally to the S7-1500 automation system and the ET 200MP distributed I/O system in the system manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792).

The information provided in this manual and the system manual enables you to commission the S7-1500 automation system and ET 200MP distributed I/O system.

Conventions

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)".

Please also observe the notes identified as follows:

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 particular attention should be paid.

Important note for maintaining the operational safety of your system

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Note

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 by means 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 in 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)
- 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)

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

Open Source Software

Open-source software is used in the firmware of the product described. Open Source Software is provided free of charge. We are liable for the product described, including the open-source software contained in it, pursuant to the conditions applicable to the product. Siemens accepts no liability for the use of the open source software over and above the intended program sequence, or for any faults caused by modifications to the software.

For legal reasons, we are obliged to publish the original text of the license conditions and copyright notices. Please read the information relating to this in the appendix.

Table of contents

Documentation guide 1

1.1 Guide to documentation S7-1500 / ET 200MP

The documentation for the SIMATIC S7-1500 automation system and the SIMATIC ET 200MP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

General information

Function manuals on general topics

- Diagnostics
- Communication
- Motion Control
- Web server
- Cycle and reaction times
- PROFINET
- PROFIBUS
- ...

Device information

Manuals with detailed information about the modules

- CPUs
- Interface modules
- Digital modules
- Analog modules
- Communication modules
- Technology modules
- Power supply modules

Basic information

Information about the system

- Getting Started S7-1500
- S7-1500/ET 200MP System Manual
- TIA Portal online help

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500 and ET 200MP systems. 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 S7-1500 and ET 200MP systems, e.g. diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (http://www.automation.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-controllers/Pages/Default.aspx).

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

You can download the product information free of charge from the Internet.

Manual Collection S7-1500/ET 200MP

The Manual Collection contains the complete documentation on the SIMATIC S7-1500 automation system and the ET 200MP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/86140384).

"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.

"mySupport" - Documentation

In the Documentation area in "mySupport" you can combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

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

"mySupport" - CAx data

In the CAx data area in "mySupport", you can access the current 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 (http://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/sc/ww/en/sc/2054).

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 (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

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2

</div>

2.1   Properties

Order number

6ES7526-1BH00-0AB0

View of the module
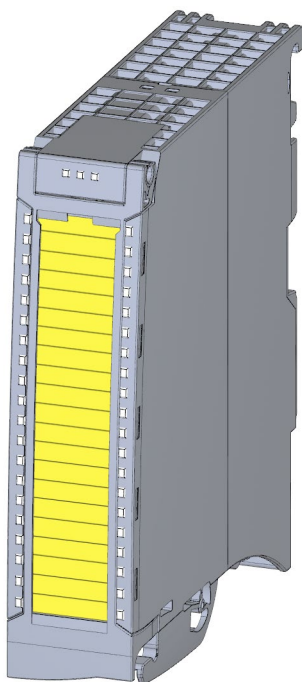
Image 2-1   View of the F-DI 16x24VDC module

Properties

- Technical properties
  - Fail-safe digital module for use in the S7-1500 automation system and in the ET 200MP distributed I/O system.
  - PROFIsafe
  - PROFIsafe address type 2
  - Supports the RIOforFA-Safety profile (on S7-1500 F-CPUs)
  - 16 inputs (SIL3/Category 3/PLd) or 8 inputs (SIL3/Category 4/PLe)
  - 4 outputs for sensor supply
  - Use of various interconnection types are possible (1oo1 & 1oo2)
  - Supply voltage L+
  - Sink input (P-reading)
  - Suitable for connection of 3/4-wire sensors according to IEC 61131:2007, type 1
  - Channel-specific assignable input delay 0.4 ms to 20 ms
  - Internal short-circuit-proof sensor supplies for each channel group
  - External sensor supply possible
  - Status display RUN (green LED)
  - Status display module diagnostics (red LED)
  - Status display channel status/channel diagnostics per input (green/red LED)
  - Status display supply voltage (green LED)
  - Diagnostics, e.g., short-circuit, channel-specific
  - Diagnostics, e.g., load voltage missing, module-specific
  - Channel-specific or module-wide passivation
- Supported functions
  - Firmware update
  - I&M identification data

⚠ **WARNING**

The fail-safe performance characteristics in the technical specifications apply for a mission time of 20 years and a repair time of 100 hours. If a repair within 100 hours is not possible, switch off the supply voltage of the affected module before 100 hours expires.

Follow the repair procedure described in section Diagnostic alarms (Page 51).

Accessories

The following accessories are supplied with the module and can also be ordered as spare part:

- Labeling strips
- U-connector
- Universal front cover
- Electronic coding element

Additional components

The following component is to be ordered separately:

- Front connector incl. potential bridges and cable ties

You can find additional information on accessories in the S7-1500/ET 200MP (http://support.automation.siemens.com/WW/view/en/59191792) system manual.

Connecting 3

3.1 Block diagram

This section includes the block diagram with the general pin assignment of the F-module.

For information on parameter assignment of the F-module, refer to "Parameters/address space (Page 17)".

Information on different connection options is available in the section Applications of the F-I/O module (Page 32).

You can find information on wiring the front connectors and creating the cable shielding, etc., in the Wiring section of the system manual Automation System S7-1500 (http://support.automation.siemens.com/WW/view/en/59191792).

Block diagram

The following figure shows the assignment of channels to addresses (input byte a and input byte b).
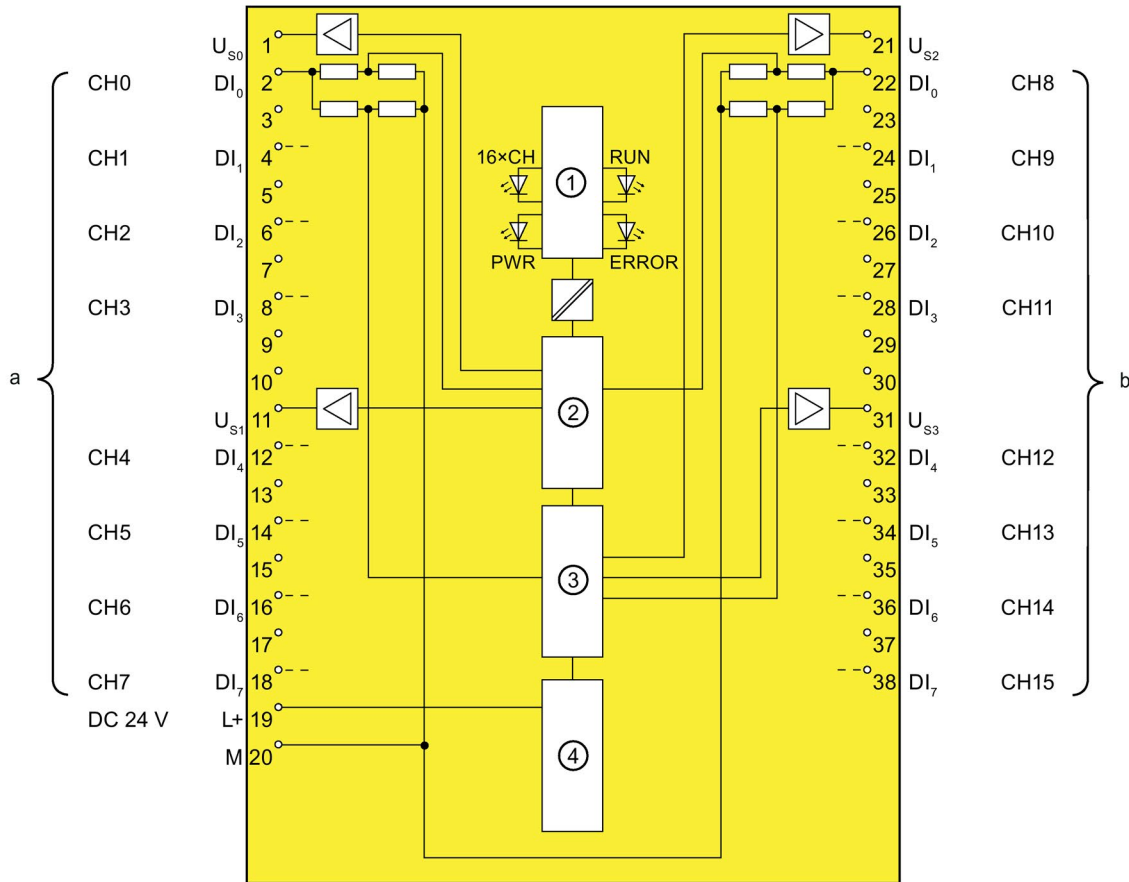
①	Backplane bus interface	L+	Supply voltage 24 V DC
②	Microcontroller 1	M	Chassis ground
③	Microcontroller 2	CH	Channel or LED channel status, channel diagnostics (green, red)
④	Reverse polarity protection	PWR	LED supply voltage (green)
U_{Sn}	Internal sensor supply n	RUN	RUN LED (green)
DI_n	Input bit n	ERROR	LED module diagnostics (red)

Image 3-1   Block diagram of the F-DI 16x24VDC

Parameters/address space

<div style="text-align: right; font-size: 2em;">4</div>

4.1 Parameters

Parameters

⚠ WARNING
Diagnostic functions must be activated or deactivated in accordance with the application, see section Applications of the F-I/O module (Page 32).

Table 4- 1   Parameters for F-DI 16x24VDC

Parameter	Value range	Parameter reas-signment in RUN	Scope
F-parameters:			
Manual assignment of F-monitoring time	• Disable • Enable	No	Module
F-monitoring time	1 to 65535 ms	No	Module
F-source address	1 to 65534	No	Module
F-destination address	1 to 65534	No	Module
F-parameter signature (without address)	0 to 65535	No	Module
Behavior after channel fault	• Passivate channel • Passivate the entire module	No	Module
Reintegration after channel fault	• Adjustable • All channels automatically • All channels manually	No	Module
F-I/O DB manual number assignment	• Disable • Enable	No	Module
F-I/O DB-number	—	No	Module
F-I/O DB name	—	No	Module
DI parameters:			
Sensor supply			

Parameter	Value range	Parameter reas-signment in RUN	Scope
Supplied channels	Sensor supply 0: • No channels • Channels [0..3] • Channels [0..7] • Channels [0..15] Sensor supply 1: • No channels • Channels [4..7] Sensor supply 2: • No channels • Channels [8..11] • Channels [8..15] Sensor supply 3: • No channels • Channels [12..15]	No	Channel group
Short-circuit test activated	• Disable • Enable	No	Channel
Time for short-circuit test	0.9 ms to 2 s	No	Channel
Startup time of sensors after short-circuit test	0.9 ms to 2 s	No	Channel
Channel parameters			
Channel n, n+8			
Sensor evaluation	• 1oo1 evaluation • 1oo2 evaluation, equivalent • 1oo2 evaluation, non-equivalent	No	Channel pair
Discrepancy behavior	• Supply value 0 • Supply last valid value	No	Channel pair
Discrepancy time	5 ms to 30 s	No	Channel pair
Reintegration after discrepancy error	• Test 0-signal not necessary • Test 0-signal necessary	No	Channel pair
Channel n			
Channel activated	• Enable • Disable	No	Channel

Parameter	Value range	Parameter reassignment in RUN	Scope
Input delay	0.4 ms 0.8 ms 1.6 ms 3.2 ms 6.4 ms 10.0 ms 12.8 ms 20.0 ms The provided value range depends on the parameter assignment of the employed sensor supply.	No	Channel
Channel failure acknowledge	- Manual - Automatic The value range offered depends on the F-CPU in use and on the configuration of the F-parameter "Reintegration after channel fault".	No	Channel
Pulse extension	— 0.5 s 1 s 2 s	No	Channel
Chatter monitoring	- Disable - Enable	No	Channel
Number of signal changes	2 to 31	No	Channel
Monitoring window	0 to 100 s (If 0 s is configured, the monitoring window is 0.5 s long.)	No	Channel

4.2 Explanation of parameters

4.2.1 F-parameters

You must assign the PROFIsafe address (F-destination address together with F-source address) to the F-module before you put it into operation.

● You define the F-source address using the "Basis for PROFIsafe addresses" parameter in the F-CPU.

● An F-destination address unique throughout the CPU is automatically assigned for each F-module. You can manually change the F-destination addresses set in the hardware configuration.

You can find information on F-parameters for the F-monitoring time, the PROFIsafe address assignment (F-source address, F-destination address) and the F I/O DB in the manual SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126).

4.2.1.1 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"

4.2.1.2 Reintegration after channel fault

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

Use in 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 in S7-1500 F-CPUs

When using the fail-safe module in S7-1500 F-CPUs, you set this parameter in the STEP 7 dialog of the fail-safe 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 Supplied channels

With this parameter, you specify whether and which internal sensor supply supplies which channel groups. The choice taken applies to the entire channel group (CH0-3, 4-7, 8-11, 12-15).

The following options are available, for example:

Parameter assignment: Left-hand module side		Meaning	Parameter assignment: Right-hand module side	
Sensor supply 0 supplies channels ...	Sensor supply 1 supplies channels …		Sensor supply 2 supplies channels …	Sensor supply 3 supplies channels …
0 to 3	4 to 7	Each channel group is supplied by its own internal sensor supply.	8 to 11	12 to 15
0 to 7	-	The channel groups of the left-hand module side are supplied by the internal sensor supply V_{S0}.	8 to 11	12 to 15
0 to 3	4 to 7	The channel groups of the right-hand module side are supplied by the internal sensor supply V_{S2}.	8 to 15	-
0 to 7	-	The channel groups of the left-hand module side are supplied by the internal sensor supply V_{S0}; the channel groups of the right-hand module side are supplied by the internal sensor supply V_{S2}.	8 to 15	-
0 to 15	-	All the channels of the module are supplied by the internal sensor supply V_{S0}.	-	-

You can also supply the sensors by means of an external sensor supply (parameter "None").

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

See also

Short-circuit test activated (Page 21)

Connecting (Page 15)

4.2.2.2 Short-circuit test activated

Here you enable the short-circuit detection for the channels of the F-module for which one of the internal sensor supplies is set ("Supplied channels").

The short-circuit test is always possible when you are using simple switches that do not have their own power supply. For switches with their own power supply, for example, 3/4-wire proximity switches or optical sensors with OSSD (Output Signal Switching Device) outputs, you must adapt the "Startup time of sensors after short-circuit test" parameter to match the sensor in use.

The short-circuit detection switches off the internal sensor supply briefly. The length of the deactivation period is equivalent to the configured "Time for sensor 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 of another channel when it 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 of the short-circuit test (Time for short-circuit test + Startup time of sensors after 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.

4.2.2.3   Time for short-circuit test

Function

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

Note the following during parameter assignment:

● If the channel is passivated, this may be due to excessively 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 is not discharged within the configured time, you need to adjust the "Time for short-circuit test" parameter.

Note

During the execution time of the short-circuit test (Time for short-circuit test + Startup time of sensors after 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.

● The "Time for short-circuit test" has to be 0.5 ms greater than the set input delay.

4.2.2.4　Startup time of sensors after short-circuit test

Function

In addition to the switch-off time ("Time for short-circuit test"), a startup time must be specified for performing the short-circuit test. You use this parameter to notify the module how long the utilized sensor needs to start up after turning on the internal sensor supply. This prevents an undefined input state due to transient reactions in the sensor.

Note the following during parameter assignment:

● This parameter must be greater than the transient recovery time of the employed sensor.

● Because the assigned time affects the response time of the module, we recommend that you set the time as short as possible but long enough so that your sensor can settle safely.

● The "Startup time of sensors after short-circuit test" must

– be set to a value greater than the set input delay

– be at least 1% of the "time for short-circuit test"

– be 0.5 ms greater than the set input delay.

Requirement

The short-circuit test is enabled.

4.2.3　Parameters of the channel pairs

4.2.3.1　Sensor evaluation

Overview

Select the type of sensor evaluation with the "Evaluation of the sensors" parameter:

● 1oo1 evaluation

● 1oo2 evaluation, equivalent

● 1oo2 evaluation, non-equivalent

1oo1 evaluation

With a 1oo1 evaluation, the sensor occupies only one input channel.

1oo2 evaluation, equivalent/non-equivalent

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

- a two-channel equivalent/non-equivalent sensor
- Two single-channel sensors

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. The evaluation result is provided in the bit of the lower-order channel of the channel pair (channel n).

Discrepancy analysis

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

Discrepancy analysis for equivalence or non-equivalence is used for fail-safe inputs to detect errors caused by the time characteristic of two signals with the same functionality. The discrepancy analysis is initiated when different levels are detected in two associated input signals (when testing for non-equivalence: the same level). A check is made to determine whether the difference in levels (when testing for non equivalence: the same level) has disappeared after an assignable time period, the so-called discrepancy time. If not, there is a discrepancy error.

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 fast 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-case scenario, the sensor-actuator response time is extended by an amount approximately equal to 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.

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 provide a 0-Signal 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 Channel activated

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

4.2.4.2   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 (in ms) are suppressed. Suppressed interference pulses are not visible in the process image input (PII).

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 sensors 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+8).

Note

If there is an input delay < 3.2 ms, you have to use shielded cables.

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 S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)).

If the interference pulses occur with a short-circuit test, the fail-safe digital inputs are passivated. Increase 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 internal sensor supply.

See also

Technical specifications (Page 57)

Response times (Page 60)

4.2.4.3   Channel failure acknowledge

Use in S7-1500 F-CPUs

This parameter is only relevant if the fail-safe module is operated on an S7-1500 F-CPU, and 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 should react to 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 in S7-300/400 F-CPUs

The value of this parameter is not relevant in the case of operation on S7-300/400 F-CPUs. There 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 (http://support.automation.siemens.com/WW/view/en/54110126) manual.

4.2.4.4   Pulse extension

Function

Pulse extension is a function to extend a digital input signal. A pulse on a digital input is extended to at least the assigned length. If the input pulse is already longer than the assigned length, the pulse is not changed.

The fail-safe electronic module only lengthens pulses with the value "0" because the basis of the safety concept is that there is a safe state for all process variables. For digital F-I/O, this is the value "0", which applies to sensors as well as to actuators.

The pulse extension can only be configured with 1oo1 evaluation.

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.

Parameter for number of signal changes = 8
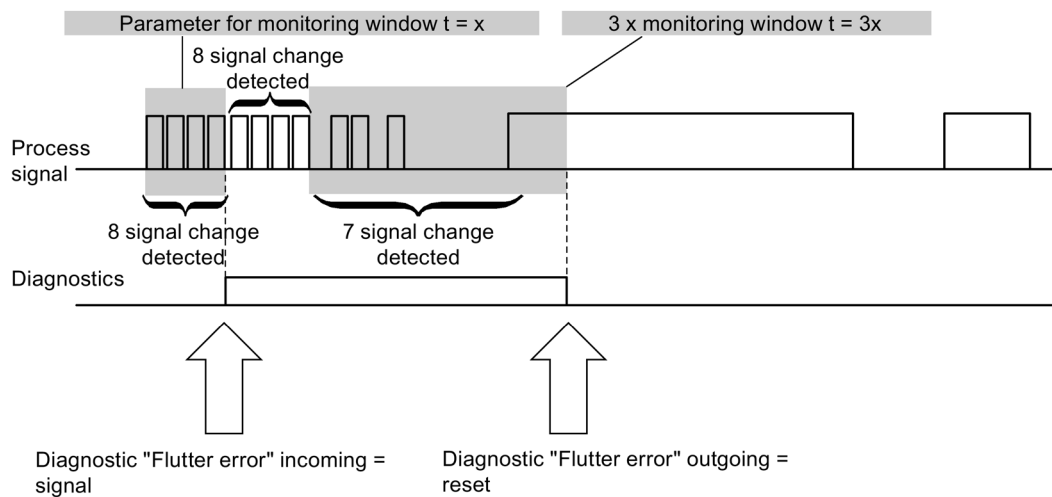
Image 4-1   Figure chatter monitoring

4.2.4.6   Number of signal changes

Sets the number of signal changes after which a chatter error should be reported (value range: 2 to 31).

4.2.4.7   Monitoring window

Sets the time for the monitoring window of flutter monitoring.

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

Enter 0 to configure a monitoring window of 0.5 s.

4.3 Address space

Address assignment of the digital input module F-DI 16x24VDC

The digital input module F-DI 16x24VDC 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
S7-300/400 F-CPUs	IB x + 0 to x + 7	QB x + 0 to x + 3
S7-1500 F-CPUs	IB x + 0 to x + 8	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 16x24VDC

The user data occupies the following addresses in the F-CPU out of all the assigned addresses of the digital input module F-DI 16x24VDC:

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 Channel group a	DI_7 (CH7)	DI_6 (CH6)	DI_5 (CH5)	DI_4 (CH4)	DI_3 (CH3)	DI_2 (CH2)	DI_1 (CH1)	DI_0 (CH0)
IB x + 1 Channel group b	DI_7 (CH15)	DI_6 (CH14)	DI_5 (CH13)	DI_4 (CH12)	DI_3 (CH11)	DI_2 (CH10)	DI_1 (CH9)	DI_0 (CH8)
IB x + 2 Channel group a	Value status for DI_7 (CH7)	Value status for DI_6 (CH6)	Value status for DI_5 (CH5)	Value status for DI_4 (CH4)	Value status for DI_3 (CH3)	Value status for DI_2 (CH2)	Value status for DI_1 (CH1)	Value status for DI_0 (CH0)
IB x + 3 Channel group b	Value status for DI_7 (CH15)	Value status for DI_6 (CH14)	Value status for DI_5 (CH13)	Value status for DI_4 (CH12)	Value status for DI_3 (CH11)	Value status for DI_2 (CH10)	Value status for DI_1 (CH9)	Value status for DI_0 (CH8)

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.

1oo2 evaluation of the sensors combines the two channels, e.g. CH0 (input bit DI_0 in channel group a) with CH8 (input bit DI_0 in channel group b). With 1oo2 evaluation of the sensors, you may only access the input bit from channel group a in the safety program, in this example CH0.

Additional information

For detailed information about F-I/O access and for evaluation and processing of the value status, refer to the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Applications of the F-I/O module

5

5.1 Applications of the F-DI 16x24VDC

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.
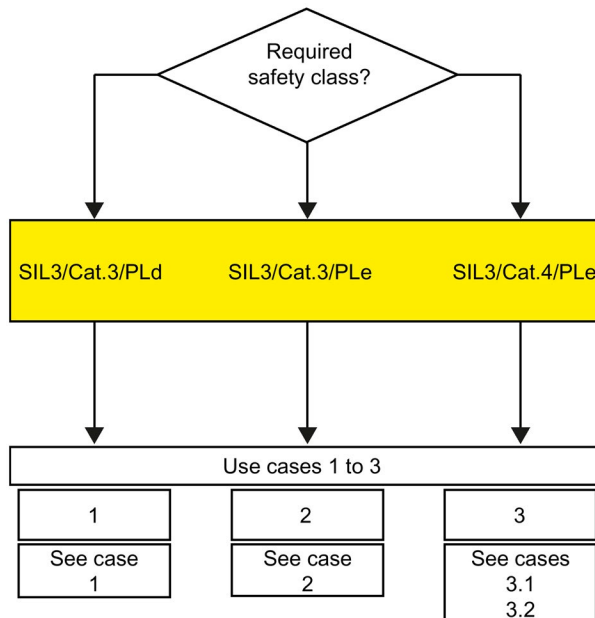
Image 5-1   Selecting the application – digital input module F-DI 16x24VDC

⚠ WARNING

The achievable safety class depends on the quality of the sensor and the duration of the mission time 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	Any	3 / 3 / d
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	External or internal, with short-circuit test	

Note

You can operate the various inputs of an F-DI module simultaneously in SIL3/Cat.3/PLd **and** in SIL3/Cat.3 or Cat.4/PLe. You only have to interconnect the inputs and assign parameters as described in the following sections.

Sensor requirements

Information on the safety-related use of sensors is available in the section Requirements for sensors and actuators for fail-safe modules of the system manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792).

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

Wiring

The wiring is carried out on the front connector of the module. Refer to the "Wiring" section in the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) system manual.

Sensor supply

The sensor supply can be powered internally or externally.

Wiring diagram – connecting one sensor via one channel

One sensor is connected via one channel (1oo1 evaluation) for each process signal.

The assignment of the input to an internal sensor supply of the module must take place according to the parameter assignment "Supplied channels" (see section Supplied channels (Page 21)).

You can also supply the sensor by means of an external sensor supply.

The figure below shows an example of the pin assignment of the fail-safe digital input module F-DI 16x24VDC with one-channel connection of a sensor.
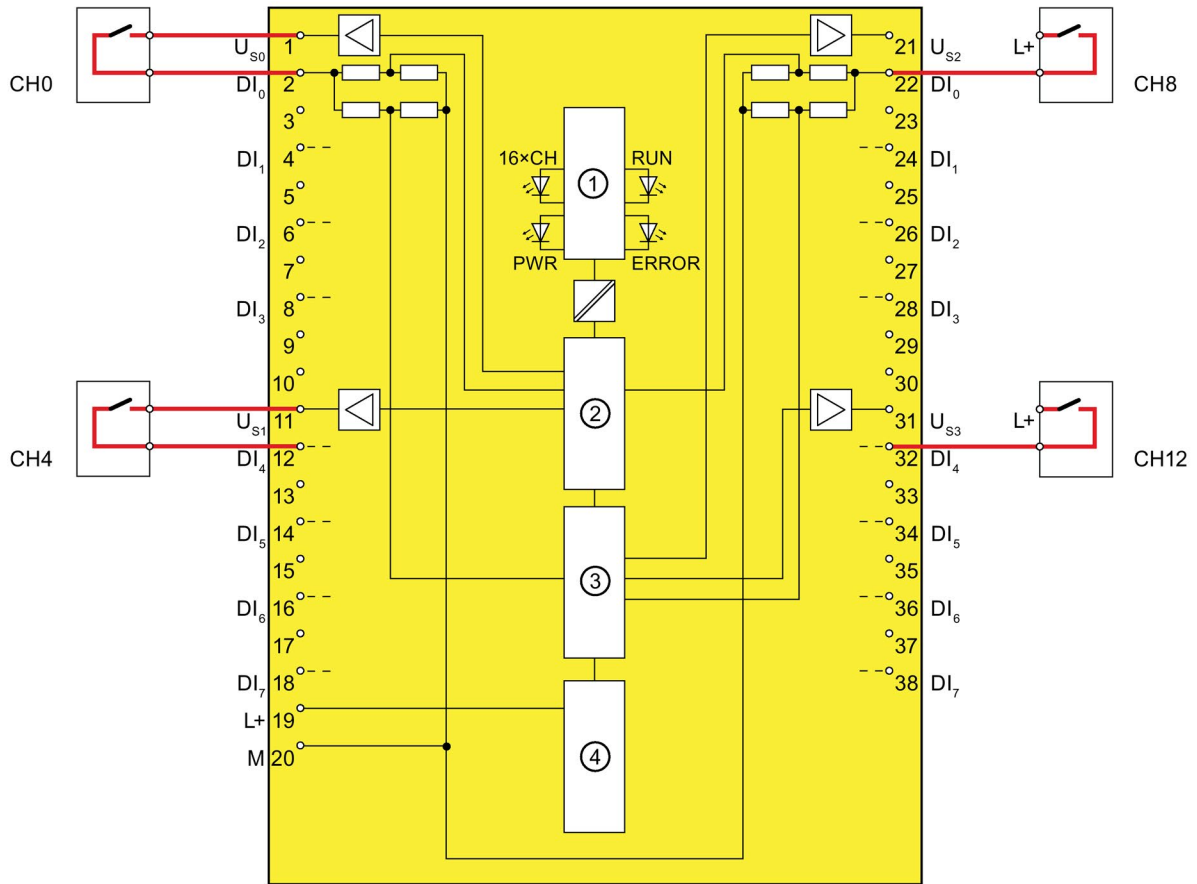
| ① | Backplane bus interface | ③ | Microcontroller 2 |
| ② | Microcontroller 1 | ④ | Reverse polarity protection |

Image 5-2   One sensor connected via one channel, internal sensor supply (left) or external sensor supply (right)

> ⚠ **WARNING**
>
> To achieve SIL3/Cat.3/PLd using this wiring, you must use a qualified 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	
Supplied channels	Channels [x...y]	None
Short-circuit test activated	• Disable • Enable*	Disable

*) optional. The selection of an internal sensor supply, however, is required for using the 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- 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 between the input and associated sensor supply	No	No	No
Short-circuit with L+ to DI_n	Yes	No	No
Short-circuit with M to DI_n	No	No	No
Discrepancy error	—	—	—
Short-circuit with L+ to U_{Sn}	Yes	No	—
Short-circuit with M to U_{Sn} 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.

> ⚠ **WARNING**
>
> If the short-circuit test is not activated or the sensor supply to digital inputs is set to "External sensor supply", the cable must be routed short-circuit proof.

See also

Connecting (Page 15)

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

Assigning inputs to each other

The digital input module F-DI 16x24VDC has 16 fail-safe inputs, DI_0 to DI_{15} (SIL3). You can combine two of these inputs each to one input.

You can combine the following inputs:

- DI_0 and DI_8

- DI_1 and DI_9

- DI_2 and DI_{10}

- DI_3 and DI_{11}

- DI_4 and DI_{12}

- DI_5 and DI_{13}

- DI_6 and DI_{14}

- DI_7 and DI_{15}

The process signals are provided by channels DI_0, DI_1, DI_2, DI_3, DI_4, DI_5, DI_6 and DI_7.

Note

You can mix 1oo1 evaluation and 1oo2 evaluation in an F-DI module. You must interconnect and parameterize the inputs according to the fail-safe requirements (SIL3/Cat.3/PLd and SIL3/Cat.3 or Cat.4/PLe).

Wiring

The wiring is carried out on the front connector of the module. Refer to the "Wiring" section in the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) system manual.

Sensor supply

The sensor supply can be powered internally or externally.

Wiring diagram – connecting a two-channel sensor equivalent

A two-channel sensor is connected equivalent to two inputs of the F-module for each process signal (1oo2 evaluation).

You can also supply one or both sensor switches by means of an external sensor supply.

The figure below shows an example of the pin assignment of the fail-safe digital input module F-DI 16x24VDC with equivalent connection of a two-channel sensor.

①	Backplane bus interface	③	Microcontroller 2
②	Microcontroller 1	④	Reverse polarity protection
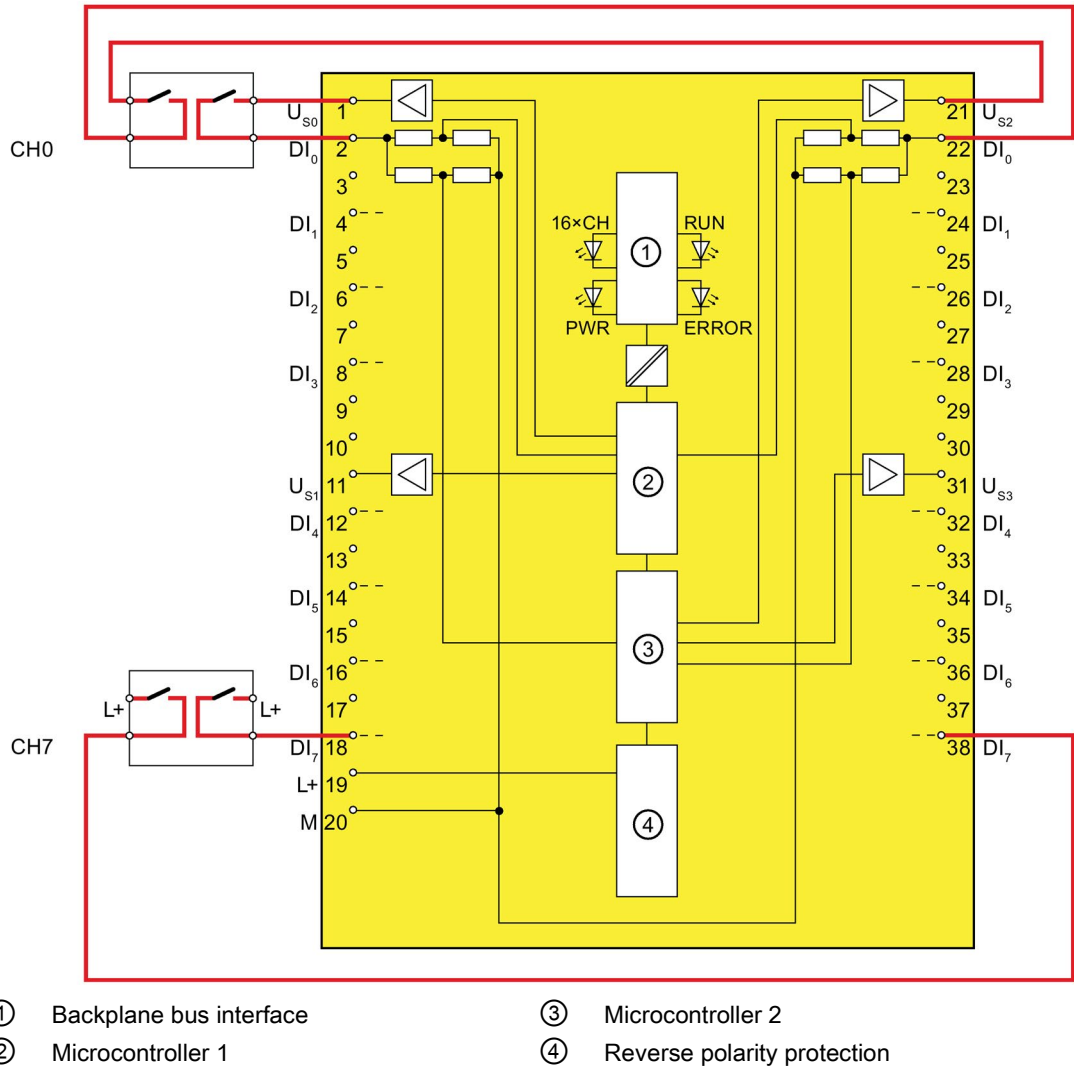
Image 5-3   One two-channel sensor connected equivalently, internal sensor supply (top) or external sensor supply (bottom)

Wiring diagram – connecting two single-channel sensors via two channels

Two single-channel sensors that capture the same process value are connected to two inputs of the F-module for each process signal (1oo2 evaluation).

You can also supply the sensors by means of an external sensor supply.

The figure below shows an example of the pin assignment of the fail-safe digital input module F-DI 16x24VDC with two-channel connection of two single-channel sensors.
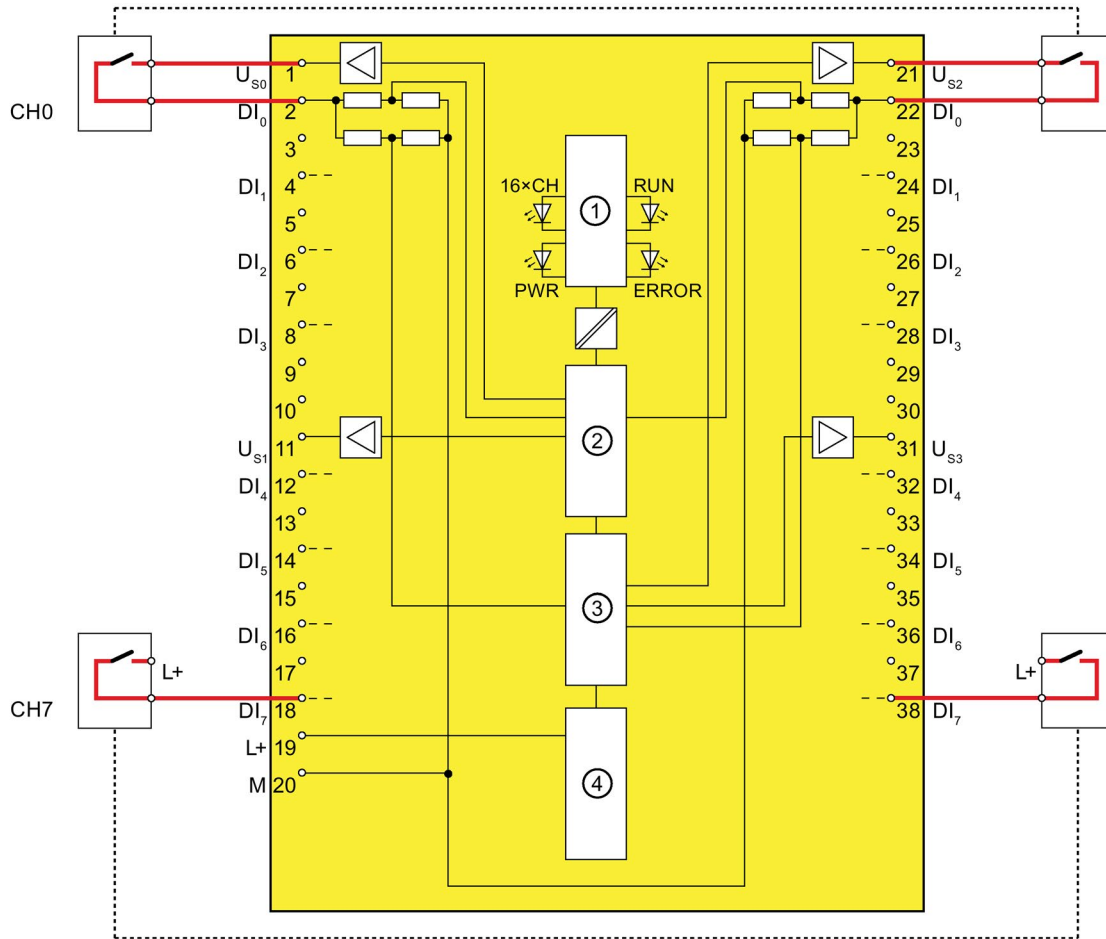
| ① | Backplane bus interface | ③ | Microcontroller 2 |
| ② | Microcontroller 1 | ④ | Reverse polarity protection |

Image 5-4 Two single-channel sensors connected via two channels, internal sensor supply (top) or external sensor supply (bottom)

⚠ WARNING

To achieve SIL3/Cat.3/PLe using this wiring, you must use a 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	
Supplied channels	Channels [x...y]	None
Short-circuit test activated	Disable	

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 U_{Sn}	No	No
Short-circuit with M to U_{Sn} 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.

See also

Connecting (Page 15)

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

Assigning inputs to each other

The digital input module F-DI 16x24VDC has 16 fail-safe inputs, DI_0 to DI_{15} (SIL3). You can combine two of these inputs each to one input.

You can combine the following inputs:

- DI_0 and DI_8
- DI_1 and DI_9
- DI_2 and DI_{10}
- DI_3 and DI_{11}
- DI_4 and DI_{12}
- DI_5 and DI_{13}
- DI_6 and DI_{14}
- DI_7 and DI_{15}

The process signals are provided by channels DI_0, DI_1, DI_2, DI_3, DI_4, DI_5, DI_6 and DI_7.

Wiring

The wiring is carried out on the front connector of the module. Refer to the "Wiring" section in the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) system manual.

Sensor supply

The sensor must be supplied internally by at least one channel group for application 3.1.

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

Requirements for applications in machine 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 with state-of-the-art engineering and standards to prevent short-circuits.

- The sensors must be wired as shown in sections Application 3.1 (SIL3/Cat.4/PLe) (Page 42) or Use case 3.2 (SIL3/Cat.4/PLe) (Page 44). You only need to detect **one** short-circuit because 2 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.

See also

Connecting (Page 15)

5.4.1 Application 3.1 (SIL3/Cat.4/PLe)

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

A two-channel sensor is connected to two inputs of the F-module for each process signal (1oo2 evaluation).

Supply the sensors from two different internal sensor supplies.

Alternatively, two single-channel sensors can be connected via two channels. In this case, the same process variable is acquired with two mechanically separate sensors.

The figure below shows an example of the pin assignment of the fail-safe digital input module F-DI 16x24VDC with two-channel connection of one two-channel sensor or two single-channel sensors.

| ① | Backplane bus interface | ③ | Microcontroller 2 |
| ② | Microcontroller 1 | ④ | Reverse polarity protection |
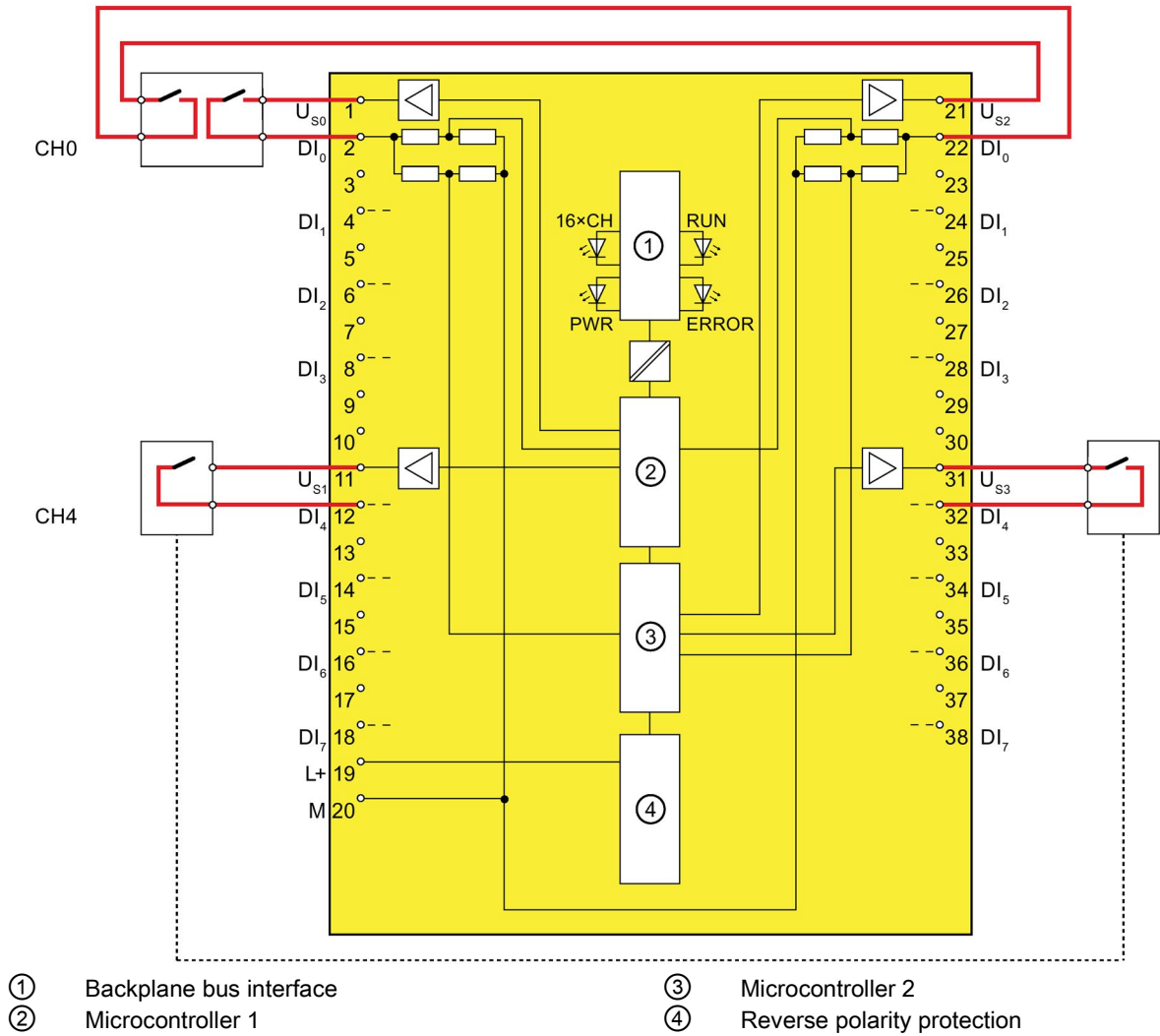
Image 5-5   One two-channel sensor connected via two channels (top) or two single-channel sensors connected via two channels (bottom); internal sensor supply

> ⚠ **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- 6   Parameter assignment

Parameter	Channel with internal sensor supply
Sensor evaluation	1oo2 evaluation, equivalent
Supplied channels	Channels [x...y]
Short-circuit test activated	Enable

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
Short-circuit within the channel pair	No
Short-circuit with other channels or other sensor supplies	Yes*
Short-circuit with L+ to DI_n	Yes* / Yes (for channel whose short-circuit test is activated)
Short-circuit with M to DI_n	Yes*
Discrepancy error	Yes
Short-circuit with L+ to U_{Sn}	Yes
Short-circuit with M to U_{Sn} 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.

5.4.2 Use case 3.2 (SIL3/Cat.4/PLe)

Wiring diagram – connecting a non-equivalent sensor

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

You can also supply the sensor by means of an external sensor supply.

The figure below shows an example of the pin assignment of the fail-safe digital input module F-DI 16x24VDC with connection of a non-equivalent sensor.
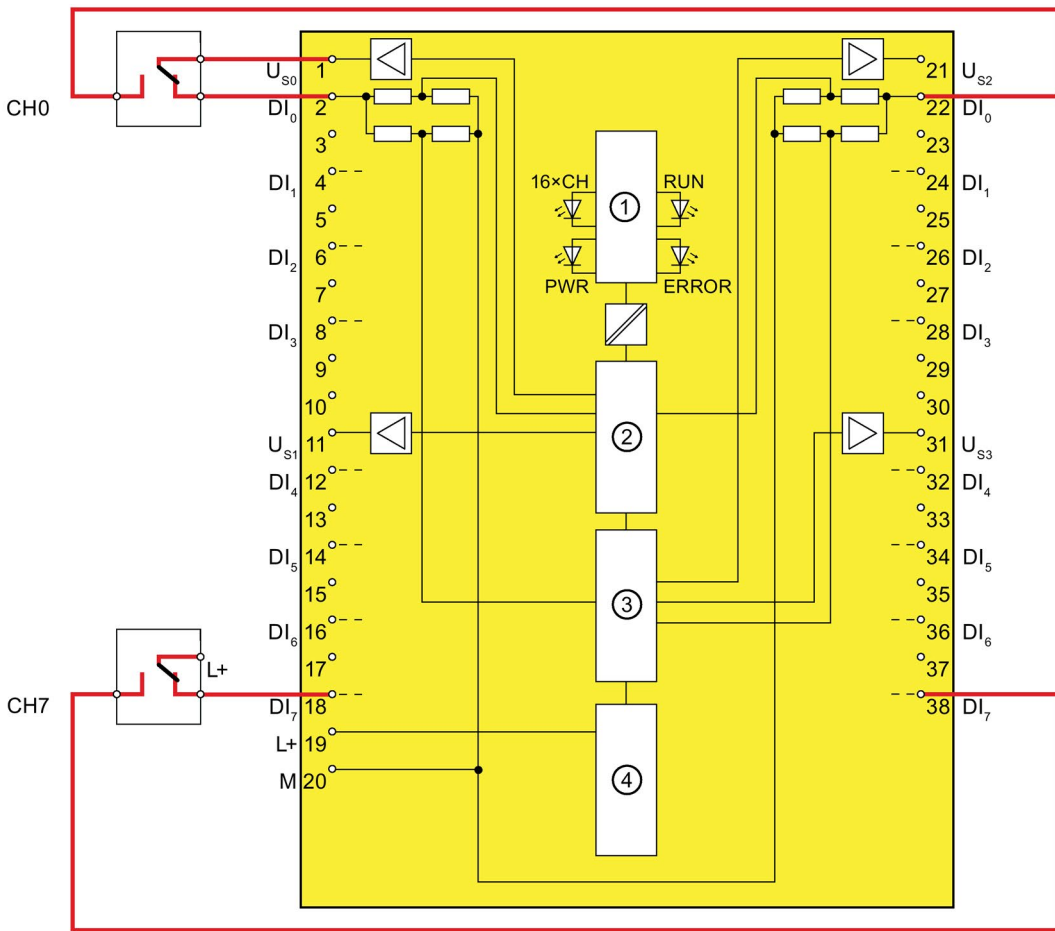
① Backplane bus interface   ③ Microcontroller 2
② Microcontroller 1   ④ Reverse polarity protection

Image 5-6   One non-equivalent sensor connected, internal sensor supply (top) or external sensor supply (bottom)

⚠ **WARNING**

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

Wiring diagram – connecting two single-channel sensors non-equivalent

Two single-channel sensors are connected non-equivalent to two inputs of the F-module for each process signal (1oo2 evaluation).

You can also supply one or both sensors by means of an external sensor supply.

The figure below shows an example of the pin assignment of the fail-safe digital input module F-DI 16x24VDC with non-equivalent connection of two single-channel sensors.
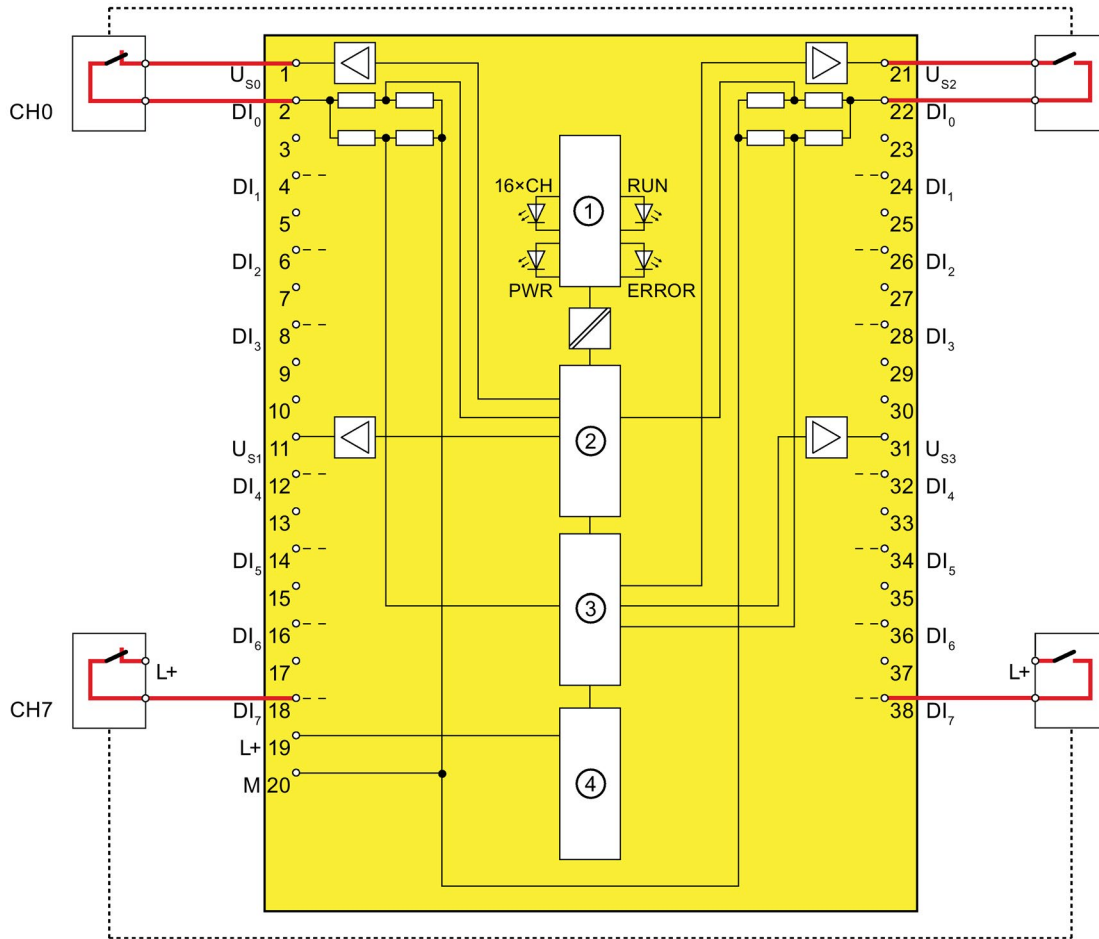
| ① | Backplane bus interface | ③ | Microcontroller 2 |
| ② | Microcontroller 1 | ④ | Reverse polarity protection |

Image 5-7   Two single-channel sensors connected non-equivalently, internal sensor supply (top) or external sensor supply (bottom)

> ⚠ **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	
Supplied channels	Channels [x...y]	None
Short-circuit test activated	• Disable • Enable*	Disable

*) optional. The selection of an internal sensor supply, however, is required for using the 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- 9   Fault detection

Fault	Fault detection
Short-circuit within the channel pair, with other channels or other sensor supplies	Yes
Short-circuit with L+ to DI_n	yes* / yes (for channel whose short-circuit test is activated)
Short-circuit with M to DI_n	Yes*
Discrepancy error	Yes
Short-circuit with L+ to U_{Sn}	Yes, if internal sensor supply is used and short-circuit test activated
Short-circuit with M to U_{Sn} or defective	Yes, if internal sensor supply is activated

*) 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.

Interrupts/diagnostic messages

6

6.1 Status and error displays

LED displays
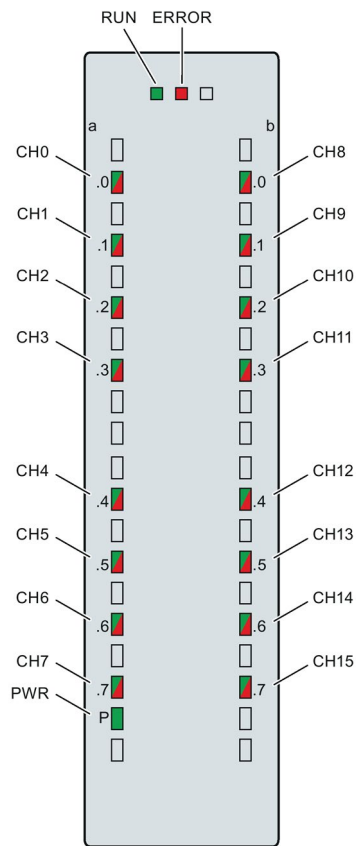
Image 6-1   LED displays of the F-DI 16x24VDC module

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedies for diagnostic alarms can be found in section Diagnostic alarms (Page 51).

> ⚠️ **WARNING**
>
> The RUN, ERROR LEDs and channel status/channel diagnostics LEDs of the inputs are not designed as safety-related LEDs and therefore may not be evaluated for safety-related activities.

RUN and ERROR LEDs

Table 6- 1 RUN and ERROR status and error displays

LED		Meaning	Remedy
RUN	ERROR		
□ Off	□ Off	Missing or insufficient voltage on the backplane bus	• Switch on the CPU and/or the system power supply modules. • Check whether the module is correctly plugged into the U-connector. • Check whether too many modules are plugged in.
☼ Flashing	□ Off	Module starts up and flashes up to the valid parameter assignment.	---
■ On	□ Off	Module parameters are assigned and module addressed.	
□ Off	☼ Flashing	Firmware is being updated.	
■ On	☼ Flashing	Indicates diagnostic interrupts: • Module fault (for example, supply voltage too high) • Channel fault (for example, frequency too high). • PROFIsafe communication error Operation in S7-1500 F-CPUs: At least one channel is waiting for user acknowledgment.	Evaluate the diagnostics and eliminate or acknowledge the error. It may be necessary to remove and re-insert the module.
☼ Flashing	☼ Flashing	Hardware defective.	Replace the module.
☼/☼ Alternately flashing		• Operation in S7-1500 F-CPUs: The F-module expects user acknowledgment after a module error. • Operation in S7-300/400 F-CPUs: At least one channel is waiting for user acknowledgment.	Acknowledge the error (see manual SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126)).

PWR LED

Table 6- 2 PWR status display

PWR LED	Meaning
□ Off	Supply voltage L+ missing
■ On	Supply voltage L+ available

CHx LED

Table 6- 3   Display channel status/channel diagnostics

Status CHx	Diagnostics CHx	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		Channel waiting for user acknowledgment

* Operation in S7-300/400 F-CPUs only: If necessary, wait for user acknowledgment, if an additional channel is also waiting for user acknowledgment due to an error that occurred later.

CHx/Error LED with PROFIsafe address assignment

Table 6- 4   Channel status/channel diagnostics/Error display with PROFIsafe address assignment

Status CHx	Diagnostics CHx	ERROR	Meaning
□ Off	■ All on	☼ Flashing	The PROFIsafe address does not match the configured PROFIsafe address
☼ All are flashing	□ Off	☼ Flashing	Identification of the F-module when assigning the PROFIsafe address

CHx/RUN/ERROR LED if supply voltage error occurs

Table 6- 5   Channel status/channel diagnostics/RUN/ERROR display if supply voltage error occurs

CHx status	Diagnostics CHx	RUN	ERROR	Meaning
□ Off	■ On	■ On	☼ Flashing	Supply voltage too high or too low. • Operation in S7-1500 F-CPUs: Module is waiting for user acknowledgment. • Operation in S7-300/400 F-CPUs: Module is automatically reintegrated after the correction of the error.

6.2 Interrupts

Introduction

The F-DI 16x24VDC fail-safe digital input module supports diagnostic interrupts.

Diagnostic interrupt

The F-module generates a diagnostic interrupt for each diagnostic alarm described in section Diagnostic alarms (Page 51).

The table below provides an overview of the diagnostic interrupts of the F-module . The diagnostic interrupts are assigned either to one channel or the entire F-module.

Table 6- 6   Diagnostic interrupts of the F-DI 16x24VDC

Diagnostic interrupt	Fault code	Signaled in application	Scope of diagnostic interrupt	Configurable
Overtemperature	5_D	1, 2, 3	F-module	No
Parameter error	16_D			
Supply voltage missing	17_D			
Mismatch of safety destination address (F_Dest_Add)	64_D			
Safety destination address not valid (F_Dest_Add)	65_D			
Safety source address not valid (F_Source_Add)	66_D			
Safety watchdog time value is 0 ms (F_WD_Time)	67_D			
Parameter F_SIL exceeds SIL from specific device application	68_D			
Parameter F_CRC_Length does not match the generated values	69_D			
Version of F-parameter set incorrectly	70_D			
CRC1 fault	71_D			
Save iParameter watchdog time exceeded	73_D			
Restore iParameter watchdog time exceeded	74_D			
Inconsistent iParameters (iParCRC error)	75_D			
F_Block_ID not supported	76_D			
Transmission error: Inconsistent data (CRC error)	77_D			
Transmission error: Timeout (watchdog time 1 or 2 expired)	78_D			
Module is defective	256_D			
Watchdog tripped	259_D			
Invalid/inconsistent firmware present	283_D			
Discrepancy failure, channel state 0/0	768_D	2, 3	Channel	
Discrepancy failure, channel state 0/1	769_D			
Discrepancy failure, channel state 1/0	770_D			
Discrepancy failure, channel state 1/1	771_D			
Input signal not recorded unique	773_D	1, 2, 3		

Diagnostic interrupt	Fault code	Signaled in application	Scope of diagnostic interrupt	Configurable
Internal sensor supply short-circuit to P	774$_D$			Yes
Overload or internal sensor supply short-circuit to ground	775$_D$			
Channel failure acknowledgment	779$_D$			
F-address memory not accessible	781$_D$		F-module	No
Sensor signal flutters	784$_D$	1	Channel	Yes
Frequency too high	785$_D$			No
Undertemperature	786$_D$		F-module	
Input shorted to P	796$_D$		Channel	Yes
Supply voltage too high	801$_D$		F-module	No
Supply voltage too low	802$_D$			

6.3   Diagnostic alarms

Diagnostic alarms

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 (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Table 6- 7   Diagnostic alarms of the F-DI 16x24VDC

Diagnostic alarm	Fault code	Meaning	Remedy
Overtemperature	5$_D$	An excessively high temperature was measured in the F-module.	Operate the F-module within the specified temperature range (see Technical specifications (Page 57)) Once the temperature has been reduced and returns to the specified range, the F-module must be re-moved and inserted or the power switched OFF and ON.
Parameter error	16$_D$	Parameter 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.

Diagnostic alarm	Fault code	Meaning	Remedy
Supply voltage missing	17$_D$	Missing or insufficient supply voltage L+	• Check supply voltage L+ at the front connector • Check the front connector
Mismatch of safety destination address (F_Dest_Add)	64$_D$	The firmware of the F-module has detected a different F-destination address.	• Check the parameter assignment of the PROFIsafe driver and the PROFIsafe address assigned to the F-module. • Assign the PROFIsafe address to the F-module (again).
Safety destination address not valid (F_Dest_Add)	65$_D$	The firmware of the F-module has detected an illegal different F-destination address.	
Safety source address not valid (F_Source_Add)	66$_D$	The firmware of the F-module has detected a different F-source address.	
Safety watchdog time value is 0 ms (F_WD_Time)	67$_D$	The firmware of the F-module has detected an invalid watchdog time.	
Parameter F_SIL exceeds SIL from specific device application	68$_D$	The firmware of the F-module has detected a discrepancy between the SIL setting of the communication and the application.	
Parameter F_CRC_Length does not match the generated values	69$_D$	The firmware of the F-module has detected a discrepancy in the CRC length.	
Version of F-parameter set incorrectly	70$_D$	The firmware of the F-module has detected an incorrect F_Par_Version or an invalid F_Block_ID.	
CRC1 fault	71$_D$	The firmware of the F-module has detected inconsistent F-parameters.	
Save iParameter watchdog time exceeded	73$_D$	iPar server does not respond to "save IPar" within 4.4 minutes.	Check the parameter assignment of the iPar server.
Restore iParameter watchdog time exceeded	74$_D$	iPar server does not respond to "restore IPar" within 4.4 minutes.	Check the parameter assignment of the iPar server.
Inconsistent iParameters (iParCRC error)	75$_D$	The firmware of the F-module has detected inconsistent iParameters.	Check the parameter assignment.
F_Block_ID not supported	76$_D$	The firmware of the F-module has detected an incorrect F_block_ID.	Check the parameter assignment of the PROFIsafe driver.
Transmission error: Inconsistent data (CRC error)	77$_D$	The firmware of the F-module has detected a CRC error. Possible causes: • The communication between the F-CPU and F-module is disturbed. • Impermissibly high electromagnetic interference is present. • An error occurred in the sign-of-life monitoring.	• Check the communication connection between the F-module and F-CPU. • Eliminate the electromagnetic interference.
Transmission error: Timeout (watchdog time 1 or 2 expired)	78$_D$	The firmware of the F-module has detected a timeout. Possible causes: • The F-monitoring time is set incorrectly. • A bus fault is present.	• Check the parameter assignment. • Ensure that communication is functioning correctly.

Diagnostic alarm	Fault code	Meaning	Remedy
Module is defective	256$_D$	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module has detected an internal error and has reacted in a safety-related manner.	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON. • If the F-module cannot be put back into operation, consider replacing it.
Watchdog tripped	259$_D$	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module has detected an internal error and has reacted in a safety-related manner.	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON. • If the F-module cannot be put back into operation, consider replacing it.
Invalid/inconsistent firmware present	283$_D$	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.
Discrepancy failure, channel state 0/0	768$_D$	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.
Discrepancy failure, channel state 0/1	769$_D$		
Discrepancy failure, channel state 1/0	770$_D$		
Discrepancy failure, channel state 1/1	771$_D$		

Diagnostic alarm	Fault code	Meaning	Remedy
Input signal not recorded unique	773$_D$	An error occurred during the plausibility check of the input signal between the processors. Possible causes: • The input signal is faulty, e.g., as a result of impermissibly high electromagnetic interference. • A high-frequency input signal is present, e.g., due to mutual interference of sensors or the signal being above the sampling frequency of the input signal. • A momentary interruption/short-circuit of the sensor cable (loose contact) is present. • The sensor/switch is bouncing.	• 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	774$_D$	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	775$_D$	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.
Channel failure acknowledgment	779$_D$	A channel fault was detected. Confirmation is required to enable the channel.	Confirm the channel fault.
F-address memory not accessible	781$_D$	The F-source address and F-destination address stored in the coding element cannot be accessed.	Verify that the coding element is present or replace the coding element.

Diagnostic alarm	Fault code	Meaning	Remedy
Sensor signal flutters	784D	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	785D	The switching frequency of the encoder is too high.	Reduce the switching frequency of the sensor.
Undertemperature	786D	The minimum permissible temperature limit has been violated.	Operate the F-module within the specified temperature range (see Technical specifications (Page 57))
Input shorted to P	796D	The input signal is short-circuited to L+.	Eliminate the short-circuit.
Supply voltage too high	801D	The supply voltage is too high.	Check the supply voltage.
Supply voltage too low	802D	The supply voltage is too low.	Check the supply voltage.

Supply voltage outside the nominal range

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

When the voltage is then recovered (level must remain within the specified value for at least 1 minute, see Technical specifications (Page 57)), the ERROR LED stops flashing. The module remains passivated and waits for user acknowledgment.

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.

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 of the F-I/O module (Page 32).

Generally applicable information on diagnostics

Information on diagnostics that pertains to all F-modules (for example, readout of diagnostics functions or passivation of channels) is available in the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Technical specifications 7

Technical specifications of F-DI 16x24VDC

	6ES7526-1BH00-0AB0
General information	
Product type designation	F-DI 16x24VDC
Firmware version	
• FW update possible	Yes
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1 with HSP0086
Operating mode	
DI	Yes
Supply voltage	
Rated value (DC)	24 V
Low limit of permitted range (DC)	19.2 V
High limit of permitted range (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	50 mA
Sensor supply	
Number of outputs	4
Short-circuit protection	Yes; electronic (response threshold 0.7 A to 1.8 A)
24 V sensor supply	
24 V	Yes; min. L+ (-1.5 V)
Short-circuit protection	Yes
Output current, max.	300 mA; max. 100 mA with vertical mounting position
Power	
Power consumption from the backplane bus	0.9 W
Power loss	
Power loss, typ.	4.6 W
Address range	
Address space per module	
Address space per module, max.	9 bytes

	6ES7526-1BH00-0AB0
Digital inputs	
Number of inputs	16
m/p-reading	Yes; p-reading
Input characteristic curve according to IEC 61131, Type 1	Yes
Input voltage	
Rated value (DC)	24 V
For "0" signal	-30 ... +5 V
For "1" signal	+15 ... +30 V
Input current	
For "1" signal, typ.	3.7 mA
Input delay (for rated value of input voltage)	
For standard inputs	
• Configurable	Yes
• For "0" to "1", min.	0.4 ms
• For "0" to "1", max.	20 ms
• For "1" to "0", min.	0.4 ms
• For "1" to "0", max.	20 ms
Cable length	
shielded, max.	1000 m
unshielded, max.	500 m
Interrupts/diagnostics/status information	
Interrupts	
Diagnostic interrupt	Yes
Hardware interrupt	No
Diagnostic alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	No
Short-circuit	Yes
Group error	Yes
Diagnostics display LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; red LED
Electrical isolation	
Electrical isolation, channels	
Between channels and backplane bus	Yes
Permitted potential difference	
Between different circuits	75 V DC/60 V AC (basic insulation)

	6ES7526-1BH00-0AB0
Insulation	
Insulation test voltage	707 VDC (type test)
Standards, approvals, certificates	
Maximum achievable safety class in safety mode	
Performance level according to EN ISO 13849-1:2008	PLe
SIL according to IEC 61508	SIL 3
Low demand mode: PFDavg according to SIL3	< 5.00E-05
High demand/continuous mode: PFH according to SIL3	< 1.00E-09 1/h
Environmental conditions	
Ambient temperature in operation	
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	40 °C
Dimensions	
Width	35 mm
Height	147 mm
Depth	129 mm
Weights	
Weight, approx.	280 g

Dimension drawing

See system manual S7-1500 Automation System
(http://support.automation.siemens.com/WW/view/en/59191792).

Response times A

Introduction

The next section shows the response times of the digital input module F-DI 16x24VDC. The response times of the digital input module F-DI 16x24VDC are included in the calculation of the F-system response time.

Definition of cycle time for fail-safe digital inputs

The cycle time indicates the time between the occurrence of an event and the transfer to the backplane bus.

Times required for the calculation

- Max. cycle time: T_{cycle} = 5 ms
- Max. acknowledgment time (Device Acknowledgment Time): T_{DAT} = 10 ms

The maximum response time in the case of fault (One Fault Delay Time, OFDT) is equivalent to the maximum response time with no faults (Worst Case Delay Time, WCDT).

Maximum response time with no faults (Worst Case Delay Time, WCDT) during 1oo1 evaluation

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

t <= 2 * cycle time + input delay

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

t <= 2 * cycle time + input delay + T1 + T2

T1	Time for short-circuit test
T2	Startup time of sensors after the short-circuit test

Maximum response time with no faults (Worst Case Delay Time, WCDT) during 1oo2 evaluation

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

t <= 2 * cycle time + input delay+ discrepancy time*

* Obsolete with discrepancy behavior "Supply value 0"

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

t <= 2 * cycle time + input delay+ max (T1p + T2p, T1s + T2s) + discrepancy time*

* Obsolete with discrepancy behavior "Supply value 0"

T1p	Test time for the sensor supply of sensor 1
T2p	Startup time of sensor after the short-circuit test (sensor 1)
T1s	Test time for the sensor supply of sensor 2
T2s	Startup time of sensor after the short-circuit test (sensor 2)

Maximum response time to external short-circuits

$t \leq \max (120\ ms, 2 * (n \times cycle\ time) + sum\ [x=0...3](T1x + T2x)) + cycle\ time$

T1x	Time for the sensor test
T2x	Startup time of sensors after the short-circuit test
n	Number of sensor supplies with activated short-circuit test
x	Sensor supply

Maximum response time to discrepancy errors during 1oo2 evaluation

$t \leq 2 * cycle\ time + input\ delay + discrepancy\ time + 2 * \max (T1p + T2p, T1s + T2s)$

n	Number of sensor supplies with activated short-circuit test
T1x	Time for the sensor test
T2x	Startup time of sensors after the short-circuit test
T1p	Test time for the sensor supply of sensor 1
T2p	Startup time of sensor after the short-circuit test (sensor 1)
T1s	Test time for the sensor supply of sensor 2
T2s	Startup time of sensor after the short-circuit test (sensor 2)
x	Sensor supply

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B

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(2011-08-01)

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