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Distributed I/O System Fail-Safe Engineering
ET 200S Distributed I/O System - Fail-Safe Modules

Installation and Operating Manual

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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

with a safety alert symbol, indicates that minor personal injury can result if proper precautions are not taken.

CAUTION

without a safety alert symbol, indicates that property damage can result if proper precautions are not taken.

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indicates that an unintended result or situation can occur if the corresponding information is not taken into account.

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The device/system may only be set up and used in conjunction with this documentation. Commissioning and operation of a device/system may only be performed by **qualified personnel**. Within the context of the safety notes in this documentation qualified persons are defined as persons who are authorized to commission, ground and label devices, systems and circuits in accordance with established safety practices and standards.

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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 adhered to. 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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℗ 12/2008

Preface

Purpose of this Manual

The information in this manual is a reference source for operations, function descriptions, and technical specifications of the fail-safe modules of the ET 200S distributed I/O system.

Basic Knowledge Requirements

This manual is a supplement to the *ET 200S Distributed I/O System* manual. Working with this manual requires general knowledge of automation engineering. You also require experience of using the *STEP 7* basic software and the ET 200S distributed I/O system.

Scope of this Manual

Module	Order Number	Release Number and Higher
Power module PM-E F pm DC24V PROFIsafe	6ES7138-4CF03-0AB0	01
Power module PM-E F pp DC24V PROFIsafe	6ES7138-4CF42-0AB0	01
Power module PM-D F DC24V PROFIsafe	3RK1903-3BA02	01
Digital electronic module 4/8 F-DI DC24V PROFIsafe	6ES7138-4FA04-0AB0	01
Digital electronic module 4 F-DI/3 F-DO DC24V PROFIsafe	6ES7138-4FC01-0AB0	01
Digital electronic module 4 F-DO DC24V/2A PROFIsafe	6ES7138-4FB03-0AB0	01
Digital electronic module 1 F-RO DC24V/AC24..230V/5A	6ES7138-4FR00-0AA0	01

What's New

Compared with the previous version, this manual includes the following major changes/additions:

- Simplified configuration rules
- Revised behavior of the electronic outputs in the event of a short-circuit
- Revised behavior in the event of a voltage dip

Approvals

See Section "Standards and Approvals"

In addition, ET 200S fail-safe modules are certified for use in safety mode up to the following levels:

- Safety class SIL3 (Safety Integrity Level) in compliance with IEC 61508
- Category 4 in accordance with EN 954-1
- Performance Level (PL) e in accordance with ISO 13849

CE Approval

See Section "Standards and Approvals"

Certification Mark for Australia (C-Tick Mark)

See Section "Standards and Approvals"

Standards

See Section "Standards and Approvals"

Position in the Information Landscape

When working with ET 200S fail-safe modules and depending on your particular application, you will need to consult the additional documentation listed below.

References to this additional documentation are included in the manual where appropriate.

Documentation	Brief Description of Relevant Contents
ET 200S Distributed I/O System operating instructions and manuals	describes all generally applicable topics related to the ET 200S hardware (including configuration, installation and wiring of the ET 200S) and the IM 151 interface module.
Safety Engineering in SIMATIC S7 system description	• Provides an overview of the implementation, configuration, and method of operation of S7 Distributed Safety and S7 F/FH fail-safe automation systems • Contains a summary of detailed technical information concerning fail-safe engineering in S7-300 and S7-400 • Includes monitoring and response time calculations for S7 Distributed Safety and S7 F/FH F-systems
For integration in the S7 F/FH F-systems	The *S7 F/FH Systems, Configuring and Programming* manual describes the tasks that must be performed to create and commission an S7 F/FH F-system.
	• The *S7-400, M7-400 Programmable Controllers Hardware and Installation* manual describes the installation and assembly of S7-400 systems • The *S7-400 Programmable Controllers, Fault-Tolerant Systems* manual describes the CPU 41x-H central modules and the tasks involved in setting up and commissioning an S7-400H fault-tolerant system • The *CFC for S7 Continuous Function Chart* manual/online help provides a description of programming with CFC

Documentation	Brief Description of Relevant Contents
For integration in the S7 Distributed Safety F-system	The *S7 Distributed Safety, Configuring and Programming* manual and online help describe the following: • Configuration of the fail-safe CPU and the fail-safe I/O • Programming of the fail-safe CPU in fail-safe FBD or LAD
	Depending on which F-CPU you use, you will need the following documentation: • The operating instructions *S7-300, CPU 31xC and CPU 31x: Configuration* describes the configuration, installation, addressing and commissioning of S7-300 systems. • The *CPU 31xC and CPU 31x, Technical Data* manual describes the standard functions of the CPU 315F-2 DP and PN/DP and the CPU 317F-2 DP and PN/DP and the CPU 319F-3 PN/DP. • The *Automation System S7-400 CPU Specifications* manual describes the standard functions of the CPU 416F-2 and CPU 416F-3 PN/DP. • The *ET 200S IM 151-7 CPU Interface Module* manual describes the standard IM 151-7 CPU. • The *ET 200S IM 151-8 PN/DP CPU Interface Module* manual describes the standard IM 151-7 *PN/DP* CPU. • A separate product information bulletin is available for each applicable F-CPU. The product information bulletins describe only the deviations from the corresponding standard CPUs.
STEP 7 manuals	• The *Configuring Hardware and Communication Connections with STEP 7 V5.x* manual describes the operation of the relevant standard tools of *STEP 7*. • The *System Software for S7-300/400 System and Standard Functions* reference manual describes functions for distributed I/O access and diagnostics.
STEP 7 online help	• Describes the operation of *STEP 7* standard tools • Contains information about how to configure and assign parameters for modules and intelligent slaves with *HW Config* • Contains a description of the programming languages FBD and LAD
PCS 7 manuals	• Describe how to operate the *PCS 7* process control system (required when ET 200S with fail-safe modules is integrated in a higher-level control system)

The entire SIMATIC S7 documentation is available on CD-ROM.

Guide

This manual describes the fail-safe modules of the ET 200S distributed I/O system. It consists of instructive sections and reference sections (technical specifications and appendices).

This manual presents the following basic aspects of fail-safe modules:

- Design and use
- Configuration and parameter assignment
- Addressing, assembly and wiring
- Diagnostic evaluation
- Technical specifications
- Order numbers

Conventions

In this manual, the terms "safety engineering" and "fail-safe engineering" are used synonymously. The same applies to the terms "fail-safe" and "F-."

"*S7 Distributed Safety*" and "*S7 F Systems*" in italics refer to the optional packages for the two F-systems: "S7 Distributed Safety" and "S7 F/FH Systems".

Recycling and Disposal

Due to the low levels of pollutants in the fail-safe modules of the ET 200S, the modules can be recycled. For proper recycling and disposal of your old module (device), consult a certified disposal facility for electronic scrap.

Additional Support

If you have any further questions about the use of products described in this manual, and do not find the right answers there, contact your local Siemens representative (http://www.siemens.com/automation/partner).

Training center

We offer courses to help you get started with the S7 automation system. Contact your regional training center or the central training center in Nuremberg (90327), Federal Republic of Germany.

Telephone: +49 911 895-3200

On the Internet (http://www.sitrain.com)

H/F Competence Center

The H/F Competence Center in Nuremberg offers special workshops on SIMATIC S7 fail-safe and redundant automation systems. The H/F Competence Center can also provide assistance with onsite configuration, commissioning and troubleshooting.

Telephone: +49 911 895-4759

Fax: +49 911 895-5193

hf-cc.aud@siemens.com

For questions about workshops / training: hf-training.industry@siemens.com

Technical Support

You can contact Technical Support for all IA products as follows:

- By completing a Support Request (http://www.siemens.de/automation/support-request) on the Internet
- Telephone: +49 180 5050 222
- Fax: +49 180 5050 223

For additional information about Siemens Technical Support, refer to Internet (http://www.siemens.de/automation/service).

Service & Support on the Internet

In addition to the information in our documentation, you can also access our knowledge base online at Internet (http://www.siemens.com/automation/service&support).

Here you will find the following information:

- Newsletter providing the latest information on your products
- Exactly the right documentation for your needs, which you can access by performing an online search in Service & Support
- Worldwide forum in which users and experts exchange ideas
- Your local contact for Automation & Drives
- Information about local service, repairs and replacement parts. Even more information can be found under "Services".

Important Note for Maintaining Operational Safety of Your System

Note

The operators of systems with safety-related characteristics must adhere to operational safety requirements. The supplier is also obliged to comply with special product monitoring measures. To keep you informed, a special newsletter is therefore available containing information on product developments and properties that are important (or potentially important) for operating systems where safety is an issue. By subscribing to the appropriate newsletter, you will ensure that you are always up-to-date and able to make changes to your system, when necessary. Point your browser to Internet (https://www.automation.siemens.com/WW/newsletter/guiThemes.aspx?parlasw=1) and register for the following newsletters:

- SIMATIC S7-300
- SIMATIC S7-400
- Distributed I/O
- SIMATIC Industrial Software

Select the "Updates" check box for this newsletter.

See also

Standards and Approvals (Page 49)

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1 Product Overview

1.1 Introduction

Overview

This chapter provides information about the following topics:

- ET 200S distributed I/O system with fail-safe modules and its place in SIMATIC S7 fail-safe automation systems
- Components comprising the ET 200S distributed I/O system with fail-safe modules
- The steps you must perform, ranging from selection of the F-modules to commissioning of ET 200S on PROFIBUS DP/PROFINET IO

1.2 ET 200S fail-safe modules

Fail-safe automation system

Fail-safe automation systems (F-systems) are used in systems with higher-level safety requirements. F-systems are used to control processes having a safe state immediately after shutdown. In other words, F-systems control processes in which an immediate shutdown does not endanger humans or the environment.

ET 200S Distributed I/O System

The ET 200S distributed I/O system is a DP slave/IO device on PROFIBUS DP/PROFINET IO that can contain fail-safe modules in addition to ET 200S standard modules.

You can use copper cables, fiber-optic cables or WLAN (*S7 Distributed Safety* as of V5.4) to assemble the PROFIBUS DP/PROFINET IO lines.

Fail-safe modules

The major difference between fail-safe modules and standard ET 200S modules is that fail-safe modules have a two-channel internal design. Both integrated processors monitor each other, automatically test the I/O circuits, and set the F-module to safe state in the event of a fault. The F-CPU communicates with the fail-safe module using the PROFIsafe safety-related bus profile.

Fail-safe power modules are used to supply load voltage to the potential group and to safely shut down the load voltage for standard output modules.

Fail-safe digital input modules record the signal states of safety-related sensors and send corresponding safety message frames to the F-CPU.

Fail-safe digital output modules are suitable for shutdown procedures with short-circuit and cross-circuit protection up to the actuator.

1.3 Using ET 200S Fail-Safe Modules

Possible Uses of ET 200S with Fail-Safe Modules

The use of ET 200S with fail-safe modules enables conventional safety engineering designs to be replaced with PROFIBUS DP/PROFINET IO components. This includes the replacement of switching devices for emergency STOP, protective door monitors, two-hand operation, etc.

Use in F-Systems

Fail-safe ET 200S modules can be used:

- In the S7 Distributed Safety F-system with the *S7 Distributed Safety* optional package V5.2 or higher
- In the S7 F/FH Systems with the *S7 F Systems*optional package version V5.2 SP 3 or higher
- To interface ET 200S fail-safe modules to PROFIBUS DP with Distributed Safety or S7 F/FH systems, you need:
  - ET 200S fail-safe modules
  - F-CPU
  - *STEP 7* V5.3 SP3 or higher
  - IM151-1 DP HIGH FEATURE interface module
  - *S7 Distributed Safety* V5.2 or higher (for the order numbers specified in the "Preface": *F Configuration Pack* Version V5.5 SP5 or higher)

    The *F Configuration Pack* can be obtained on the Internet (http://support.automation.siemens.com/WW/view/en/15208817).
  - *S7 F Systems* V5.2 SP3 or higher

  You should also observe the readme file for the *F Configuration Pack* and the operating instructions for your F system.
- To connect ET 200S fail-safe modules to PROFINET IO modules with Distributed Safety, you need:
  - ET 200S fail-safe modules
  - F-CPU
  - *STEP 7* V5.3 SP3 or higher
  - IM 151-3 PN HIGH FEATURE interface module
  - *S7 Distributed Safety* V5.4 or higher (for the order numbers specified in the "Preface": *F Configuration Pack* Version V5.5 SP5 or higher)

    The current *F Configuration Pack* can be obtained on the Internet (http://support.automation.siemens.com/WW/view/en/15208817).

  You should also observe the readme file for the *F Configuration Pack* and the operating instructions for your F system.

- For the central use of the fail-safe ET 200S modules with distributed safety, you require an IM 151-7 F-CPU or IM 151-8 PN/DP F-CPU.

When using fail-safe ET 200S I/O modules in F-systems, the information contained in the following manuals applies:

- *ET 200S distributed I/O system*
- *Safety Engineering in SIMATIC S7*
- *S7 Distributed Safety, Configuring and Programming* or *S7 F/FH Systems, Configuring and Programming*

F-System with ET 200S

The following figure presents an example configuration for an S7 Distributed Safety F-system including an ET 200S on PROFIBUS DP/PROFINET IO.

The fail-safe DP master/IO controller exchanges safety-related and non-safety-related data with the fail-safe and standard ET 200S modules, etc.

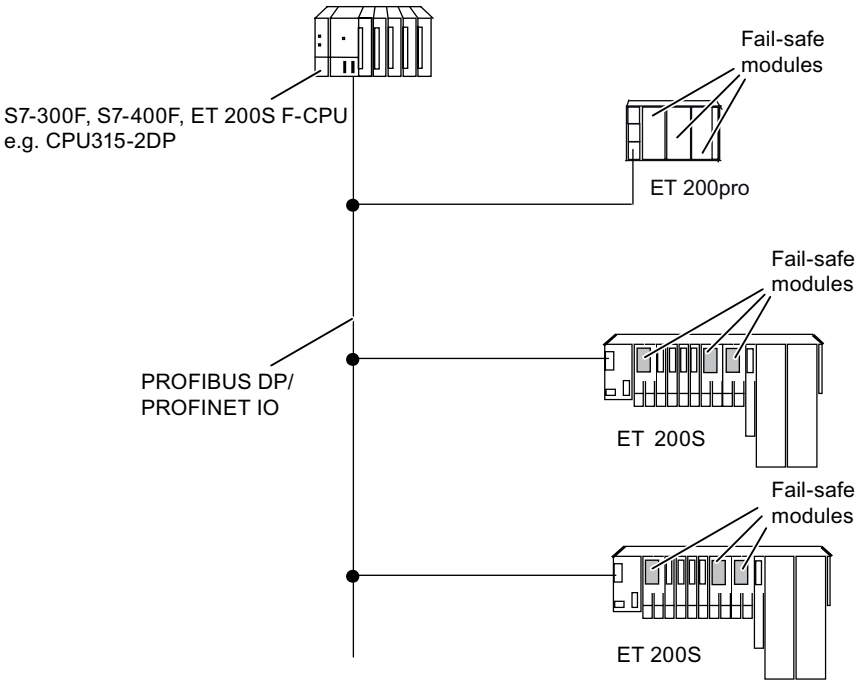


Figure 1-1 S7 Distributed Safety Fail-Safe Automation System (Example Configuration)

Availability of Fail-Safe Electronic Modules

The following fail-safe electronic modules are available for ET 200S:

- Power module PM-E F pm DC24V PROFIsafe; switching to P/M potential, with 2 additional, fail-safe digital outputs
- Power module PM-E F pp DC24V PROFIsafe; switching to P/P potential
- Power module PM-D F DC24V PROFIsafe; switching to P/P potential
- Digital electronic module 4/8 F-DI DC24V PROFIsafe
- Digital electronic module 4 F-DI/3 F-DO DC24V PROFIsafe
- Digital electronic module 4 F-DO DC24V/2A PROFIsafe; switching to P/M potential
- Digital electronic module 1 F-RO DC24V/AC24..230V/5A

The PM-D F DC24V PROFIsafe is used for selective shutdowns of fail-safe motor starters via six fail-safe shutdown groups.

A range of terminal modules is available for fail-safe power and electronic modules. You will find a detailed list in this manual.

Using Interface Modules in ET 200S with Fail-Safe Modules

Depending on the F system, select the interface module for ET 200S as follows:

Table 1- 1 Using Interface Modules in ET 200S with Fail-Safe Modules

Interface module	As of order number	Can be used in ET 200S with optional package	As of version
IM 151-1 HIGH FEATURE for PROFIBUS DP interface	6ES7151-1BA01-0AB0	*S7 Distributed Safety*	V5.2
		S7 F Systems	V5.2
IM 151-7 F-CPU for PROFIBUS DP interface	6ES7151-7FA01-0AB0	*S7 Distributed Safety*	V5.2
IM 151-8 DP/PN F-CPU for PROFINET IO interface	6ES7151-8FB00-0AB0	*S7 F Configuration Pack*	V5.5 SP5
IM 151-3 PN HIGH FEATURE for PROFINET IO interface	6ES7151-3BA00-0AB0 6ES7151-3BA20-0AB0 6ES7151-3BB20-0AB0	*S7 Distributed Safety*	V5.4

The IM 151-1 HIGH FEATURE and the IM 151-3 PN HIGH FEATURE are described in the respective manuals *ET 200S Distributed I/O System*. The IM 151-7 F-CPU and IM 151-8 PN/DP F-CPU are described in a separate product information.

Restrictions with EM 4 F-DI/3 F-DO DC24V PROFIsafe

The EM 4 F-DI/3 F-DO DC24V PROFIsafe only supports operation in distributed systems with the following interface modules:

- 6ES7151-1BA01-0AB0 V2.0.0 or higher
- 6ES7151-3BA20-0AB0 V3.0.0 or higher
- 6ES7151-3BB21-0AB0 V3.0.0 or higher

The EM 4 F-DI/3 F-DO DC24V PROFIsafe can be used centrally with IM 151-7 F-CPU 6ES7151-7FA20-0AB0 V2.6 or higher or IM 151-8 F-CPU 6ES7151-8FB00-0AB0.

Using the fail-safe power module PM E F pp DC24V PROFIsafe

Using the fail-safe power module PM E F pp DC24V PROFIsafe is only possible:

- As of order number 6ES7151-1BA01-0AB0, Firmware version V1.1.1 or higher
- As of order number 6ES7151-7FA01-0AB0, Firmware version V2.1.4 or higher

Use in Safety Mode Only

Fail-safe modules can only be used in safety mode. They cannot be used in standard mode.

Achievable Safety Classes

Fail-safe modules are equipped with integrated safety functions for safety mode.

The following safety classes can be achieved in safety mode by assigning appropriate parameters to the safety functions in *STEP 7* with the *S7 Distributed Safety* or *S7 F Systems* optional package, by combining certain standard and F-modules and by arranging the wiring of the sensors and actuators in a specific way:

Table 1- 2 Achievable Safety Classes in Safety Mode

In accordance with IEC 61508	In accordance with EN 954-1	In accordance with ISO 13849
SIL2	Category 3	Performance Level (PL) d
SIL3	Category 3	Performance Level (PL) e
SIL3	Category 4	Performance Level (PL) e

See also

Configuring ET 200S with Fail-Safe Modules (Page 19)

Requirements for Sensors and Actuators (Page 37)

Applications for the 4/8 F-DI DC24V PROFIsafe Electronic Module (Page 113)

Input applications of EM 4 F-DI/3 F-DO DC24V PROFIsafe (Page 145)

1.4 Guide for Commissioning of ET 200S with Fail-Safe Modules

Introduction

The following table lists all the important steps required for commissioning ET 200S distributed I/O systems with fail-safe modules as DP slaves/IO devices on PROFIBUS DP/PROFINET IO.

Steps from Selecting the F-Modules to Commissioning the ET 200S

Table 1- 3 Steps from Selecting the F-Modules to Commissioning the ET 200S

Step	Procedure	See ...
1.	Select F-modules for ET 200S configuration	"Configuring" chapter
2.	Configure and assign parameters to F-modules in *STEP 7*	"Configuration and Parameter Assignment" and "Fail-Safe Modules" chapters
3.	Set PROFIsafe addresses on F-modules	"Address Assignment and Installation" chapter
4.	Install ET 200S	"Address Assignment and Installation" chapter
5.	Wire the ET 200S	"Wiring and Fitting Modules" chapter
6.	Commission ET 200S on PROFIBUS DP/PROFINET IO	*ET 200S Distributed I/O System* operating instructions
7.	Run diagnostics on ET 200S if commissioning failed	"Diagnostics" chapter, "Fail-Safe Modules" chapter and *ET 200S Distributed I/O System* operating instructions

Note

You must configure and assign parameters to the F-modules in *STEP 7* before you start commissioning.

Reason: *STEP 7* automatically assigns the PROFIsafe addresses to the F-modules. You must set these PROFIsafe addresses by means of switches on all F-modules prior to their installation.

Configuring

2

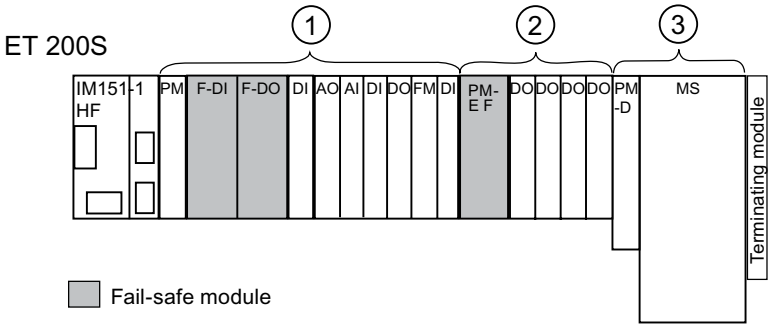
2.1 Configuring ET 200S with Fail-Safe Modules

Introduction

The ET 200S distributed I/O systems support configurations with standard and fail-safe modules. This chapter presents an example configuration.

Configuration example of ET 200S with Fail-Safe Modules

In the following figure you will find a configuration example using standard and fail-safe modules in an ET 200S. You *can* divide and install the modules in fail-safe and standard potential groups. A new potential group always begins with a power module.



① Fail-safe and standard potential groups mixed

② Fail-safe potential group

③ Standard potential group

Figure 2-1 ET 200S Configuration Example with Fail-Safe Modules

WARNING

If the implemented standard module has electrical isolation of ≥ 60 VAC / 75 VDC and test voltage of 500 VDC, it is possible to mix F-DI-/F-DO modules and standard DI-/DO-/FM modules within one potential group as of the following MLFBs for the SIL3/Category 4/PLe:

- 6ES7138-4CF03-0AB0
- 6ES7138-4CF42-0AB0
- 3RK1903-3BA02
- 6ES7138-4FA04-0AB0
- 6ES7138-4FC01-0AB0
- 6ES7138-4FB03-0AB0
- 6ES7 138-4FR00-0AA0

For the predecessor modules, you can achieve SIL2/Category 3/PLd with a mix of F-DI-/F-DO modules and standard DI-DO modules.

Configuration Rules for Fail-Safe Potential Groups

The "Assigning Power Modules to Electronic Modules/Motor Starters and Safety Class" table lists all the fail-safe and standard power modules and electronic modules you can implement in a potential group.

Configuration with Fail-Safe Motor Starters and Frequency Converters

Use a PM-D F DC24V PROFIsafe for the selective shutdown of:

- Fail-safe motor starters (F-MS) F-DS1e-x, F-RS1e-x
- SINAMICS fail-safe frequency converters (F-FU) with ICU24(F)
- Fail-safe F-CM connection multipliers
- PM-D F X1 fail-safe power/expansion modules.

The PM-D F DC24V PROFIsafe cannot supply other motor starters (such as DS1-x/RS1-x, DS1e-x/RS1e-x, DSS1e-x)!

The fail-safe motor starters can be expanded:

- Up to safety class SIL3/Category 4/PLe with the Brake Control xB1, xB2 expansion modules
- Up to safety class SIL2/Category 3/PLd with the Brake Control xB3, xB4 expansion modules

Example of a Configuration with Fail-safe Motor Starters

The figure below shows an example of an ET 200S configuration with two fail-safe potential groups. The first potential group contains fail-safe motor starters and a connection multiplier. This configuration achieves safety class SIL3/Category 4/PLe.

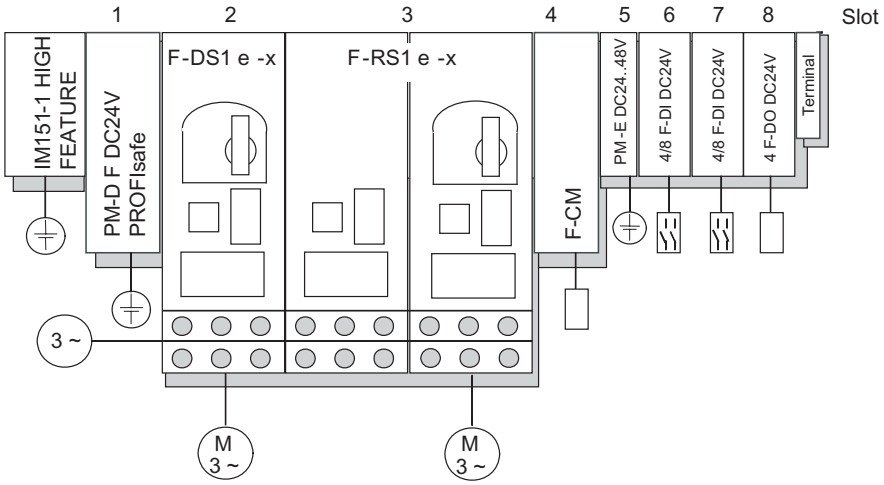


Figure 2-2 Configuration Example of ET 200S with Fail-Safe Motor Starters and Connection Multiplier

Additional Information on Fail-Safe Motor Starters

All submodules and modules that can be supplied by the PM-D F DC24V PROFIsafe are described in the *ET 200S Motor Starter* manual.

Positioning and Connecting Power Modules

An ET 200S containing fail-safe modules is no different than an ET 200S containing standard modules with regard to the positioning and connection of power modules.

You can position the power modules as you wish. Each TM-P terminal module (for a power module) that you add to the ET 200S opens a new potential group. All sensor and load current supplies of the electronic modules/motor starters that follow are fed from this terminal module.

By placing another TM-P terminal module after an electronic module/motor starter you interrupt the voltage buses (P1/P2) and simultaneously open a new potential group. This allows individual interconnection of sensor and load current supplies.

AUX(iliary) bus (AUX 1)

A TM-P terminal module (for a power module) allows the additional connection of a potential (up to the maximum rated load voltage of the module) which you can apply via the AUX(iliary) bus. You can use the AUX(iliary) bus as follows:

- As a protective conductive bus
- When additional voltage is required

Additional Information about Positioning and Connecting Power Modules

For further information about positioning and connecting power modules refer to the *ET 200S Distributed I/O System* Operating Instructions.

2.2 Assigning Modules of an ET 200S

Introduction

This section presents the ET 200S module assignments for:

- Fail-safe power modules to terminal modules
- Fail-safe electronic modules to terminal modules
- Power modules to electronic modules/motor starters

Assigning Fail-Safe Power Modules to Terminal Modules

You can use the F-power modules with the following terminal modules:

Table 2- 1 Assigning Fail-Safe Power Modules to Terminal Modules

F-Power Modules	Terminal Modules	For a Description, See ...
PM-E F pm DC24V PROFIsafe and PM-E F pp DC24V PROFIsafe	TM-P30S44-A0 (screw-in type)	*Terminal Modules* manual for the ET 200S distributed I/O system
	TM-P30C44-A0 (snap-in type)	
PM-D F DC24V PROFIsafe	TM-PF30S47-F1 (snap-in type)	

Assigning Fail-Safe Electronic Modules to Terminal Modules

You can use the following fail-safe electronic modules and terminal modules together:

Table 2- 2 Assigning Fail-Safe Electronic Modules to Terminal Modules

F-Electronic Modules	Terminal Modules	For a Description, See ...
4/8 F-DI DC24V PROFIsafe, 4 F-DI/3 F-DO DC24V PROFIsafe, 4 F-DODC24V/2A PROFIsafe and 1 F-RO DC24V/AC24..230V/5A	TM-E30S46-A1 (screw-in type)	*ET 200S Distributed I/O System* Operating Instructions
	TM-E30C46-A1 (snap-in type)	
	TM-E30S44-01 (screw-in type)	
	TM-E30C44-01 (snap-in type)	

Assigning Power Modules to Electronic Modules/Motor Starters

The table below lists the power modules and electronic modules/motor starters you can operate within the same potential group.

Note that certain combinations limit the maximum safety class which can be attained.

Table 2- 3 Assigning Power Modules to Electronic Modules/Motor Starters and Safety Class

Power Modules	For a Description, See ...	Electronic Module/Motor Starter	Use and achievable SIL/Category/PL	
PM-E F pm DC24V PROFIsafe	"Power module PM-E F pm DC24V PROFIsafe"	can be used with all standard electronic modules	Safe shutdown of DO modules of the ET 200S series	SIL2/Category 3/PLd
PM-E F pp DC24V PROFIsafe	"Power module PM-E F pp DC24V PROFIsafe"			
PM-D F DC24V PROFIsafe	"Power module PM-D F DC24V PROFIsafe"	Can only be used for: • F-DS1e-x, F-RS1e-x fail-safe motor starters (F-MS) • Connection multiplier F-CM • PM-D F X1 power/expansion module • Expansion modules Brake Control xB1 and xB2	Safe shutdown of motor starters	SIL3/Cat. 4/PLe
		Can be used for the F-motor starters indicated above: Brake Control xB3 and xB4 expansion modules	Safe shutdown of motor starters	SIL2/Category 3/PLd
PM-E DC24V	*Power Module* manual *PM-E DC24V (bis 6ES7138-4CA01-0AA0)*	can be used with all standard and fail-safe electronic modules	Power supply to F-DI, F-DO and F-RO modules: up to 6ES7138-4FA03-0AB0 up to 6ES7138-4FC01-0AB0 up to 6ES7138-4FB02-0AB0 up to 6ES7138-4FR00-0AA0	SIL2/Category 3/PLd
			Supply of F-DI modules, F-DO modules: 6ES7138-4FA04-0AB0 6ES7138-4FB03-0AB0	SIL3/Cat. 4/PLe

Power Modules	For a Description, See ...	Electronic Module/Motor Starter	Use and achievable SIL/Category/PL	
PM-E DC24..48V	*PM-E DC24..48V (6ES7138-4CA50-0AB0) Power Module* manual	Can be used with all standard and fail-safe electronic modules	Power supply to F-DI, F-DO and F-RO modules	SIL3/Cat. 4/PLe
PM-E DC24..48V/ AC24..230V	*PM-E DC24..48V/AC 24..230V (bis 6ES7138-4CB11-0AB0) Power Module* manual			

See also

Properties of the PM-E F pm DC24V PROFIsafe Power Module (Page 62)

Properties of the PM-E F pp DC24V PROFIsafe Power Module (Page 83)

Properties of the PM-D F DC24V PROFIsafe Power Module (Page 96)

2.3 Maximum Number of Connectable Modules/Maximum Configuration

Maximum Number of Modules

The modules include the interface module, the power and electronic modules, and the motor starters.

The overall width of an ET 200S is limited to 2 m.

The following restriction applies for IMs as of 6ES7151-1BA01-0AB only when operated in DPV0 mode:

- The maximum number of modules in an ET 200S also depends on the parameter length of the modules. Each ET 200S supports a total of 244 bytes.

For further additional information refer to the *ET 200S Distributed I/O System* Operating Instructions.

Table 2- 4 Parameter Length of F-Modules in Bytes

Fail-Safe Module	Parameter Length
PM-E F pm DC24V PROFIsafe	22 bytes
PM-E F pp DC24V PROFIsafe	20 bytes
PM-D F DC24V PROFIsafe	20 bytes
4/8 F-DI DC24V PROFIsafe	32 bytes
4 F-DI/3 F-DO DC24V PROFIsafe	32 bytes
4 F-DO DC24V/2A PROFIsafe	22 bytes

Example

In the following example, modules with a total parameter length of 234 bytes were used in an ET 200S.

Number and type of modules	:	1 x IM151-1 HIGH FEATURE	+ 1 x PM-E DC24..48V/ AC24..230V	+ 5 x F-DI module*	+ 2 x F-DO module**	= 9 modules
Parameter length	:	27 bytes***	+ 3 bytes	+ 160 bytes	+ 44 bytes	= 234 bytes

* 5 F-DI modules are available: 20 SIL3 or 40 SIL2 inputs

** 2 F-DO modules are available: 8 SIL2/SIL3 outputs

*** 56 bytes in isochronous mode

Power Modules: Maximum Configuration per Potential Group

Table 2- 5 Maximum configuration per potential group

Power Modules	Maximum Current Carrying Capacity	Connectable Modules/Motor Starters
PM-E F pm DC24V PROFIsafe	10 A	The number of modules that can be connected depends on the total current of all modules in the potential group. The total current may not exceed 10 A. The total current is influenced primarily by the digital output modules.
PM-E F pp DC24V PROFIsafe		
PM-D F DC24V PROFIsafe	10 A briefly* 5 A permanent*	The number of motor starters/modules that can be connected depends on the total current of all motor starters/modules in the potential group. The total current may not exceed 10 A.

* Reason:	Current Consumption of the F-Motor Starters	
	U1 (electronics supply)	SG (shutdown groups)
Switching time (up to 200 ms)	0.15 A	0.25 A
Duration (after 200 ms)	0.15 A	0.06 A

ET 200S: Limitations and maximum configuration

For further information about limitations and maximum configuration of the standard ET 200S refer to the *ET 200S Distributed I/O System* Operating Instructions.

2.4 Configuration and Parameter Assignment

Prerequisite

The requirements from chapter Using ET 200S Fail-Safe Modules (Page 14) apply to configuring and assigning parameters for ET 200S fail-safe modules.

Configuration

Follow the usual procedure with *STEP 7 HW Config* to configure fail-safe modules (in the same way as standard ET 200S modules).

Parameter Assignment for Module Properties

To assign parameters for fail-safe module properties, select the module in *STEP 7 HW Config* and select the menu command "Edit > Object Properties".

Parameters are downloaded from the programming device to the F-CPU, where they are stored and then transferred to the fail-safe module.

Parameter Description

You will find a description of assignable fail-safe module parameters in this manual.

PROFIsafe Address and PROFIsafe Address Assignment

You can find a description of PROFIsafe addresses and the address assignment procedure in this manual.

See also

Assignment of the PROFIsafe address (Page 29)

Parameters of the PM-E F pm DC24V PROFIsafe (Page 74)

Parameters of the PM-E F pp DC24V PROFIsafe (Page 90)

Parameters of the PM-D F DC24V PROFIsafe (Page 100)

Parameters of the EM 4/8 F-DI DC24V PROFIsafe (Page 108)

EM 4 F-DI/3 F-DO DC24V PROFIsafe parameters (Page 142)

Parameters for the EM 4 F-DO DC24V/2A PROFIsafe (Page 171)

Address Assignment and Installation

3

3.1 Address assignments in the F-CPU

Address Assignment

The fail-safe modules occupy the following address ranges in the F-CPU:

- For S7 Distributed Safety: in the area of the process image
- For S7 F/FH systems: in the area of the process image

Table 3- 1 Address Assignment in the F-CPU

F-Module	Occupied Bytes in the F-CPU:	
	In Input Range	In Output Range
PM-E F pm DC24V PROFIsafe	x + 0 to x + 4	x + 0 up to x + 4
PM-E F pp DC24V PROFIsafe	x + 0 up to x + 4	x + 0 up to x + 4
PM-D F DC24V PROFIsafe	x + 0 up to x + 4	x + 0 up to x + 4
4/8 F-DI DC24V PROFIsafe	x + 0 to x + 5	x + 0 to x + 3
4 F-DI/3 F-DO DC24V PROFIsafe	x + 0 up to x + 6	x + 0 up to x + 4
4 F-DO DC24V/2A PROFIsafe	x + 0 up to x + 4	x + 0 up to x + 4
1 F-RO DC24V/AC24..230V/5A	x.0 and x.1*	—
x = Module start address * The bit addresses can be moved using the "Pack addresses" function.		

Addresses Occupied by Useful Data

The useful data occupy the following addresses of the assigned addresses of the fail-safe modules in the F-CPU:

Table 3- 2 Addresses Occupied by Useful Data

Byte in the F-CPU	Occupied Bits in F-CPU per F-Module:							
	7	6	5	4	3	2	1	0
PM-E F pm DC24V PROFIsafe:								
x + 0	—	—	—	—	—	Channel 2	Channel 1	Channel 0
PM-E F pp DC24V PROFIsafe:								
x + 0	—	—	—	—	—	—	—	Channel 0
PM-D F DC24V PROFIsafe:								
x + 0	—	—	Channel 5	Channel 4	Channel 3	Channel 2	Channel 1	Channel 0
4/8 F-DI DC24V PROFIsafe:								

	Occupied Bits in F-CPU per F-Module:							
x + 0	Channel 7	Channel 6	Channel 5	Channel 4	Channel 3	Channel 2	Channel 1	Channel 0
4 F-DI/3 F-DO DC24V PROFIsafe:								
x + 0 (inputs)	—	—	—	—	Channel 3	Channel 2	Channel 1	Channel 0
x + 0 (outputs)	—	—	—	—	—	Channel 2	Channel 1	Channel 0
4 F-DO DC24V/2A PROFIsafe:								
x + 0	—	—	—	—	Channel 3	Channel 2	Channel 1	Channel 0
1 F-RO DC24V/AC24..230V/5A:								
x + 0	—	—	—	—	—	—	0	Channel 0 (Readback channel)
x = Module start address								

⚠ WARNING

You may only access the addresses occupied by useful data. The other address ranges 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 the 1oo2 evaluation of sensors, only the less significant channel of the channels that are grouped as a result of the 1oo2 sensor evaluation can be accessed in the safety program.

Additional Information

Detailed information about fail-safe I/O access can be found in the *S7 Distributed Safety, Configuring and Programming* manual or the *S7 F/FH Systems, Configuring and Programming* manual.

3.2 Assignment of the PROFIsafe address

PROFIsafe address

Every fail-safe module has an own PROFIsafe address. Before installing fail-safe modules, you must set the PROFIsafe address on each F-module.

PROFIsafe Address Assignment

The PROFIsafe addresses (F_source_address, F_destination_address) are assigned automatically when you configure the fail-safe modules in *STEP 7*.

You can view the F_destination_address in binary format in *HW Config* in the Object properties of the fail-safe modules in the "DIP switch setting" parameter. You read the PROFIsafe address from the parameter assignment dialog box and set it on the fail-safe module using the address switch.

You can edit the configured F_destination_address in *HW Config*. To prevent addressing errors, however, we recommend that you use the automatically assigned F_destination_address.

Address Switch for Setting PROFIsafe Addresses

The address switch (10-pin DIP switch) is located on the left-hand side of every fail-safe module. Use this address switch to set the PROFIsafe address (F_destination_address) of the F-module.

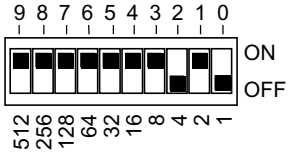
Note

Fail-safe modules in ET 200S can only be operated in safety mode.

Setting the Address Switch

Before installing the F-module, ensure that the address switch is set correctly.

Valid range of the PROFIsafe addresses: 1 to 1022. The figure below shows an example of an address switch setting.



Example: Address=512+256+128+64+32+16+8+2=1018

Figure 3-1 Example for Setting the Address Switch (DIP Switch)

Note

An address switch of the smallest possible dimensions is installed for reasons of space saving. This makes it sensitive to pressure and objects with sharp edges. Always use a suitable tool to operate the address switch.

Diverse tools suitable for activating the address switch are available on the market, for example, the Grayhill DIPSTICK. A ballpoint pen may be employed if used carefully. It is imperative to avoid any burring which would prevent the switch from reaching its home position. Therefore, DO NOT use screwdrivers or knives to operate the address switch.

Rules for Address Assignment

⚠ WARNING

Observe the following rules when assigning addresses:

- Make sure that the address switch setting on the module matches the PROFIsafe address in the *HW Config*.
- **Rule for PROFIBUS subnets:**

  The switch setting on the F-I/O address switch, i.e. its PROFIsafe destination address, must be unique within the network* and station** (system-wide). You can assign up to 1,022 different PROFIsafe destination addresses.

  Exception: The fail-safe I/Os in different I slaves may have the same PROFIsafe destination address assigned, as they are only addressed within the station, that is, by the F-CPU in the I-slave.

  Rules for Ethernet subnets and combined PROFIBUS and Ethernet subnet configurations:

  The address switch setting on the fail-safe I/O, i.e. the PROFIsafe destination address only*** has to be unambiguous within the Ethernet subnet, including all sublevel PROFIBUS subnets and station-wide** (system-wide). You can assign up to 1,022 different PROFIsafe destination addresses.

  Exception: The fail-safe I/Os in different I slaves may have the same PROFIsafe destination address assigned, as they are only addressed within the station, that is, by the F-CPU in the I-slave.

  The networked nodes of an Ethernet subnet are characterized by having IP addresses with a shared subnet address, i.e. the IP addresses are congruent with the "1" digits in the subnet mask.

  Example:

  IP address: 140.80.0.2

  Subnet mask: 255.255.0.0 = 11111111.11111111.00000000.00000000

  Meaning: Bytes 1 and 2 of the IP address define the subnet; subnet address = 140.80.

*: A network consists of one or more subnets. "Network-wide" = across subnet boundaries.

**: "Station-wide" means one station in *HW Config* (e.g. an S7-300 station or an I-slave)

***: Beyond Ethernet subnet boundaries if cyclic PROFINET IO communication (RT communication) is excluded.

3.3 Installing

Installing the fail-safe modules

The fail-safe power modules, electronic modules, and terminal modules are part of the ET 200S range of modules. They are installed using the same procedure as for all standard modules in an ET 200S.

Detailed information about module installation is available in the *ET 200S Distributed I/O System* Operating Instructions.

Installation dimensions

Note that fail-safe modules are 30 mm wide (twice the width of standard ET 200S modules). Otherwise, the information provided in the *ET 200S Distributed I/O System* Operating Instructions applies.

Wiring and Fitting Modules

4

4.1 Introduction

WARNING

In order to prevent hazardous risks to persons or to the environment, you must not under any circumstances override safety functions or implement any measures that cause safety functions to be bypassed or that result in the bypassing of safety functions. The manufacturer is not liable for the consequences of such manipulation or for damages that result from failure to heed this warning.

This chapter

This chapter covers the special features involved in wiring and fitting fail-safe modules. Information about this subject that applies to both ET 200S with fail-safe modules and ET 200S with standard modules can be found in the *ET 200S Distributed I/O System* operating instructions.

4.2 Safe Functional Extra Low Voltage for Fail-Safe Modules

Safe Functional Extra-Low Voltage

WARNING

Fail-safe modules must be operated with safe functional extra-low voltage (SELV, PELV). This means that these modules, even in the event of a fault, can only have a maximum voltage of U_m. The following applies for all fail-safe modules:

U_m < 60.0 V

You can find additional information about safe functional extra-low voltage in the data sheets, for example, of the applicable power supplies.

All system components that can supply electrical energy in any form whatsoever must fulfill this condition.

Each additional power circuit (24 VDC) installed in the system must be operated on safe functional extra-low voltage (SELV, PELV). Refer to the relevant data sheets or contact the manufacturer.

Sensors and actuators with an external power supply can also be connected to F-modules. Make sure here, too, that power is supplied to these components from safe functional extra-low voltage. The process signal of a 24 VDC digital module may not exceed a fault voltage U_m in the event of a fault.

WARNING

All voltage sources, for example, internal 24 VDC load voltage supplies, external 24 VDC load voltage supplies and 5 V DC bus voltage, must be electrically connected externally. This prevents potential differences from causing voltage additions at the individual voltage sources which would cause the fault voltage U_m to be exceeded.

Ensure that line cross-sections are sufficient for electrical connection in accordance with the ET 200S configuration guidelines (see *ET 200S distributed I/O system* operating instructions).

Power supply Requirements for Compliance with NAMUR Recommendations

Note

Always use power packs or power supplies (230 VAC --> 24 VDC) with a power failure ride-through of at least **20 ms** to ensure compliance with NAMUR recommendation NE 21, IEC 61131-2 and EN 298. The latest up-to-date information on PS components is available on the Internet (https://mall.ad.siemens.com).

These requirements also apply, of course, to power packs and power supplies which are not manufactured to ET 200S or S7-300/-400 configuration standards.

See also

Specifications for Nominal Line Voltages, Isolation Tests, Protection Class, and Type of Protection (Page 60)

4.3 Wiring fail-safe modules

Same Wiring Procedure as for ET 200S

Fail-safe power modules, electronic modules and terminal modules are part of the ET 200S range of modules. They are wired using the same procedure as for all standard modules in an ET 200S.

Refer to the *ET 200S Distributed I/O System* operating instructions for detailed information on wiring and fitting the modules and IM 151.

WARNING

When assigning signals of the F-DI module, remember that signals should only be routed within a cable or sheathed cable if:

- A short-circuit in the signals does not conceal a serious safety risk
- Signals are supplied by different sensor supplies of this F-DI module

Mounting Rails

The ET 200S distributed I/O system is installed on a mounting rail according to EN 60715 (35 x 7.5 mm or 35 x 15 mm).

Appropriate surface designs are:

- Steel strip according to Appendix A of EN 60715, or
- Tinned steel strip. We recommend the following mounting rails for this purpose:
  - 6ES5710-8MA11 (length: 483 mm)
  - 6ES5710-8MA21 (length: 530 mm)
  - 6ES5710-8MA31 (length: 830 mm)
  - 6ES5710-8MA41 (length: 2000 mm)

Note

If you use rails from other manufacturers, please ensure that these have the properties necessary to withstand your climatic ambient conditions.

Terminal assignment of the TMs

The terminal assignment of the TMs depends on the installed power or electronic module.

See also

Wiring of the PM-E F pm DC24V PROFIsafe (Page 70)
Wiring of the PM-E F pp DC24V PROFIsafe (Page 88)
Wiring of the PM-D F DC24V PROFIsafe (Page 100)
Wiring of the EM 4/8 F-DI DC24V PROFIsafe (Page 108)
Wiring of EM 4 F-DI/3 F-DO DC24V PROFIsafe (Page 141)
Wiring diagram of the EM 4 F-DO DC24V/2A PROFIsafe (Page 167)
Wiring of EM 1 F-RO DC24V/AC24..230V/5A (Page 181)

4.4 Insertion and removal of fail-safe modules

Inserting and Removing Electronic Modules

In ET 200S, the same procedure is used to insert and remove both fail-safe modules and standard modules on terminal modules (see ET 200S Distributed I/O System manual).

Inserting and Removing Electronic Modules during Operation

F-modules can be inserted and removed during operation in exactly the same way as standard modules in ET 200S.

Note

Hot-swapping fail-safe modules in ET 200S during operation generates a communication error on the F-CPU.

You must acknowledge this communication error in your safety program. (For information on the response of the F-system after communication errors, output of a fail-safe value and user acknowledgment, refer to the *S7 Distributed Safety, Configuration and Programming*or *S7 F/FH Systems, Configuring and Programming)*.

If the communication error is not acknowledged, the useful data of the F modules remain passivated (inputs and outputs in "0" state).

Conditions for Insertion and Removal during Operation

The table below lists the F-modules which support hot-swapping and the conditions under which this is possible:

Table 4- 1 Conditions for Hot-Swapping Fail-Safe Modules

Module	Insertion and Removal	Conditions
Interface module	No	—
Fail-safe power module (PM E-F pm)	Yes	Load voltage must be switched off
Fail-safe power module (PM E-F pp)	Yes	
Fail-safe power module (PM D-F)	Yes	
Fail-safe electronic module (F-DI)	Yes	—
Fail-safe electronic module (F-DI/DO)	Yes	Load voltage must be switched off
Fail-safe electronic module (F-DO)	Yes	Load voltage must be switched off
Fail-safe electronic module (F-RO)	Yes	Load voltage must be switched off

Remember to Set the PROFIsafe Address

When replacing F-modules, ensure that the address switch (DIP switch) settings of the left of the modules match.

See also

Assignment of the PROFIsafe address (Page 29)

4.5 Requirements for Sensors and Actuators

General Requirements for Sensors and Actuators

Please note the following important information for safety-related use of sensors and actuators:

⚠ WARNING

The use of sensors and actuators is beyond our sphere of influence. We have equipped our electronics with such safety engineering features as to leave 85% of the maximum permissible hazardous faults probability for sensors and actuators to you (this corresponds to the recommended load sharing in safety engineering between sensing devices, actuating devices and electronic switching for input, processing and output).

Note, therefore, that instrumentation with sensors and actuators bears a considerable **safety responsibility**. Remember, too, that sensors and actuators do not generally withstand proof-test intervals of 10 years as defined in IEC 61508 without considerable loss of safety.

The probability of hazardous faults and the rate of hazardous faults of safety functions must comply with an SIL-defined upper limit. You will find a listing of values achieved by F-modules in the technical specifications of the F-modules under "Fail-safe performance characteristics".

To achieve SIL3 (Category 4/PLe), suitably qualified sensors are necessary.

Additional Sensor Requirements

General rule: A single-channel sensor is sufficient to achieve SIL2/Category 3/PLd. However, the sensors must be wired to two channels in order to achieve SIL3/Category 4/PLe. However, to achieve SIL2/Category 3/PLd with a single-channel sensor, the sensor itself must be SIL2/Category 3/PLd-capable, otherwise the sensor must be wired to two channels in order to achieve this safety level.

Duration Requirements for Sensor Signals

⚠ WARNING

Observe the following requirements for sensor signals:

- In order to guarantee accurate detection of sensor signals by the F-DI module, you must ensure that the sensor signals have a defined minimum duration.
- Reliable pulse detection requires an interval between two signal changes (pulse duration) greater than the PROFIsafe monitoring time.

Reliable detection by the F-DI module

The table below lists the minimum duration of sensor signals for the F-DI module. This depends on the parameter settings made in *STEP 7* for the short-circuit test and the input delay.

Table 4- 2 Minimum Duration of Sensor Signals to Allow Correct Detection by F-DI-Module

Short-Circuit Test Parameter	Programmed Input Delay		
	0.5 ms	3 ms	15 ms
Deactivated	7 ms	9 ms	23 ms
Activated	7 ms	12 ms	37 ms

Reliable Detection by the Safety Program on the F-CPU

Information about the times required for the reliable detection of sensor signals in the safety program is available in *"Fail-Safe Modules"* of the *Safety Engineering in SIMATIC S7* system description.

Additional Requirements for Actuators

The F-modules test the outputs at regular intervals. To do so, the F-module briefly switches off the activated outputs. Duration of these test pulses:

- Dark period < 1 ms

Rapid response actuators may briefly drop out during the test. If your process does not tolerate this, you must use actuators with a sufficient lag (> 1 ms).

⚠ WARNING

If the actuators are operated at voltages greater than 24 VDC (for example, 230 VDC) or if the actuators switch higher voltages, safe isolation must be ensured between the outputs of a fail-safe output module and the components carrying a higher voltage (in accordance with EN 50178).

This is generally the case for relays and contactors. Particular attention must be paid to this issue for semiconductor switching devices.

See also

Using ET 200S Fail-Safe Modules (Page 14)
Assignment of the PROFIsafe address (Page 29)
Technical Specifications for PM-E F pm 24 VDC PROFIsafe (Page 78)
Technical Specifications for the PM-E F pp 24 VDC PROFIsafe (Page 93)
Technical Specifications of the PM-D F DC24V PROFIsafe (Page 103)
Applications for the 4/8 F-DI DC24V PROFIsafe Electronic Module (Page 113)
Technical Specifications of the EM 4/8 F-DI DC24V PROFIsafe (Page 133)
Input applications of EM 4 F-DI/3 F-DO DC24V PROFIsafe (Page 145)
Technical specifications of the EM 4 F-DI/3 F-DO DC24V PROFIsafe (Page 159)
Technical Specifications of the EM 4 F-DO DC24V/2A PROFIsafe (Page 174)
Technical specifications of the EM 1 F-RO DC24V/AC24..230V/5A (Page 184)

Diagnostics

5

5.1 Reactions to Faults

Safe State (Safety Concept)

The basic principle behind the safety concept is the existence of a safe state for all process variables.

Note

For digital F-modules, this safe state is the value "0". This applies to both sensors and actuators.

Reactions to Faults and Startup of the F-System

The safety function requires that fail-safe values (safe state) be applied to the fail-safe module instead of process values (**passivation of the fail-safe module**) in the following situations:

- When the F-system is started up
- If errors are detected during safety-related communication between the F-CPU and the F-module via the PROFIsafe safety protocol (communication error).
- If fail-safe I/O or channel faults occur (for example wire break, discrepancy error)

Faults detected are entered in the diagnostic buffer of the F-CPU and reported to the safety program in the F-CPU.

F-modules cannot save errors as retentive data. When the system is powered down and then restarted, any faults still existing are detected again during startup. However, you have the option of saving faults in your safety program.

⚠ WARNING

Channel faults do not trigger any diagnostic reactions or error handling for channels that have been set to "deactivated" in *STEP 7*, even when this channel is affected indirectly by a channel group fault ("Channel activated/deactivated" parameter).

Remedying faults in the F-system

To remedy faults in your F-system, proceed as described in EN 61508-1 Section 7.15.2.4 and EN 61508-2 Section 7.6.2.1 e.

The following steps must be performed:

1. Diagnosis and repair of the fault
2. Revalidation of the safety function
3. Recording in the service report

Fail-safe value output for F-modules

If channels are passivated **with F-DI modules**, the F-system provides fail-safe values for the safety program instead of the process values applied to the fail-safe inputs.

- For F-DI modules, this is always the fail-safe value "0".

In the case of F-DO modules and PM-E F pm DC24V PROFIsafe, if passivation occurs the F-system transfers fail-safe values (0) to the fail-safe outputs instead of the output values provided by the safety program. The output channels are de-energized. This also applies when the F-CPU goes into STOP mode. You cannot program fail-safe values.

Depending on the F-system used and the type of fault that occurred, (F-I/O, channel or communication fault), fail-safe values are used either for the affected channel only or for all channels of the fail-safe module involved.

In S7 distributed safety F-systems up to V5.3, the entire F-module is passivated when a channel fault occurs. Starting with S7 distributed safety V5.4, F-modules as of the indicated order numbers can also be passivated on a channel-level basis.

Reintegration of a Fail-Safe Module

The system changes from fail-safe to process values (reintegration of an F-module) either automatically or only after user acknowledgment in the safety program. It may be necessary to remove and insert the F-module to clear certain channel faults. For an exact list of such faults, see section *"Power module PM-E F pm DC24V PROFIsafe"* to *"Digital electronic module4 F-DO DC24V/2A PROFIsafe"* in the "Causes of errors and troubleshooting" tables.

After reintegration, the following occurs:

- For a fail-safe DI module, the process values pending at the fail-safe inputs are provided for the safety program
- For a fail-safe DO module, the output values provided in the safety program are again transferred to the fail-safe outputs

Additional Information on Passivation and Reintegration

For further information about fail-safe I/O access refer to the *S7 Distributed Safety, Configuring and Programming* manual or the *S7 F/FH Systems, Configuring and Programming* manual.

Reaction of the F-module with inputs to communication errors

The F-module with inputs responds differently to communication errors compared to other errors.

If a communication error is detected, the current process values remain set at the inputs of the F module and the channels are not passivated. The current process values are sent to the F-CPU and are passivated in the F-CPU.

See also

Properties of the PM-E F pm DC24V PROFIsafe Power Module (Page 62)

Properties of the PM-E F pp DC24V PROFIsafe Power Module (Page 83)

Properties of the PM-D F DC24V PROFIsafe Power Module (Page 96)

Properties of the 4/8 F-DI 24 VDC PROFIsafe Digital Electronic Module (Page 105)

Properties of the 4 F-DI/3 F-DO DC24V PROFIsafe Digital Electronic Module (Page 136)

Properties of the 4 F-DO DC24V/2A PROFIsafe digital electronic module (Page 163)

Properties of the EM 1 F-RO DC24V/AC24..230V/5A (Page 177)

5.2 Fault Diagnostics

Purpose of Diagnostics

Diagnostics are used to determine whether error-free signal acquisition is taking place at the fail-safe modules. Diagnostics information is assigned either to a single channel or to the entire F-module.

Diagnostics functions are not safety critical

None of the diagnostic functions (displays and messages) are safety critical and therefore not designed to be safety-related functions. Consequently, they are not tested internally.

Diagnostic Options for Fail-Safe Modules in ET 200S

The following diagnostic options are available for fail-safe modules:

- LED display on the module front panel
- Diagnostic functions of F-modules (slave diagnostics in accordance with IEC 61784-1:2003.)

Non-Programmable Diagnostic Functions

Fail-safe electronic and power modules provide diagnostic functions which cannot be programmed by the user. This means that the diagnostic functions are always activated, and are automatically made available by the F-module in *STEP 7* and passed on to the F-CPU in the event of a fault.

Programmable Diagnostic Functions

You can program (activate) certain diagnostic functions in *STEP 7*:

- Wire-break detection for the F-DI/F-DO module, the F-DO module and the PM-E F pm
- Short-circuit monitoring for the F-DI/F-DO module and F-DI module

⚠ WARNING

Diagnostic functions should be activated or deactivated in accordance with the application.

Diagnostics by LED Display

Every fail-safe power and electronic module (with the exception of the EM 1 F-RO DC24V/AC24..230V/5A) indicates faults by means of its SF LED (group fault LED). The SF-LED lights up as soon as a diagnostic function is triggered by the F-module. The SF LED flashes as long as a cleared fault has not been acknowledged (as of release version 02.) It goes dark when all faults have been eliminated and acknowledged.

The power module is also equipped with a PWR LED which displays the status of the load voltage supply of the potential group.

The 4/8 F-DI DC24V PROFIsafe electronic module is equipped with two additional fault LEDs (1VsF and 2VsF) that display faults for the two internal sensor power supplies.

The 4 F-DI/3 F-DO DC24V PROFIsafe electronic module also has a fault LED (VsF) that displays the faults of the internal sensor supply, and a channel LED, the channel LED and the SF LED light up red as soon as a diagnostic function is triggered by the F-module. The LEDs go dark when all faults have been eliminated.

The SF LED flashes until you acknowledge passivation following a module fault.

Slave Diagnostics

Slave diagnostics comply with IEC 61784-1:2003. The fail-safe EMs and PMs support slave diagnostics in exactly the same way as standard ET 200S modules.

Information about the general structure of slave diagnostics for the ET 200S and the fail-safe modules can be found in the *ET 200S Distributed I/O System* manual. A description of channel-specific diagnostics for fail-safe modules is presented below.

Channel-Specific Diagnostics

As with the ET 200S, there are three bytes available for channel-specific diagnostics, starting at byte 35. Up to 9 channel-specific diagnostic messages are possible per station. Channel-specific diagnostics for fail-safe modules are structured as follows.

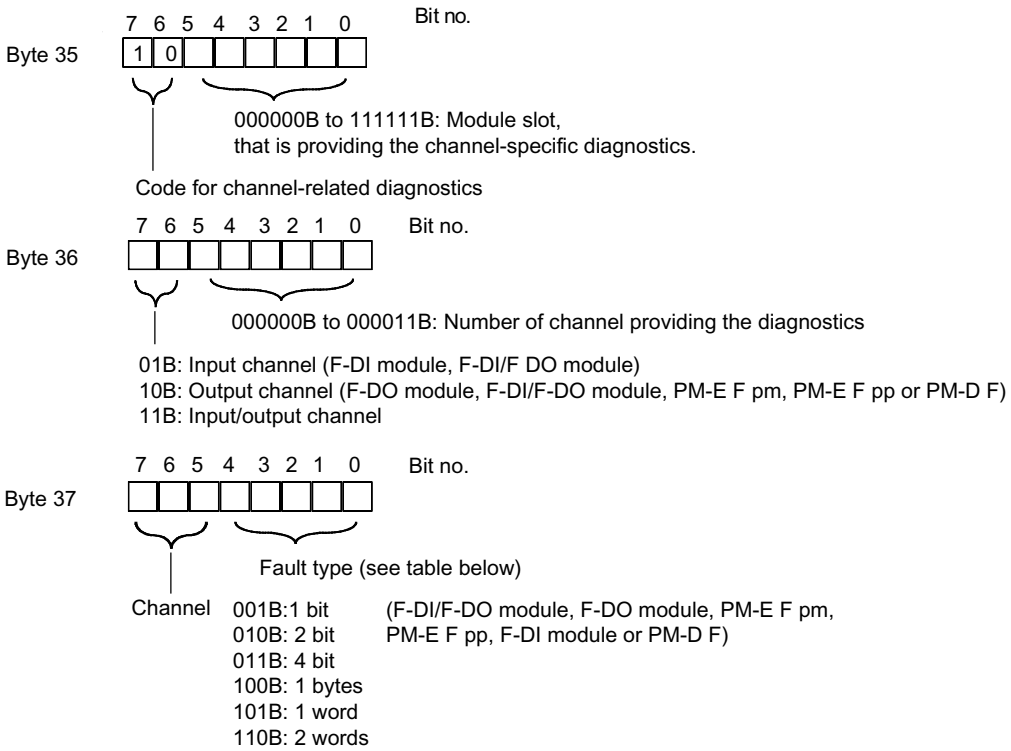


Figure 5-1 Structure of Channel-Specific Diagnostics

Note

The module slot coding is contained in byte 35, bits 0 to 5. The following applies:

displayed number + 1 = module slot

(0 = slot 1; 1 = slot 2, and so forth)

Note

Channel-specific diagnostics data are always updated to the current diagnostic function in the diagnostic message frame. Older, successive diagnostic functions are not deleted.

Remedy: Evaluate the valid, current length of the diagnostic message frame. To do this, use the parameter RET_VAL of the SFC 13 in *STEP 7*.

Possible Fault Types of Fail-Safe Modules

The table below lists the messages of the IM 151-1 HIGH FEATURE. When using the IM 151-7 F-CPU or IM 151-8 DP/PN F-CPU, you can obtain detailed diagnostic information using *HW diagnostics* in *STEP 7*.

Table 5- 1 Error types of channel-related diagnostics (apart from EM 1 F-RO DC24V/AC24..230V/5A)

Fault Type		Diagnostic Function in STEP 7	F-Module	Special Meaning for F-Modules
00001_B	1_D	Short circuit	EM 4/8 F-DI EM 4 F-DI/3 F-DO	Short circuit to L+ on the unconnected sensor cable Short circuit to sensor supply L+ Short circuit to ground or sensor supply failure Internal fault at the read circuit/test circuit
			PM-E F pm DC24V 4 F-DO 4 F-DI/3 F-DO	P output driver failure Short circuit of output to L+ or output driver M output driver failure Short circuit of output to M, or output driver failure
			4 F-DI/3 F-DO	Overload
00100_B	4_D	Overload	PM-E F pm DC24V 4 F-DO	Overcurrent at output driver
00101_B	5_D	Overtemperature	all apart from 4 F-DI/3 F-DO	—
00110_B	6_D	Line break	PM-E F pm DC24V 4 F-DO	Wire break
01001_B	9_D	Fault	all	RAM fault EPROM fault Processor failure (expected DIP switch value / actual DIP switch value) Internal fault at the read circuit/test circuit
10000_B	16_D	Parameter assignment error	all	Parameter assignment error
10001_B	17_D	Sensor voltage or load voltage missing	all	External auxiliary supply missing
10011_B	19_D	Communication error	all	CRC (cyclic redundancy check) error in data message frame Monitoring time for data message frame exceeded
11001_B	25_D	Safety-related shutdown	4/8 F-DI 4 F-DI/3 F-DO	Discrepancy error
			PM-E F pm DC24V PM-E F pp DC24V 4/8 F-DI / 4 F-DO 4 F-DI/3 F-DO	Switching frequency exceeded

Reaction of F-Modules to Module Failure

The following events occur following a serious internal fault in the F-module, causing F-module failure:

- The connection to the backplane bus is interrupted and the fail-safe I/O are passivated
- Diagnostics are not transmitted from the F-module and the default diagnostic message "Module Fault" is reported
- The SF LED of the corresponding F-module illuminates

Specific Information about Diagnostic Functions

All module-specific diagnostic functions, possible causes and their troubleshooting can be found in the *Chapters "Power modulePM-E F pm DC24V PROFIsafe"* to *"Digital electronic module 1 F-RO DC24V/AC24..230V/5A"*.

These sections also provide information about the status and diagnostic functions indicated by the LEDs on the front panel of the relevant F-module.

Reading Out Diagnostic Functions

You can display the cause of a fault in the *STEP 7* module diagnostics (see *STEP 7 Online Help*).

You can read the diagnostic functions (slave diagnostics) by calling SFC 13 in the standard user program (see *System and Standard Functions* reference manual).

See also

Diagnostic functions of the PM-E F pm DC24V PROFIsafe (Page 75)

Diagnostic functions of the PM-E F pp DC24V PROFIsafe (Page 90)

Diagnostic Functions of PM-D F DC24V PROFIsafe (Page 101)

Diagnostic Functions of the EM 4/8 F-DI DC24V PROFIsafe (Page 130)

Diagnostic functions of EM 4 F-DI/3 F-DO DC24V PROFIsafe (Page 156)

Diagnostic Functions of the EM 4 F-DO DC24V/2 A PROFIsafe (Page 172)

Diagnostic functions of EM 1 F-RO DC24V/AC24..230V/5A (Page 184)

General Technical Specifications

6

6.1 Introduction

This chapter

This chapter provides information about fail-safe modules:

- The most important standards and approvals
- General technical specifications

General Technical Specifications

The General Technical Specifications comprise the standards and test values with which the fail-safe modules must comply when installed in an ET 200S and the test criteria for fail-safe modules on the one hand, and requirements of fail-safe modules in terms of shipping, storage and environmental conditions.

6.2 Standards and Approvals

CE approval

CE

The ET 200S fail-safe modules meet the requirements and protection targets of the following EC Directives and comply with the harmonized European standards that have been issued for PLCs in the official gazettes of the European Community:

- 2006/108/EC "Electrical equipment for use within specific voltage limits" (Low-voltage directive)
- 2004/108/EC "Electromagnetic Compatibility" (EMC Directive)
- 94/9/EC "Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres" (Explosion Protection Guideline)

The EC declarations of conformity are kept available for the relevant authorities at:

Siemens Aktiengesellschaft
Industry Sector
IA AS RD ST
P.O. Box 1963
D-92209 Amberg

UL approval

Underwriters Laboratories Inc., in accordance with
- UL 508 (Industrial Control Equipment)

CSA Approval

Canadian Standard Association (CSA) in accordance with
- C22.2 No. 142 (Process Control Equipment)

or

Underwriters Laboratories Inc., in accordance with
- UL 508 (Industrial Control Equipment)
- CSA C22.2 No. 142 (Process Control Equipment)

or

Underwriters Laboratories Inc., in accordance with
- UL 508 (Industrial Control Equipment)
- CSA C22.2 No. 142 (Process Control Equipment)
- UL 1604 (Hazardous Location)
- CSA-213 (Hazardous Location)

APPROVED for use in
Class I, Division 2, Group A, B, C, D Tx;
Class I, Zone 2, Group IIC Tx

Note

The nameplate on each module indicates the currently valid approvals.

FM Approval

Factory Mutual Research (FM) to

- Approval Standard Class Number 3611, 3600, 3810

APPROVED for use in
Class I, Division 2, Group A, B, C, D Tx;
Class I, Zone 2, Group IIC Tx

In accordance with EN 60079-15 (Electrical Apparatus for Potentially Explosive Atmospheres; Type of Protection "n")

II 3 G Ex nA II T4..T5

WARNING

There is a risk of personal injury or damage to property.

In areas exposed to explosion hazard, personal injury or damage to property can occur if plug-in connections are disconnected during operation.

Before disconnecting plug-in connections in areas exposed to explosion hazard, always de-energize the distributed I/O first.

Marking for Australia

The fail-safe modules of the ET 200S satisfy the requirements of AS/NZS 2064 (Class A).

IEC 61131

The fail-safe modules of the ET 200S satisfy the requirements and criteria of IEC 61131-2 (Programmable Controllers - Part 2: Equipment Requirements and Tests).

PROFIBUS Standard

The ET 200S distributed I/O system is based on the IEC 61784-1:2003 standard.

Shipbuilding approval

Submitted to the following classification bodies
(exception: PM-D F DC24V PROFIsafe to GL (German Lloyd) only):
ABS (American Bureau of Shipping)
BV (Bureau Veritas)
DNV (Det Norske Veritas)
GL (Germanischer Lloyd)
LRS (Lloyds Register of Shipping)
Class NK (Nippon Kaiji Kyokai)

Use in Industry

SIMATIC products are designed for use in industrial environments.

Field of Application	Requirement Relating to	
	Emitted Interference	Immunity to Interference
Industry	EN 61000-6-4	EN 61000-6-2

Use in Residential Areas

ET 200S applications in residential areas must be compliant with limit class B to EN 61000-6-4 for emission of radio interference.

Suitable measures for achieving limit class B for emission of radio interference are:

- Installing the ET 200S in grounded control cabinets/control boxes
- Use of filters in power supply lines

TÜV Certificate and Standards

The fail-safe modules are certified in accordance with standards and guidelines in terms of functional safety. Refer to the report on the safety certificate (TÜV certificate) and the associated annex for more details in this regard. The current TÜV documents can be found on the Internet (http://support.automation.siemens.com/WW/view/en/12461959/133300).

Requesting TÜV Certificates

You can request copies of the TÜV certificate and the accompanying report from the following address:

Siemens Aktiengesellschaft
Industry Sector
IA AS RD ST
P.O. Box 1963
D-92209 Amberg

See also

Safety engineering in SIMATIC S7
(http://support.automation.siemens.com/WW/view/en/12490443)

6.3 Electromagnetic Compatibility

Introduction

This chapter presents information about immunity to interference of fail-safe modules and about EMC conformity.

Definition of EMC

Electromagnetic compatibility is the ability of an electrical device to function in its electromagnetic environment in a satisfactory manner without affecting this environment.

Fail-safe modules also comply with the requirements of the EMC law for the European Single Market. As a requirement, the ET 200S distributed I/O system must comply with the specifications and guidelines for electrical configuration.

Pulse-Shaped Interference

The following table presents the electromagnetic compatibility of fail-safe modules with regard to pulse-shaped interference.

Pulse-Shaped Interference	Tested With	Degree of Severity
Electrostatic discharge in accordance with IEC 61000-4-2 (DIN VDE 0843 Part 2)	8 kV 6 kV (cabinet installation mandatory) 4 kV (no cabinet installation)	3 (air discharge) 3 (contact discharge)
Burst pulse (rapid transient interference) in accordance with IEC 61000-4-4 (DIN VDE 0843 Part 4)	2 kV (supply line) 2 kV (signal line)	3 4
Zone B in accordance with IEC 61131-2 Surge in accordance with IEC 61000-4-5 (DIN VDE 0839 Part 10) Degrees of severity 2 and 3 require an external protective circuit (see paragraph below) More stringent requirements to EN 298 regarding electromagnetic interference for modules which conform to this standard.		
Asymmetrical connection	1 kV (supply line) 1 kV (signal lead/data lead)	2
Symmetrical connection	2 kV (supply line) 0.5 kV (supply line) 0.5 kV (signal lead/data lead) 1 kV (supply line) 1 kV (signal lead/data lead)	3 2 3

Protecting the ET 200S with Fail-Safe Modules from Overvoltage

If your equipment makes protection from overvoltage necessary, we recommend that you use an external protective circuit (surge filter) between the load voltage power supply and the load voltage input of the terminal modules to ensure surge immunity for the ET 200S with fail-safe modules.

Note

Lightning protection measures always require a case-by-case examination of the entire system. Nearly complete protection from overvoltages, however, can only be achieved if the entire building surroundings have been designed for overvoltage protection. In particular, this involves structural measures in the building design phase.

Therefore, for detailed information regarding overvoltage protection, we recommend that you contact your Siemens representative or a company specializing in lightning protection.

The following figure illustrates an example configuration with F-modules and standard modules and the power modules PM-E DC24..48V/AC24..230V and PM-E F pm DC24V PROFIsafe. Voltage is supplied over four power supplies.

You can also use fewer power supplies. However, you must ensure that the total current of the modules fed by one power supply does not exceed the permissible limits.

You can also use power modules PM-E DC24V. The protective circuit corresponds to that of the PM-E DC24..48V/AC24..230V + automatic circuit breaker (as with PM-E F pm DC24V PROFIsafe).

For further information about surge protection for standard modules, see the *ET 200S Distributed I/O System* operating instructions.

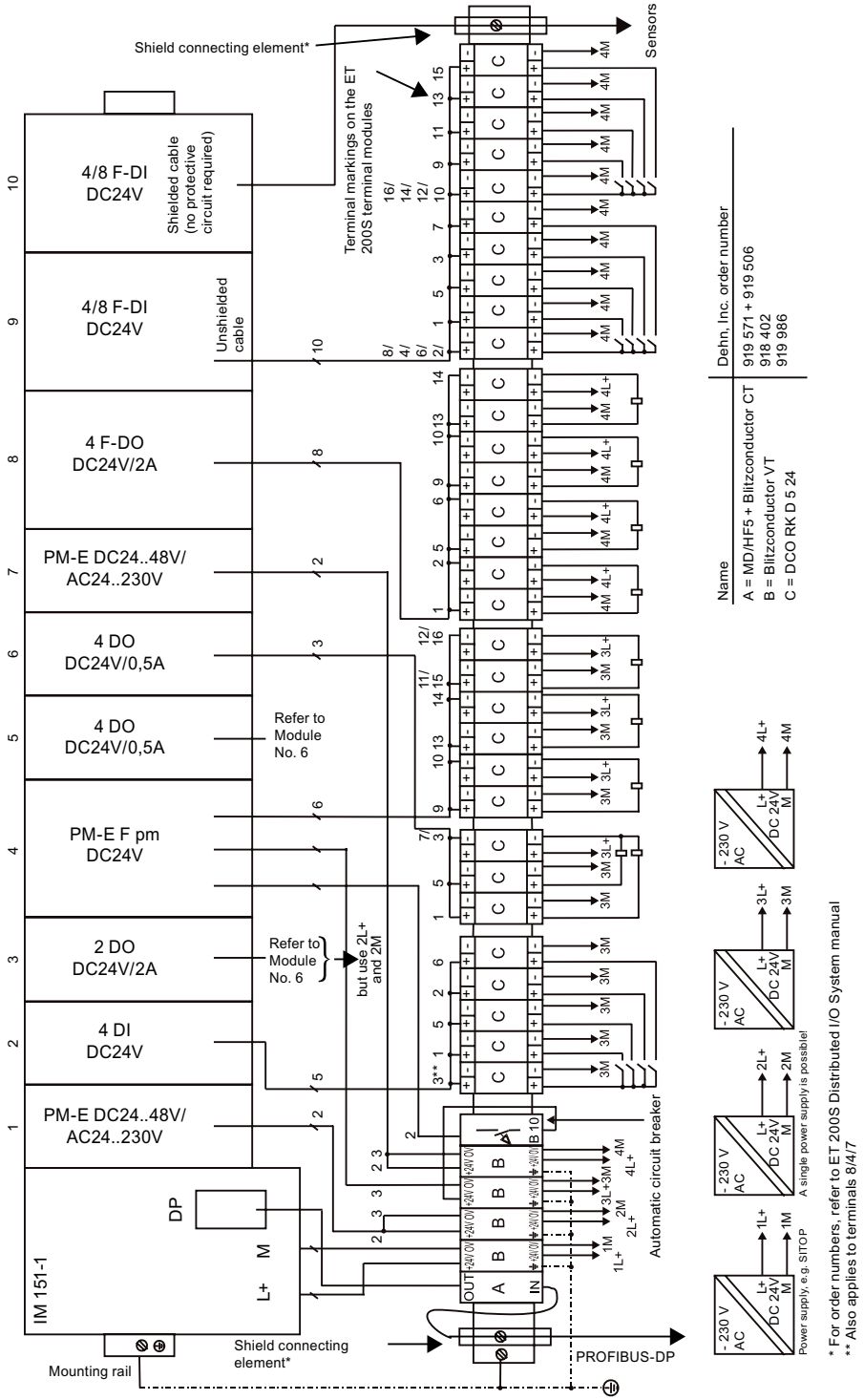


Figure 6-1 External Protective Circuit (Surge Filter) for ET 200S with Fail-Safe Modules

Sinusoidal interference

HF radiation:

Tested in accordance with IEC 61000-4-3, "Radiated Electromagnetic Field Requirements"

- Standard test:
  - from 80 MHz through 1 GHz, tested at 10 V/m and 20 V/m; 80 % AM (1 kHz)
  - from 1.4 GHz through 2.7 GHz, tested at 10 V/m; 80 % AM (1 kHz)
- GSM/ISM/UMTS field interference of different frequencies (Standard: EN 298: 2004, IEC 61326-3-1)

Electromagnetic interference on signal and data lines:

Tested in accordance with IEC 61000-4-6, "Testing and measurement techniques – Immunity to conducted disturbances induced by radio-frequency fields"

- Standard test:
  - RF band, asymmetrical, amplitude modulated:

    from 0.15 MHz through 80 MHz, tested at 10 V and 20 V rms; 80% AM (1 kHz)
- ISM interference of different frequencies (Standard: EN 298: 2004, IEC 61326-3-1)

Radio Interference Emission

Interference transmission of electromagnetic fields in accordance with EN 55011: Limit class A, group 1 (measured at a distance of 10 m).

Frequency	Emitted Interference
Between 30 MHz and 230 MHz	< 40 dB (µV/m)Q
Between 230 MHz and 1000 MHz	< 47 dB (µV/m)Q

Emitted interference by means of network-AC power supply in accordance with EN 55011: Limit class A, group 1.

Frequency	Emitted Interference
Between 0.15 MHz and 0.5 MHz	< 79 dB (µV)Q, < 66 dB (µV)M
Between 0.5 MHz and 5 MHz	< 73 dB (µV)Q, < 60 dB (µV)M
Between 5 MHz and 30 MHz	< 73 dB (µV)Q, < 60 dB (µV)M

6.4 Shipping and Storage Conditions

Requirements for Fail-Safe Modules

Fail-safe modules surpass the requirements for transport and storage conditions defined in IEC 61131, Part 2. The following specifications apply for fail-safe modules that are transported and stored in the original packaging.

Type of Condition	Permissible Range
Free fall	≤ 1 m
Temperature	From –40 °C to +70 °C
Temperature variation	20 K/h
Air pressure	1080 hPa to 660 hPa (corresponds to an altitude of -1000 m to 3500 m)
Relative humidity	5% to 95%, no condensation

6.5 Mechanical and Climatic Environmental Conditions

Conditions of Use

The F-modules are intended for use as stationary installations in sheltered locations. The conditions of use surpass the requirements in accordance with IEC 61131-2.

Fail-safe modules comply with conditions of use Class 3C3 in accordance with DIN EN 60721 3-3 (use in locations with heavy traffic and in the immediate vicinity of industrial systems with chemical emissions).

Restrictions

F-modules **cannot** be implemented without additional measures being taken:

- In locations with a high level of ionizing radiation
- In locations with severe operating conditions, due for example to:
  - Dust
  - Corrosive vapors or gases
- In systems which require special monitoring, such as:
  - Electrical systems in particularly hazardous areas

An additional measure for the implementation of fail-safe modules can be installing the ET 200S in cabinets, for example.

Mechanical Environmental Conditions

The table below shows the mechanical environmental conditions for F-modules in the form of sinusoidal oscillations.

Frequency Range (Hz)	Continuous	Intermittent
10 ≤ f ≤ 58	Amplitude = 0.15 mm	Amplitude = 0.35 mm
58 ≤ f ≤ 150	Constant acceleration = 2 g	Constant acceleration = 5 g

Reduction of Vibration

If the F-modules are exposed to substantial shock or vibration, you must take appropriate measures to reduce the acceleration and amplitude.

We recommend that you mount the ET 200S on damping material (for example, on a rubber-metal vibration damper).

Testing of Mechanical Environmental Conditions

The table below provides information about the type and scope of testing of mechanical environmental conditions.

Condition ...	Test Standard	Comments
Vibration	Vibration test in accordance with IEC 60068-2-6 (sinusoidal)	Type of vibration: Frequency cycles at a rate of change of 1 octave/minute. 10 Hz ≤ f ≤ 58 Hz, constant amplitude 0.35 mm 58 Hz ≤ f ≤ 150 Hz, constant acceleration 5 g Duration of vibration: 10 frequency cycles per axis at each one of the three perpendicular axes
Shock	Shock, tested in accordance with IEC 60068-2-27	Shock type: Half-sine Shock severity: 15 g peak value, 11 ms duration Direction of shock: 3 shocks in +/- direction at each of the three perpendicular axes
Continuous shock	Shock, tested in accordance with IEC 60068-29	Shock type: Half-sine Shock severity: 25 g peak value, 6 ms duration Direction of shock: 1000 shocks in +/- direction at each of the three perpendicular axes

Climatic Environmental Conditions

ET 200S with fail-safe modules can be used under the following climatic environmental conditions:

Environmental Conditions	Operating Range	Comments
Temperature	0 °C to 60 °C	For horizontal installation
	0 °C to 40 °C	For vertical installation
Temperature variation	10 K/h	
Relative humidity	15 % to 95 %	No condensation; corresponds to relative humidity (RH) stress level 2 in accordance with IEC 61131-2
Air pressure	1080 hPa to 795 hPa	Corresponds to an altitude of -1000 m to 2000 m
Pollutant concentration	 SO_2: < 0.5 ppm; relative humidity < 60%, no condensation H_2S: < 0.1 ppm; relative humidity < 60%, no condensation	Test: 10 ppm; 4 days 1 ppm; 4 days
	ISA-S71.04 severity level G1; G2; G3	—

6.6 Specifications for Nominal Line Voltages, Isolation Tests, Protection Class, and Type of Protection

Rated Voltages for Operation

The fail-safe signal modules operate at a rated voltage of 24 VDC. The tolerance range is = 20.4 VDC to 28.8 VDC.

Test Voltages

Refer to the technical specifications of the fail-safe modules for information regarding the test voltages.

Protection Class

Protection class I in accordance with IEC 60536 (VDE 0106, Part 1), i.e. ground terminal required on DIN rail!

Type of Protection

Type of protection IP20 to EN 60529 for all F-modules, that is:

- Protection from contact with standard probes
- Protection from foreign bodies larger than 12.5 mm in diameter
- No special protection against water

See also

Safe Functional Extra Low Voltage for Fail-Safe Modules (Page 33)

Fail-Safe Modules

7

7.1 Introduction

This chapter

Fail-safe power modules and fail-safe digital modules are available for connecting digital sensors/encoders and actuators/loads to the ET 200S. This chapter provides the following information for each fail-safe module:

- Properties and special features
- Front view, terminal assignment for terminal modules and the block diagram
- Wiring diagram and programmable parameters
- Diagnostic functions, including corrective measures
- Technical specifications

WARNING

The safety characteristics in the technical specifications apply for proof test intervals of 20 years and repair times of 100 hours. If a repair within 100 hours is not possible, then remove the respective module from the terminal module or switch off its supply voltage before 100 hours expires.

Then proceed as described in the chapter "Reactions to Faults (Page 41)".

Description of Usable Standard Power Models and Terminal Modules

Usable standard power modules and terminal modules are described in the ET 200S distributed I/O system operating instructions.

7.2 PM-E F pm DC24V PROFIsafe Power Module

7.2.1 Properties of the PM-E F pm DC24V PROFIsafe Power Module

Order Number

6ES7138-4CF03-0AB0

Properties

The PM-E F pm DC24V PROFIsafe power module possesses the following properties:

- 2 relays for switching the voltage buses P1 and P2, output current = 10 A
- 2 fail-safe digital outputs, P/M-switching, output current 2 A
- Rated load voltage 24 VDC
- Suitable for solenoid valves, DC contactors and indicator lights
- Group fault display (SF; red LED)
- Status display for each output (green LED)
- Status display for load current power supply (PWR; green LED)
- Assignable diagnostics
- Achievable safety classes are listed in the table below

Note

The PM-E F pm DC24V PROFIsafe power module is not suitable for the supply of F-SMs.

Table 7- 1 Overview of available safety classes with PM-E F pm DC24V PROFIsafe

PM-E F pm DC24V PROFIsafe			Maximum Attainable Safety Class
Relay outputs P1 and P2	Without standard DO modules	Signal switches daily or more often	SIL3/Category 4/PLe
		Signal switches less than once a day	SIL2/Category 3/PLd
	With standard DO modules refer to the Internet (http://support.automation.siemens.com/WW/view/en/12461959/133300)		SIL2/Category 3/PLd
Electronic outputs DO 0 and DO 1	refer to the applications in the "Wiring of the PM-E F pm DC24V PROFIsafe (Page 70)" chapter.		SIL3/Category 4/PLe

Two Fail-Safe Digital Outputs

In addition to the voltage buses P1 and P2, the power module has two fail-safe digital outputs DO0 and DO1. You can achieve SIL3/Category 4/PLe with these outputs.

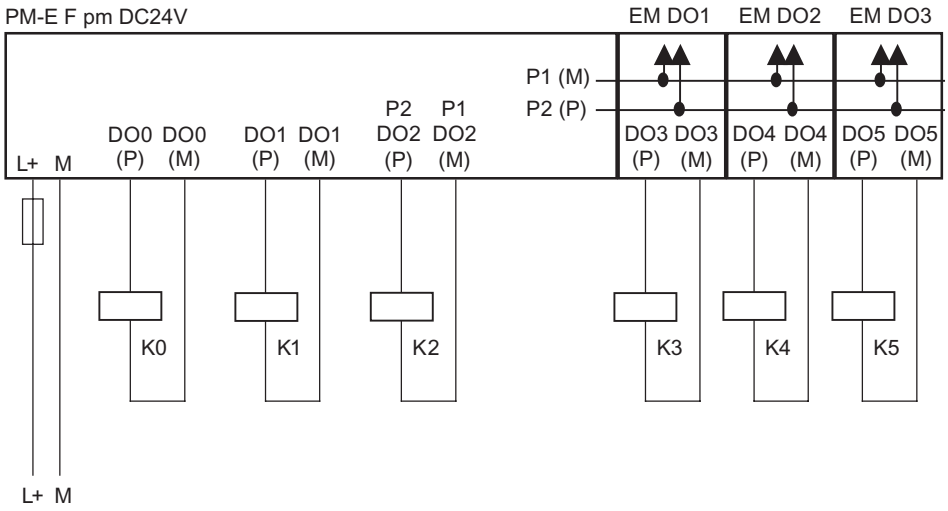


Figure 7-1 Wiring diagram of the PM-E F pm DC24V PROFIsafe

Power Module Supplies for Standard ET 200S Modules

WARNING

Always connect the 24 VDC supply for the standard ET 200S modules on the PM-E F pm DC24V PROFIsafe. Otherwise, the outputs of DO modules may exhibit safety critical behavior.

WARNING

When supplying standard DO modules, always use the terminal modules to supply the actuators (actuator feedback on the DO module).

Refer also to the section "Switching grounded loads".

Safety-Related Shutdown of Standard Output Modules

Refer to the Internet (http://support.automation.siemens.com/WW/view/en/12461959/133300) for a list of all the standard ET 200S modules.

⚠ WARNING

Safety-related activation of standard DO module outputs is not possible. Only safety-related **shutdown** is possible. The following issues must therefore be taken into consideration:

In the worst case you must consider all possible faults of the standard DO modules and the programs controlling them for which the faults cannot be found directly. For example, the PM-E F pm DC24V PROFIsafedoes not detect external short-circuits to L+ at the standard DO module outputs. All faults developing at the standard DO modules influence the process via final controlling elements. The process status must be made known to the F-CPU by way of sensors and a suitable safety program.

Diagnostic functions must be handled indirectly in the controlled process since the self-test function of standard DO modules cannot be used to detect safety-critical faults: The safety control function does not intervene in the faulty process as long as hazards can be excluded. However, it shuts down the system if the process develops unwanted or potentially dangerous activities.

Consequently, instead of the short fault reaction times defined in S7, the reaction time to internal faults in standard DO modules is determined by the controlled process and its corresponding feedback signals.

Safety-related process values must be

- safely
- read in by way of fail-safe input modules, such as an F-DI,
- prepared by the F-CPU for command output and
- output at the fail-safe output module for shutdown of the corresponding safety relay or
- output at the fail-safe power module PM-E F.

If the process does not respond as expected due to malfunctions within a process or faulty standard DO modules, these standard DO modules must be set to safe state by way of the higher-level safety circuit.

The process safety time is of particular importance here. Risks due to any malfunctions within the process control system can be ruled out within this process safety time.

The safety program must react in a safety-related and logically suitable fashion to unwanted or potentially dangerous states in the process via the PM-E F pm DC24V PROFIsafe and fail-safe output modules.

If you want to avoid the problems described above completely, we recommend that you use P/M-switching fail-safe electronic modules 4 F-DO DC24V/2A PROFIsafe with standard ET 200S power modules (see *"Digital electronic module 4 F-DO DC24V/2A PROFIsafe"* and the *table "Assigning power modules to electronic modules / motor starters and safety class"*).

Property of safety-oriented tripping of standard DO modules with the PM-E F pm DC24V PROFIsafe:

This cost-effective solution allows the full and simultaneous shutdown of all outputs involved when a fault is detected in the process or on the PM-E F pm DC24V PROFIsafe.

Property of the individual shutdown of F-modules with fail-safe outputs:

The scope of shutdown is kept to a minimum when a fault is detected. It is also possible to react to critical process states staggered over time, or to perform safety-related shutdown of individual outputs.

Switching Grounded Loads

If the PM-E F pm DC24V PROFIsafe switches loads that have a chassis-ground connection (for example to improve EMC characteristics) **and** if chassis and ground are connected at the power supply being used, a "short-circuit" is detected.

From the perspective of the F-module, the M-switch is bridged by the chassis-ground connection (refer to the diagram below as an example of an PM-E F pm DC24V PROFIsafe).

For the PM-E F pm DC24V PROFIsafe, as of Order No. 6ES7138-4CF02-0AB0, release version 02, the resistance to capacitive loads between the M switch and chassis was increased from approx. 1 µF to around 20 µF.

Remedy:

- Using the PM-E F pp DC24V PROFIsafe
- The value of the resistance between chassis and ground at the load end must be greater than 100 kΩ
- The capacity value at the load end between chassis and ground must be less than 20 µF.

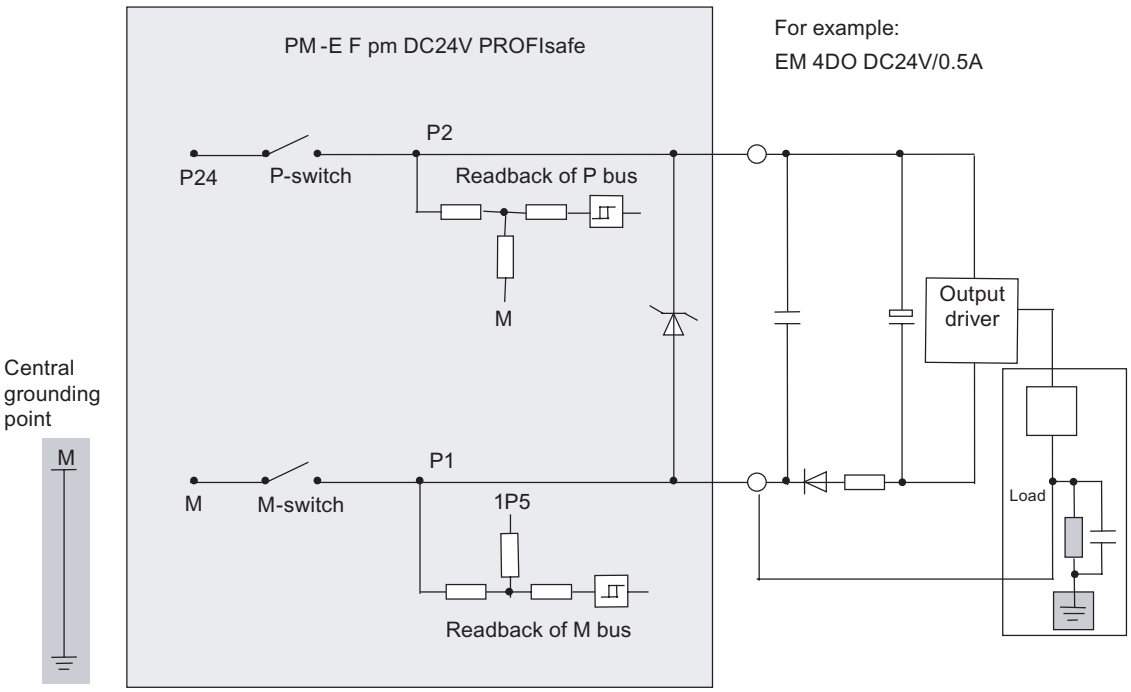


Figure 7-2 Switching Grounded Loads (resistance exists between chassis and ground)

⚠ WARNING

During startup, the PM-E F pm DC24V PROFIsafe carries out a power on self-test that takes around 3 ms. The load capacitance between chassis and ground is charged by way of the load resistance. This low charging current may briefly trigger sensitive load circuits.

Capacitive Crosstalk of Digital Input/Output Signals

Readback errors may occur on the PM-E F pm DC24V PROFIsafe power module or on the F-DO modules if the fail-safe digital output and fail-safe digital input signals are routed through one cable. The module signals a short circuit in this situation.

Cause

The steep switching edge of the output driver during the sensor supply test of the 4/8 F-DI DC24V PROFIsafe module may lead to crosstalk on other inactive output channels due to the coupling capacitance of the wire, for example, on the PM-E F pm DC24V PROFIsafe power module. This situation may lead to a response in the readback circuit in these channels. The module detects a cross circuit and performs safety-related shutdown.

Remedy

- Use separate cables for the F-DI modules and F-DO modules or standard DO modules that are controlled by a PM-E F pm DC24V PROFIsafe.
- Coupling relay or diodes in the outputs
- Disable the sensor supply test if safety class requirements allow this.

See also

Assigning Modules of an ET 200S (Page 22)

Properties of the 4 F-DO DC24V/2A PROFIsafe digital electronic module (Page 163)

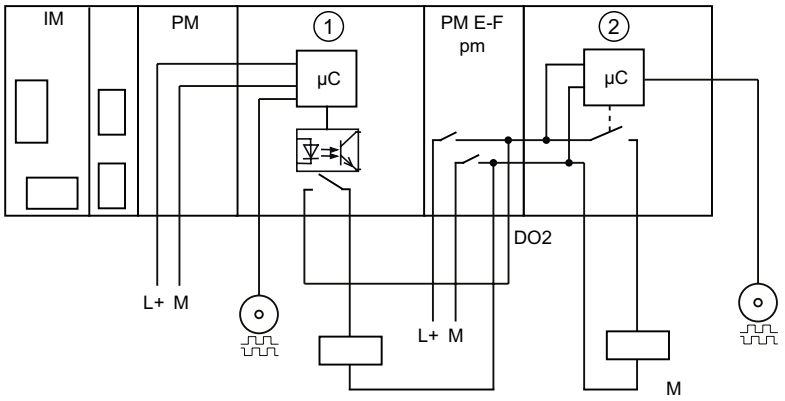
7.2.2 Terminal assignment of the PM-E F pm DC24V PROFIsafe

Incoming 24 VDC supply to Electronic Modules with Technology Functions

Depending on whether the electronic and load current supplies are electrically isolated in the electronic modules with technology functions (positioning, counting), you must comply with the following wiring rules:

- If electrically isolated, you can connect the electronic module to an external 24 VDC power supply.
- If not electrically isolated, you must supply the electronic module from voltage bus P1 and P2 of the PM-E F pm DC24V PROFIsafe.

SIL2/Category 3/PLd is attainable in both cases.



① Technology module with electrically isolated DO

② Technology module without electrically isolated DO

Front View

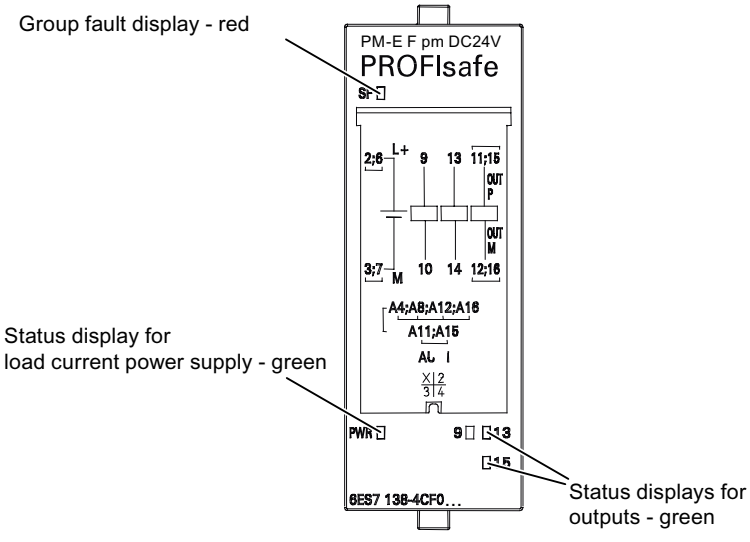


Figure 7-3 Front view PM-E F pm DC24V PROFIsafe

WARNING

The SF LED and the status displays of the inputs/outputs are not designed for safety-related functions and may therefore not be evaluated for safety-related activities.

Terminal Assignment

The following figure and the following table show the terminal assignment of the PM-E F pm DC 24V PROFIsafe for the supported terminal modules TM-P30S44-A0 or TM-P30C44-A0.

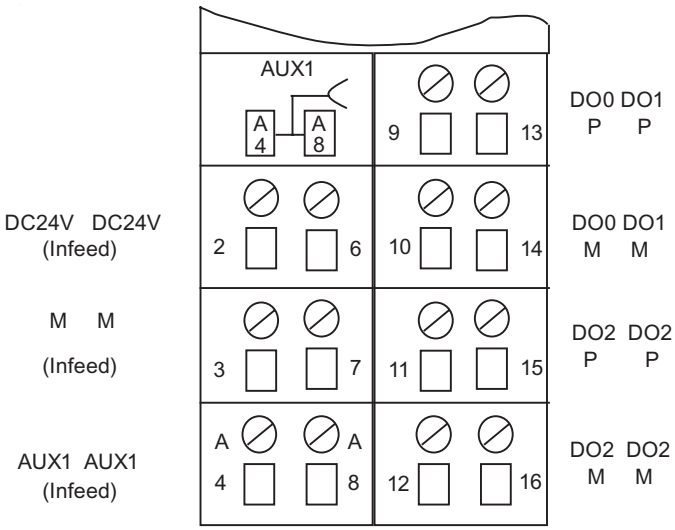


Figure 7-4 Terminal assignment TM-P30S44-A0 or TM-P30C44-A0 for PM-E F pm DC 24V PROFIsafe

Table 7- 2 Terminal assignment of the TM-P30S44-A0 or TM-P30C44-A0

Terminal		Designation
2	24 VDC	24 VDC rated load voltage for: • Inserted power module • Corresponding potential group • DO 0 and DO 1 • Voltage buses P1 and P2
3	M	Ground
A 4	AUX 1	Any terminal for PE or voltage bus up to the maximum rated load voltage of the module
6	24 VDC	24 VDC rated load voltage for: • Inserted power module • Corresponding potential group • DO 0 and DO 1 • Voltage buses P1 and P2
7	M	Ground

Terminal		Designation
A 8	AUX 1	Any terminal for PE or voltage bus up to the maximum rated load voltage of the module
9	DO 0 P	Terminals for fail-safe digital output 0 (P/M-switching)
10	DO 0 M	
11	DO 2 P	Terminals (relay contacts) for fail-safe switching of voltage buses P1 and P2 P1 and P2 can also be used as DO 2 M and DO 2 P
12	DO 2 M	
13	DO 1 P	Terminals for fail-safe digital output 1 (P/M-switching)
14	DO 1 M	
15	DO 2 P	Terminals (relay contacts) for fail-safe switching of the voltage buses P1 and P2 P1 and P2 can also be used as DO 2 M and DO 2 P
16	DO 2 M	

⚠ CAUTION

If high currents can occur on DO 2 P and DO 2 M, you must wire terminals 11 and 15 (DO 2 P) and 12 and 16 (DO 2 M) in parallel.

Otherwise, high current loads may cause the terminals to heat up.

7.2.3 Wiring of the PM-E F pm DC24V PROFIsafe

Block Diagram

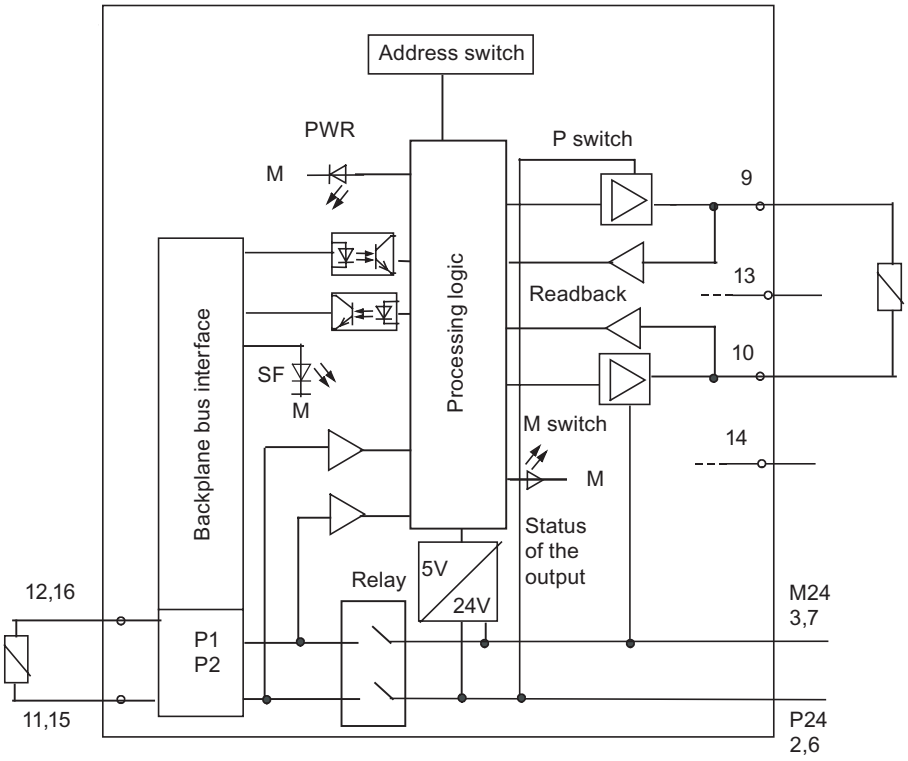


Figure 7-5 Block diagram of the PM-E F pm DC24V PROFIsafe

Application 1: Wiring a load to each digital output

The two switches are always energized so that voltage is applied to the load. The two switches are always activated so that voltage is applied to the load.

Wire the PM using the special terminal module.

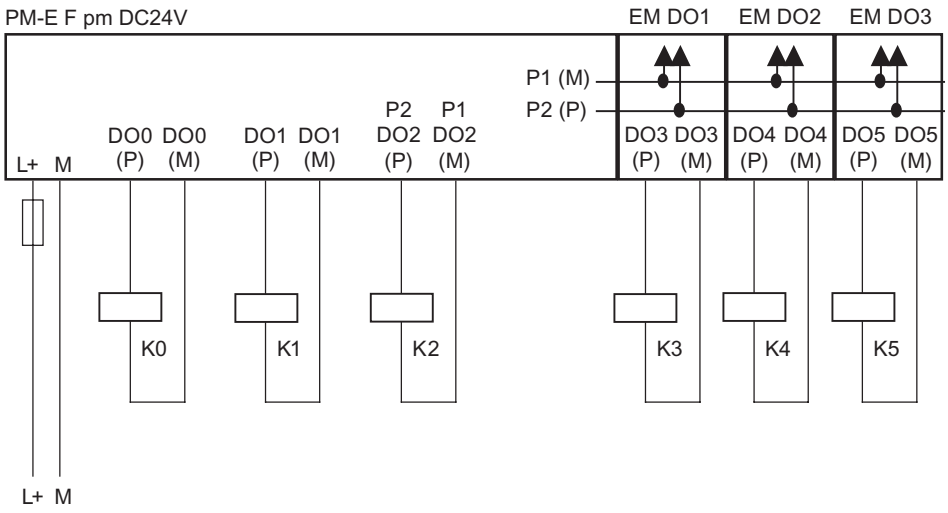


Figure 7-6 Wiring diagram of the PM-E F pm DC24V PROFIsafe

Note

In order to achieve SIL3/Category 4/PLe with this wiring, you must install a suitably-qualified sensor, for example in accordance with IEC 60947.

WARNING

Please always use an external fuse for L+ at the PM-E F pm with the following properties to protect the relay contacts from overload: Circuit-breaker, characteristics B, 10 A.

Relay Output DO 2

The relay output DO 2 connects the voltage L+ and M using one relay contact for each. The voltage is fed outwards to the terminal module and to the internal voltage buses P1 and P2. This results in two connection options that can also be used at the same time if desired:

- A load can be connected directly to the terminal module (K2 in the figure above)
- Electronic modules can be supplied by means of the internal voltage buses P1 and P2. Loads can be connected to these modules in turn (K3, K4, K5 in the figure above)

Application 2: Wiring loads to L+ and M at each digital output

You can connect two relays using one fail-safe digital output. The following conditions should be kept in mind:

- L+ and M of the relays must be connected with L+ and M of the PM-E F pm (reference potential must be equal).
- The normally open contacts of the two relays must be connected in series.

This connection can only be made on digital outputs DO 0 and DO 1 (not DO 2). With this circuit, you achieve:

- SIL3/Category 4/PLe

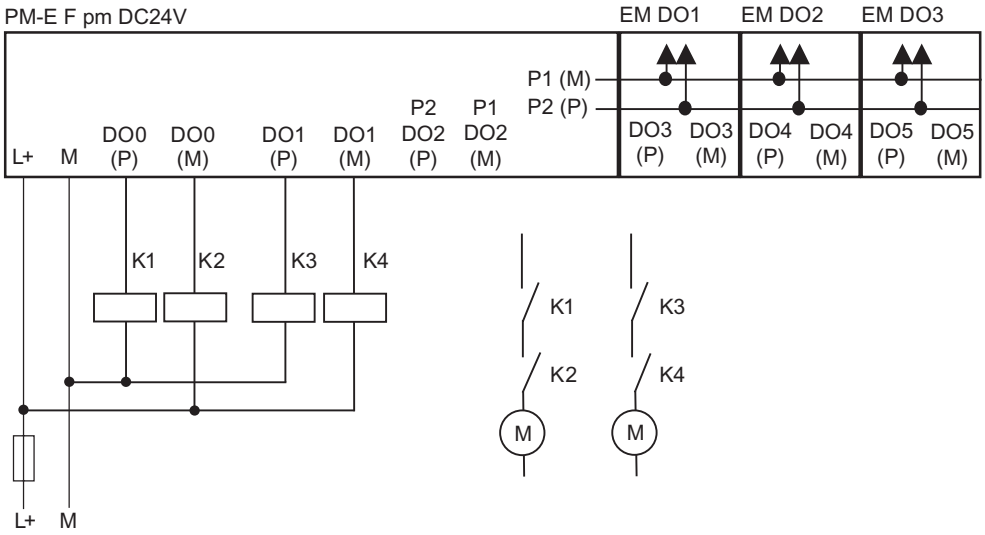


Figure 7-7 Wiring diagram for each of two relays on DO 0 and DO 1 of the PM-E F pm DC24V PROFIsafe

⚠ WARNING

When connecting two relays on one digital output (as shown in the figure above), the errors "wire break" and "overload" are detected only at the P-switch of the output (not at the M-switch).

WARNING

The controlled actuator can no longer be switched off when there is a cross circuit between the P and M-switches of the output. To avoid cross circuits between the P and M-switches of a fail-safe digital output, you should always wire the relay connection to the P and M-switches separately, in order to prevent any cross-circuits (for example with separately-sheathed cables or using separate cable ducts).

Note

The PM-E F pm DC24V PROFIsafe carries out a bit pattern test every 15 minutes or so. The module then sends an impulse for max. 4 ms. This test is executed deferred between P and M-switches, so that the actuator is not switched on. This impulse may cause the corresponding relay to tighten, which may reduce its service life.

We therefore recommend adhering to the wiring scheme detailed below.

Application 3: Wiring two loads in parallel to each digital output

Avoiding / Managing Cross Circuits:

To protect against cross circuits between P and M-switches in fail-safe digital outputs, we recommend the following wiring scheme:

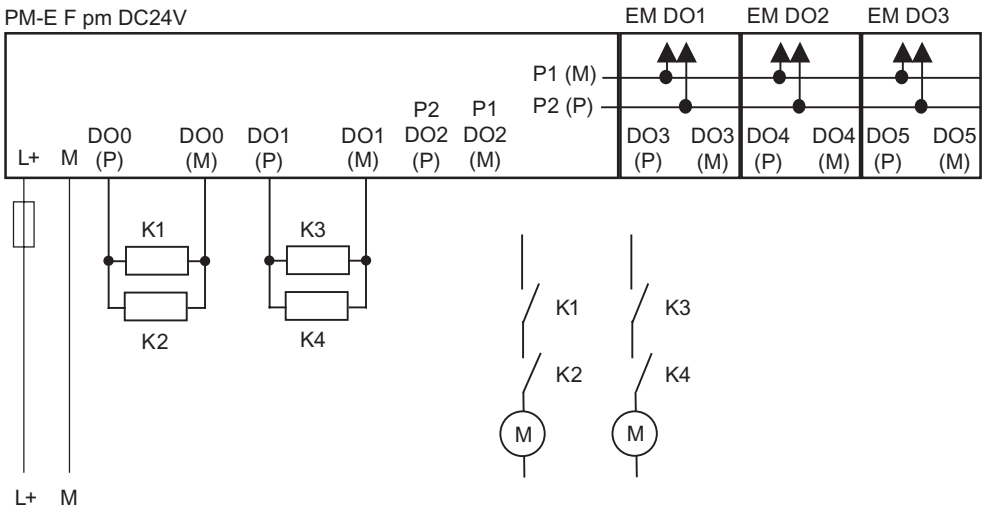


Figure 7-8 Wiring diagram for each of two relays parallel on DO 0 and DO 1 of the PM-E F pm DC24V PROFIsafe

Note

With parallel connection of two relays to one digital output (as shown above), the "wire break" fault is only detected if the wire break disconnects both relays from P or M. This diagnosis is not safety-related.

7.2.4 Parameters of the PM-E F pm DC24V PROFIsafe

Parameters in *STEP 7*

The table below lists the parameters that can be set for the PM-E F pm DC24V PROFIsafe.

Table 7- 3 Parameters of the PM-E F pm DC24V PROFIsafe

Parameter	Range	Default	Type of Parameter	Effective Range
F-Parameters:				
F_destination_address	1 to 1022	is assigned by *STEP 7*	Static	Module
F monitoring time	10 to 10 000 ms	150 ms	Static	Module
Module Parameters:				
Behavior after channel faults*	Passivate the entire module/Passivate the channel	Passivate the entire module	Static	Module
DO channel 0	Activated/deactivated	Activated	Static	Channel
Readback time	1 to 400 ms	1 ms	Static	Channel
Diagnostics: Wire break	Activated/deactivated	Deactivated	Static	Channel
DO channel 1	Activated/deactivated	Activated	Static	Channel
Readback time	1 to 400 ms	1 ms	Static	Channel
Diagnostics: Wire break	Activated/deactivated	Deactivated	Static	Channel
* This setting is relevant only with an installed *S7 distributed safety* V 5.4 or higher or generally with *S7 F systems* optional packages.				

Readback Time Parameter

Each output channel has its own selectable readback time. This time specifies the maximum duration of the turn off test for the corresponding channel and therefore also the readback time for turning off the channel.

The following readback times can be set: 1 ms, 5 ms, 10 ms, 50 ms, 100 ms, 200 ms and 400 ms.

You should set an adequately high readback time if the channel involved switches high capacitive loads. If the readback time for a controlled capacitive load is set too low, the output channel is passivated because the discharge of the capacitance does not take place within the turn off test.

If the readback signals are incorrect, the "short circuit" fault only causes passivation of the output channel after the readback time has elapsed.

Note

Note that an inductive load connected to the DO channels can induce voltages in the case of electromagnetic interference of a strong magnetic field. This can cause a short-circuit error message.

Remedy:

- Spatially disconnect the inductive loads or shield against the magnetic field.
- Set the parameters for the readback time to 50 ms or higher.

⚠ WARNING

With a configured readback time of ≥ 50 ms, short-circuits (cross circuits) can be suppressed with an interference signal with a frequency > 10 Hz (50:50 duty cycle).

Short-circuits (cross circuits) on an output of the same module will be detected.

7.2.5 Diagnostic functions of the PM-E F pm DC24V PROFIsafe

Behavior in Case of Supply Voltage Failure

The failure of the PM-E F pm DC24V PROFIsafe power supply is always indicated by the PWR LED on the module (light off). This information is also provided in the module (diagnostic entry). Either all channels of the module are passivated or, in case of channel-specific passivation, only the relevant channels are passivated.

In the case of a voltage dip in the external auxiliary voltage, the SF LED lights up, the module is passivated.

With the subsequent supply recovery (level must remain above the specified value for at least 1 minute (refer to the technical specifications: voltages, currents, electrical potentials)) the SF LED goes out again, the module remains passivated. The SF LED flashes if there are no other errors, until the error is acknowledged.

Diagnostic functions

The table below provides an overview of the diagnostic functions of the PM-E F pm DC24V PROFIsafe. The diagnostic functions are assigned either to one channel or to the entire module.

Table 7- 4 Diagnostic functions of the PM-E F pm DC24V PROFIsafe

Diagnostic Function*	Fault Number	LED	Effective Range of Diagnostics	Can be Assigned Parameters
Short circuit	1_H	SF	Channel	No
Overload	4_H	SF	Channel	No
Overtemperature	5_H	SF	Module	No
Wire break	6_H	SF	Channel	Yes
Internal error	9_H	SF	Module	No
Parameter assignment error	10_H	SF	Module	No
Sensor voltage or load voltage missing	11_H	SF	Module	No
Communication error	13_H	SF	Module	No
Safety-related shutdown	19_H	SF	Channel	No
*: Specially for F-modules; display in *STEP 7*, see "Channel-Specific Diagnostics, Fault Types of Fail-Safe Modules" table				

⚠ WARNING

Before acknowledging the short-circuit diagnosis, remedy the respective error and validate your safety function. To do this, proceed as described in chapter "Fault Diagnostics (Page 43)".

Causes of Faults and Corrective Measures

The following table contains the possible causes of the faults described for the individual diagnostic messages of the PM-E F pm DC24V PROFIsafe and remedies.

Table 7- 5 Diagnostic messages of the PM-E F pm DC24V PROFIsafe, causes of errors and remedies

Diagnostic Message	Fault Detection	Possible Causes	Corrective Measures
Short circuit	Always	Short circuit in the actuator	Eliminate the short-circuit.
		Cross circuit in the actuator	Eliminate the cross-circuit within 100 hours after the error has occurred.
		Internal error	Replace module
		Short circuit in P1 and P2 because actuators connected to standard DO modules are not supplied by means of the terminal modules of the standard DO modules	Actuators connected to standard DO modules are supplied via the terminal module of the standard DO module; replace the fuse after a short-circuit Acknowledge the error within 100 hours after the error has occurred
Overload	For output signal "1" only	Output stage is overloaded and becomes too hot	Eliminate overload
Overtemperature	Always	Shutdown due to violation of upper or lower temperature limit value in the module case	Check load wiring, check ambient temperature, check whether permissible output current is exceeded for the ambient temperature. Once the fault has been eliminated, the module must be removed and inserted, or the power switched OFF and ON.
Wire break	for "1" output signal only	Line break	Eliminate broken wire, ensure specified minimum load (see Technical Specifications)
Internal error	Always	Internal module fault has occurred	Replace module
Parameter assignment error	Always	Inserted module does not match configuration; incorrect parameter assignment	Correct the configuration (compare actual and preset configuration). Check communication paths. Correct parameter assignment
		PROFIsafe address set incorrectly in the F-module	Check whether the PROFIsafe address on the module matches the configuration in *HW Config*
Sensor voltage or load voltage missing	Always	Supply voltage not available or too low (e.g. voltage dip on F-module, this can also be caused, among other things, by a short-circuit on the P1/P2 buses.	Check module for correct contact

Diagnostic Message	Fault Detection	Possible Causes	Corrective Measures
Communication error	Always	Error in communication between F-CPU and module, e.g. due to defective PROFIBUS connection or higher than permissible EMI	Check the PROFIBUS/PROFINET connection Eliminate the interference
		PROFIsafe monitoring time set too low	Set a greater value for the "F monitoring time" parameter for the module in *HW Config*
		Configuration of the F-module does not match safety program	Generate safety program again; then load configuration and safety program into F-CPU again
Safety-related shutdown	Always	Switching frequency exceeded	Reduce the switching frequency or use a semiconductor output

Generally Applicable Information on Diagnostics

For information on diagnostics that pertains to all fail-safe modules (e.g. for reading out diagnostic functions, passivating channels), refer to the *"Diagnostics"* chapter in this manual.

See also

Reactions to Faults (Page 41)

7.2.6 Technical Specifications for PM-E F pm 24 VDC PROFIsafe

Overview

Technical Specifications	
Dimensions and Weight	
Dimensions W x H x D (mm)	30 x 81 x 52
Weight	Approx. 88 g
Data for Specific Module	
Number of outputs	
• Semiconductor outputs (P/M switching)	2
• Relay outputs (P/M switching)	1
Assigned address area	
• In the I/O area for inputs	5 bytes
• In the I/O area for outputs	5 bytes
Length of cable*	
• Unshielded	200 m, maximum

Technical Specifications	
• Shielded	200 m, maximum
Maximum achievable safety class	
• according to IEC 61508, according to EN 954, according to ISO 13849	Max. SIL3, category 4, PLe (for conditions see *"Power modulePM-E F pm DC24V PROFIsafe")*
Fail-safe performance characteristics	SIL3
• Low demand mode (average probability of failure on demand)	< 1.00E-05
• High demand/continuous mode (probability of a dangerous failure per hour)	< 1.00E-10
• Acceptance ID	FM, cULus, CE, C-Tick
Voltages, Currents, Potentials	
Rated supply voltage L+	24 VDC
• permissible range **	20.4 V to 28.8 V
• Power loss ride-through of L+	None
• Power loss ride-through of internal P5	5 ms
• Reverse polarity protection	No
Total current	
• Horizontal installation – Up to 40 °C – Up to 55 °C – Up to 60 °C	 10 A 7 A 6 A
• Vertical installation – Up to 40 °C	 6 A
Electrical isolation	
• Between channels and backplane bus	Yes
• Between channels and power supply	No
• Between channels	No
• Between channels/power supply and shield	Yes
Permissible potential difference between	
• Shield and ET 200S bus connection	75 VDC/60 VAC
• Shield and I/O (DOs, P1/P2 buses)	75 VDC/60 VAC
• ET 200S bus connection and I/O (DOs, P1/P2 buses)	250 VAC
Isolation in the series tested with	
• Shield and ET 200S bus connection	500 VDC/1 min or 600 VDC/1 s
• Shield and I/O (DOs, P1/P2 buses)	500 VDC/1 min or 600 VDC/1 s
• ET 200S bus connection and I/O (DOs, P1/P2 buses)	1500 VAC/1 min or 2545 VDC/1 s
Isolation in the type test tested with	
• Shield and ET 200S bus connection	350 VAC/1 min

Technical Specifications	
• Shield and I/O (DOs, P1/P2 buses)	350 VAC/1 min
• ET 200S bus connection and I/O (DOs, P1/P2 buses)	2830 VAC/1 min
• Surge voltage test between ET 200S bus connection and I/O (DOs, P1/P2 buses)	6000 VDC/5 positive and 5 negative pulses
Current consumption	
• From backplane bus	28 mA, maximum
• From load voltage L+ (without load)	100 mA, typical
Power dissipation of the module	4 W, typical
Status, Interrupts, Diagnostics	
Status display	• Green LED per channel • Green LED for the load voltage
Diagnostic functions	
• Group fault display	Red LED (SF)
• Diagnostic information can be displayed	Possible
Data for selecting an actuator for the semiconductor outputs* **	
Output voltage	
• For "1" signal	• Minimum L+ (-2.0 V) • P-switch: minimum L+ (-1.5 V), voltage drop in M-switch: Maximum, 0.5 V
Output current for "1" signal	
• Rated value	2 A
• Permissible range	20 mA to 2.4 A
For "0" signal (residual current)	0.5 mA, maximum
Indirect control of load by means of interface relay:	
Residual current for "0" signal	
• P-switch	0.5 mA, maximum
• M-switch	4 mA, maximum
Load resistance range	12 Ω to 1 kΩ
Lamp load	10 W, maximum
Wire break monitoring (open load detection) and overload monitoring	
• Response threshold	I < 4 to 19 mA
• Fault detection time	depending on the selected readback time (see *"Response Times"*)
Parallel connection of 2 outputs	Not possible
Control of a digital input	Not possible
Switching frequency	
• With resistive load	30 Hz symmetrical, maximum
• With inductive load in accordance with IEC 60947-5-1, DC13	0.1 Hz symmetrical, maximum

Technical Specifications		
• With lamp load	10 Hz symmetrical, maximum	
Voltage induced on current interruption limited to		
• Semiconductor outputs	L+ (-2x 47 V)	
• Relay outputs	P1/P2 (1 V)	
Short-circuit protection of semiconductor outputs	Yes, electronic	
• Response threshold of short circuit	5 A to 12 A	
• Response threshold (external M-short circuit)	5 A to 12 A	
• Response threshold (external P-short circuit)	25 A to 45 A	
Overload protection of semiconductor outputs	Yes	
• Response threshold	I >2.6 A to 2.8 A	
Data for selecting an actuator for the relay outputs* **		
Switching capacity and service life of contacts (voltage 24 VDC)		
• Mechanical endurance (without load)	Current	Number of switching cycles (typ.)
	0 A	10 million
• For resistive load	Current	Number of switching cycles (typ.)
	10 A	0.23 million
	8 A	0.3 million
	6 A	0.38 million
	4 A	0.5 million
	2 A	1.0 million
	1 A	2.0 million
• For inductive load in accordance with IEC 60947-5-1, DC13	Current	Number of switching cycles (typ.)
	10 A	0.1 million
	8 A	0.15 million
	6 A	0.2 million
	4 A	0.3 million
	2 A	0.5 million
	1 A	1.0 million
• For lamp load	Power	Number of switching cycles (typ.)
	100 W	0.12 million
Contact protection (internal)	Internal readback circuit	
• Between P and M relay output	39 V suppressor diode	
Wire break monitoring	No	
Parallel connection of 2 outputs	Not possible	
Control of a digital input	Not possible	
Switching frequency		
• With resistive load	2 Hz, maximum	
• With inductive load in accordance with IEC 60947-5-1, DC13	0.1 Hz, maximum	

Technical Specifications	
• With lamp load	2 Hz, maximum
Short-circuit protection of output	No, 10 A external circuit-breaker, "B" characteristics required
Time, Frequency	
Internal processing times	See *"Response Times"*
Acknowledgment time in safety mode	4 ms minimum/8 ms maximum
Protection against Overvoltage	
Protection of power supply L+ from surge in accordance with IEC 61000-4-5 with external protection elements only	
• Symmetrical (L+ to M)	+ 1 kV; 1.2/50 µs
• Asymmetrical (L+ to PE, M to PE)	+2 kV; 1.2/50 µs
Protection of outputs from surge in accordance with IEC 61000-4-5 with external protection elements only	
Symmetrical (DO to M)	+ 1 kV; 1.2/50 µs
Asymmetrical (DO to PE, M to PE)	+ 1 kV; 1.2/50 µs
*: In order to achieve the specified cable length, you must route the P- and M-signal lines in a cable or a sheathed cable. **: Operating below the permissible supply voltage is only permissible for the repair time. See chapter "Introduction (Page 61)." ***: For more information on the requirements for sensors and actuators, see *"Wiring and Fitting Modules"*.	

7.3 PM-E F pp DC24V PROFIsafe power module

7.3.1 Properties of the PM-E F pp DC24V PROFIsafe Power Module

Order Number

6ES7138-4CF42-0AB0

Properties

The PM-E F pp DC24V PROFIsafe power module possesses the following properties:

- Two relays for connecting voltage bus P2, 10 A output current
- Relay contacts must be fused externally
- Rated load voltage 24 VDC
- Suitable for solenoid valves, DC contactors and indicator lights
- Suitable for applications in which a grounded configuration is specified or where an ungrounded configuration cannot be guaranteed
- Group fault display (SF; red LED)
- Status display for voltage bus P2 (green LED)
- Status display for load current power supply (PWR; green LED)
- Assignable diagnostics
- Achievable safety classes are listed in the table below

Table 7- 6 Overview of available safety classes with PM-E F pp DC24V PROFIsafe

PM-E F pp DC24V PROFIsafe			Maximum Attainable Safety Class
Relay outputs P1 and P2	Without standard DO modules	Signal switches daily or more often	SIL3/Category 4/PLe
		Signal switches less than once a day	SIL2/Category 3/PLd
	With standard DO modules refer to the Internet (http://support.automation.siemens.com/WW/view/en/12461959/133300)		SIL2/Category 3/PLe

Supported Interface Modules

Refer to chapter "Using ET 200S Fail-Safe Modules (Page 14)" for the supported interface modules.

Switching the P2 Voltage Bus

The power module is capable of fail-safe switching the P2 voltage bus by means of two series-connected relay contacts in accordance with SIL2/Category 3/PLd or SIL3/Category 4/PLe. P2 is available as P on the terminal module, and P1 as M.

Power Module Supplies for Standard ET 200S Modules

⚠ WARNING

Always connect the 24 VDC supply for the standard ET 200S modules on the PM-E F pp DC24V PROFIsafe. Otherwise, the outputs of DO modules may exhibit safety critical behavior.

⚠ WARNING

When supplying standard DO modules, always use the terminal modules to supply the actuators (actuator feedback on the DO module).

Redundant ground conductor required

⚠ WARNING

The ground conductor to the terminal module for PM-E F pp DC24V PROFIsafe must be installed twice for safety reasons. Any interruption of a single ground conductor would prevent the safety-related shutdown of voltage bus P2.

Safety-Related Shutdown of Standard Output Modules

Refer to the Internet (http://support.automation.siemens.com/WW/view/en/12461959/133300) for a list of all the standard ET 200S modules.

WARNING

Safety-related activation of standard DO module outputs is not possible. Only safety-related **shutdown** is possible. The following issues must therefore be taken into consideration:

In the worst case you must consider all possible faults of the standard DO modules and the programs controlling them for which the faults cannot be found directly. For example, the PM-E F pp DC24V PROFIsafedoes not detect external short-circuits to L+ at the standard DO module outputs.

All faults developing at the standard DO modules influence the process via final controlling elements.

The process status must be made known to the F-CPU by way of sensors and a suitable safety program.

The safety program must react in a safety-related and logically suitable fashion to unwanted or potentially dangerous states in the process via the PM-E F pp DC24V PROFIsafe and fail-safe output modules.

If you want to avoid the problems described above completely, we recommend that you use P/M switching fail-safe electronic modules 4 F-DO DC24V/2A PROFIsafe with standard ET 200S power modules instead of standard DO modules.

Properties of safety-related shutdown of standard DO modules with the PM-E F pp DC24V PROFIsafe:

This cost-effective solution allows the full and simultaneous shutdown of all outputs involved when a fault is detected in the process or on the PM-E F pp DC24V PROFIsafe.

Property of the individual shutdown of F-modules with fail-safe outputs:

The scope of shutdown is kept to a minimum when a fault is detected. It is also possible to react to critical process states staggered over time, or to perform safety-related shutdown of individual outputs. Compared to the safety-related shutdown by the PM-E F pp DC24V PROFIsafe, this solution costs more.

See also

Assigning Modules of an ET 200S (Page 22)

Properties of the 4 F-DO DC24V/2A PROFIsafe digital electronic module (Page 163)

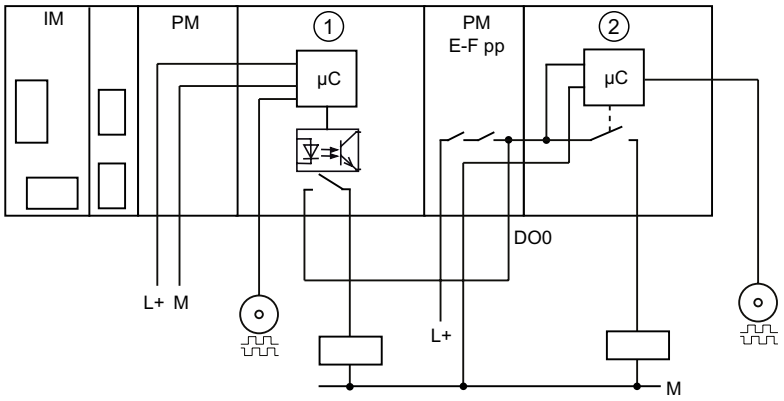
7.3.2 Terminal assignment of the PM-E F pp DC24V PROFIsafe

Incoming 24 VDC supply to Electronic Modules with Technology Functions

Depending on whether the electronic and load current supplies are electrically isolated in the electronic modules with technology functions (positioning, counting), you must comply with the following wiring rules:

- If electrically isolated, you can connect the electronic module to an external 24 VDC power supply.
- if not electrically isolated, you must supply the electronic module from the voltage bus P2 of the PM-E F pp DC24V PROFIsafe.

SIL2/Category 3/PLd is attainable in both cases.



① Technology module with electrically isolated DO

② Technology module without electrically isolated DO

Front View

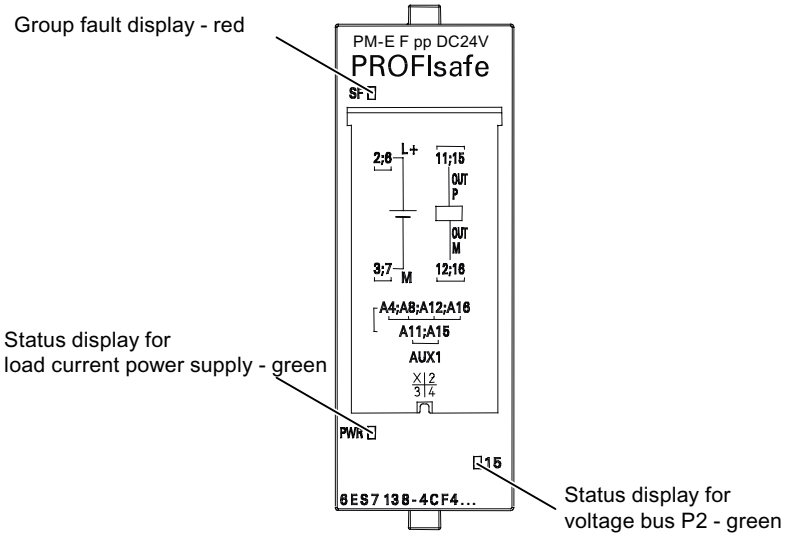


Figure 7-9 Front view PM-E F pp DC24V PROFIsafe

⚠ WARNING

The SF LED and the status displays of the inputs/outputs are not designed for safety-related functions and may therefore not be evaluated for safety-related activities.

Terminal Assignment

The following figure and the following table show the terminal assignment of the PM-E F pp DC 24V PROFIsafe for the supported terminal modules TM-P30S44-A0 or TM-P30C44-A0.

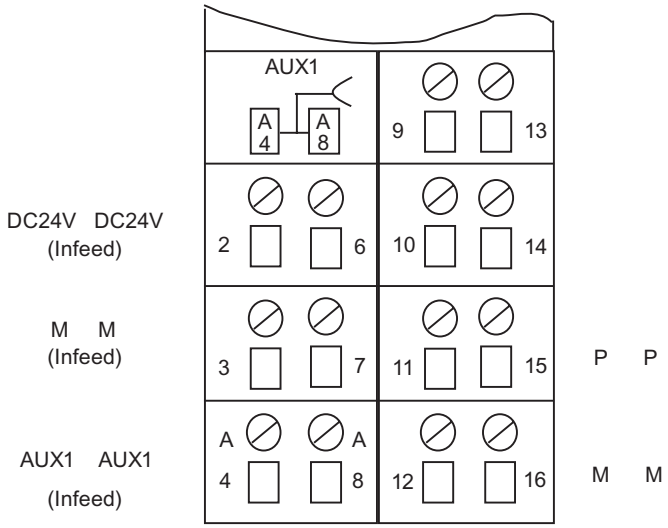


Figure 7-10 Terminal assignment TM-P30S44-A0 or TM-P30C44-A0 for PM-E F pp DC 24V PROFIsafe

Table 7- 7 Terminal assignment of the TM-P30S44-A0 or TM-P30C44-A0

Terminal		Designation
2	24 VDC	24 VDC rated load voltage for: • Inserted power module • Corresponding voltage group and • Voltage bus P2
3	M	Ground
A 4	AUX 1	Any terminal for PE or voltage bus up to the maximum rated load voltage of the module
6	24 VDC	24 VDC rated load voltage for: • Inserted power module • Corresponding voltage group and • Voltage bus P2
7	M	Ground
A 8	AUX 1	Any terminal for PE or voltage bus up to the maximum rated load voltage of the module

Terminal		Designation
11	P	Terminals (relay contacts) for fail-safe switching of voltage bus P2
12	M	
15	P	Terminals (relay contacts) for fail-safe switching of voltage bus P2
16	M	

CAUTION

If high currents can occur on P and M, you must wire terminals 11 and 15 (P) and 12 and 16 (M) in parallel.

Otherwise, high current loads may cause the terminals to heat up.

7.3.3 Wiring of the PM-E F pp DC24V PROFIsafe

Block Diagram

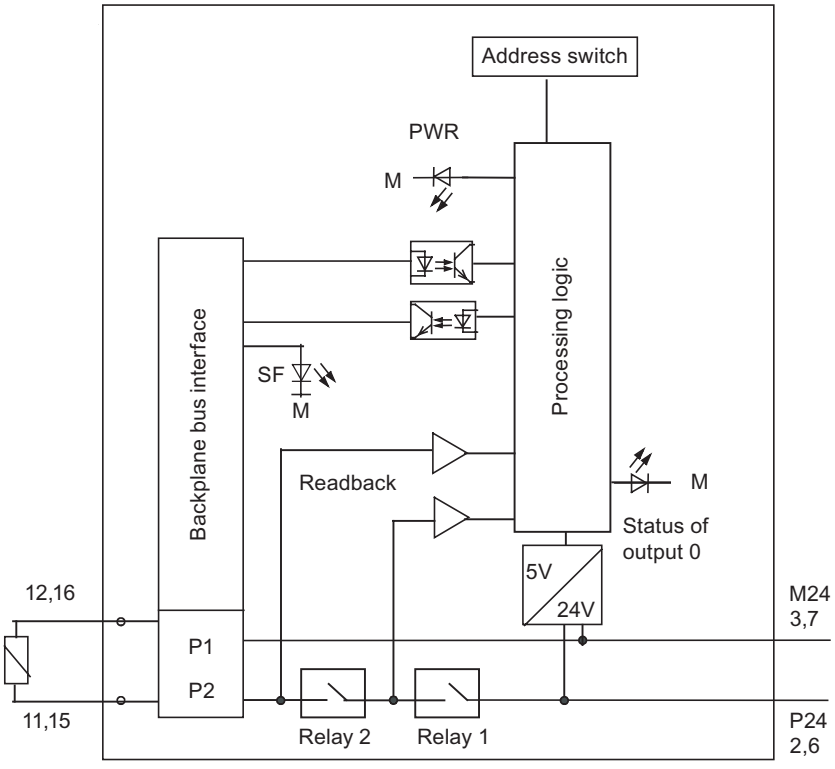


Figure 7-11 Block diagram of the PM-E F pp DC24V PROFIsafe

Wiring Diagram

Wire the PM using the special terminal module.

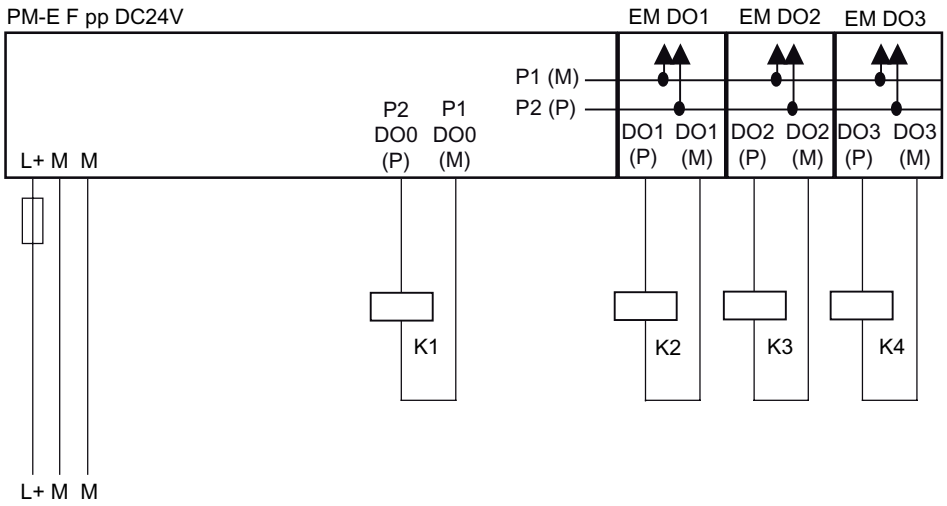


Figure 7-12 Wiring diagram of the PM-E F pp DC24V PROFIsafe

WARNING

Please always use an external fuse for L+ at the PM-E F pp with the following properties to protect the relay contacts from overload: Circuit-breaker, characteristics B, 10 A.

Relay Output

The two contacts of the relay output are used to switch voltage L+. The switched voltage is supplied to the external terminal module and to the internal voltage buses P1 and P2. This results in two connection options that can be used at the same time, if desired:

- One load can be wired directly to the terminal module (K1 in the figure above).
- Electronic modules can be supplied by means of the internal voltage buses P1 and P2. Loads can be connected to these modules in turn (K2, K3, K4 in the figure above).

WARNING

In the event of a cross circuit between 2L+ and DO, the controlled actuator is no longer switched off. You should always wire the actuators separately, for example, using sheathed cables or separate cable ducts, in order to prevent any cross-circuits between 2L+ and DO.

7.3.4 Parameters of the PM-E F pp DC24V PROFIsafe

Parameters in *STEP 7*

The table below lists the parameters that can be set for the PM-E F pp DC24V PROFIsafe.

Table 7- 8 Parameters of the PM-E F pp DC24V PROFIsafe

Parameter	Range	Default	Type of Parameter	Effective Range
F-Parameters:				
F_destination_address	1 to 1022	is assigned by *STEP 7*	Static	Module
F monitoring time	10 to 10000 ms	150 ms	Static	Module

See also

Configuration and Parameter Assignment (Page 26)

7.3.5 Diagnostic functions of the PM-E F pp DC24V PROFIsafe

Behavior in Case of Supply Voltage Failure

The failure of the PM-E F pp DC24V PROFIsafe power supply is always indicated by the PWR LED on the module (light off). This information is also provided in the module (diagnostic entry). The relay output of the module is passivated.

In the case of a voltage dip in the external auxiliary voltage, the SF LED lights up, the module is passivated.

With the subsequent supply recovery (level must remain above the specified value for at least 1 minute (refer to the technical specifications: voltages, currents, electrical potentials)) the SF LED goes out again, the module remains passivated. The SF LED flashes if there are no other errors, until the error is acknowledged.

Diagnostic functions

The table below provides an overview of the diagnostic functions of the PM-E F pp DC24V PROFIsafe. The diagnostic functions are assigned either to one channel or to the entire module.

Table 7- 9 Diagnostic functions of the PM-E F pp DC24V PROFIsafe

Diagnostic Function*	Fault number	LED	Effective Range of Diagnostics	can be assigned parameters
Short circuit	1_H	SF	Channel	No
Overtemperature	5_H	SF	Module	No
Internal error	9_H	SF	Module	No
Parameter assignment error	10_H	SF	Module	No
Sensor voltage or load voltage missing	11_H	SF	Module	No
Communication error	13_H	SF	Module	No
Safety-related shutdown	19_H	SF	Channel	No
*: Specially for F-modules; display in *STEP 7*, see "Channel-Specific Diagnostics, Fault Types of Fail-Safe Modules" table				

WARNING

Before acknowledging the short-circuit diagnosis, remedy the respective error and validate your safety function. To do this, proceed as described in chapter "Fault Diagnostics (Page 43)".

Causes of Faults and Corrective Measures

The following table contains the possible causes of the faults described for the individual diagnostic messages of the PM-E F pp DC24V PROFIsafe and remedies.

Table 7- 10 Diagnostic messages of the PM-E F pp DC24V PROFIsafe, causes of errors and remedies

Diagnostic Message	Fault Detection	Possible Causes	Corrective Measures
Short circuit	For "0" output signal only	Cross-circuit between P1 and L+	Remedy the cross-circuit and acknowledge the error within 100 hours after the error has occurred
		Internal error	Replace module
Overtemperature	Always	Shutdown due to violation of upper or lower temperature limit value in the module case	Check load wiring, check ambient temperature, check whether permissible output current is exceeded for the ambient temperature. Once the fault has been eliminated, the module must be removed and inserted or the power switched off and on.

Diagnostic Message	Fault Detection	Possible Causes	Corrective Measures
Internal error	Always	Internal module fault has occurred	Replace module
Parameter assignment error	Always	Inserted module does not match configuration; incorrect parameter assignment	Correct the configuration (compare actual and preset configuration), and check communication paths. Correct parameter assignment.
		PROFIsafe address set incorrectly in the F-module	Check whether the PROFIsafe address on the module matches the configuration in *HW Config*
Sensor voltage or load voltage missing	Always	Supply voltage not available or too low (e.g. voltage dip on F-module, this can also be caused, among other things, by a short-circuit on the P1/P2 buses)	Check module for correct contact
Communication error	Always	Error in communication between F-CPU and module due to defective PROFIBUS connection or higher than permissible EMI, for example	Test PROFIBUS/PROFINET connection. Correct faults
		PROFIsafe monitoring time set too low	Set a greater value for the "F monitoring time" parameter for the module in *HW Config*
		Configuration of the F-module does not match safety program	Generate safety program again; then load configuration and safety program into F-CPU again
Safety-related shutdown	Always	Switching frequency exceeded	Reduce the switching frequency

Generally Applicable Information on Diagnostics

For information on diagnostics that pertains to all fail-safe modules (for example, for reading out diagnostic functions, or passivating channels), refer to the *Diagnostics* chapter in this manual.

7.3.6 Technical Specifications for the PM-E F pp 24 VDC PROFIsafe

Overview

Technical Specifications	
Dimensions and Weight	
Dimensions W x H x D (mm)	30 x 81 x 52
Weight	Approx. 80 g
Data for Specific Module	
Number of outputs	
• Relay outputs (PP switching)	1
Assigned address area	
• In the I/O area for inputs	5 bytes
• In the I/O area for outputs	5 bytes
Length of cable	
• Unshielded	200 m, maximum
• Shielded	200 m, maximum
Maximum achievable safety class	
• according to IEC 61508, according to EN 954, according to ISO 13849	SIL3, category 4, PLe (for conditions see *"Power modulePM-E F pp DC24V PROFIsafe")*
Fail-safe performance characteristics	SIL3
• Low demand mode (average probability of failure on demand)	< 1.00E-05
• High demand/continuous mode (probability of a dangerous failure per hour)	< 1.00E-10
• Acceptance ID	FM, cULus, CE, C-Tick
Voltages, Currents, Potentials	
Rated supply voltage L+	24 VDC
• permissible range **	20.4 V to 28.8 V
• Power loss ride-through of L+	None
• Power loss ride-through of internal P5	5 ms
• Reverse polarity protection	No
Total current of the relay output	
• Horizontal installation – Up to 40 °C – Up to 55 °C – Up to 60 °C	 10 A 8 A 7 A
• Vertical installation – Up to 40 °C	 8 A

Technical Specifications		
Electrical isolation		
• Between output and backplane bus	Yes	
• Between output and power supply	No	
• Between output/power supply and shield	Yes	
Permissible potential difference between		
• shield and ET 200S bus connection	75 VDC/60 VAC	
• Shield and I/O (DOs, P1/P2 buses)	75 VDC/60 VAC	
• ET 200S bus connection and I/O (DOs, P1/P2 buses)	250 VAC	
Isolation in the series tested with		
• Shield and ET 200S bus connection	500 VDC/1 min or 600 VDC/1 s	
• Shield and I/O (DOs, P1/P2 buses)	500 VDC/1 min or 600 VDC/1 s	
• ET 200S bus connection and I/O (DOs, P1/P2 buses)	1500 VAC/1 min or 2545 VDC/1 s	
Isolation in the type test tested with		
• Shield and ET 200S bus connection	350 VAC/1 min	
• Shield and I/O (DOs, P1/P2 buses)	350 VAC/1 min	
• ET 200S bus connection and I/O (DOs, P1/P2 buses)	2830 VAC/1 min	
• Surge voltage test between ET 200S bus connection and I/O (DOs, P1/P2 buses)	6000 VDC/5 positive and 5 negative pulses	
Current consumption		
• From backplane bus	28 mA, maximum	
• From load voltage L+ (without load)	100 mA, typical	
Power dissipation of the module	4 W, typical	
Status, Interrupts, Diagnostics		
Status display	• Green LED per channel • Green LED for the load voltage	
Diagnostic functions		
• Group fault display	Red LED (SF)	
• Diagnostic information can be displayed	Possible	
Data for Selecting an Actuator for the Relay Output*		
Switching capacity and service life of contacts (voltage 24 VDC)		
• Mechanical endurance (without load)	Current	Number of switching cycles (typ.)
	0 A	10 million
• For resistive load	Current	Number of switching cycles (typ.)
	10 A	0.23 million
	8 A	0.3 million
	6 A	0.38 million
	4 A	0.5 million

Technical Specifications		
	2 A	1.0 million
	1 A	2.0 million
• For inductive load in accordance with IEC 60947-5-1, DC13	Current	Number of switching cycles (typ.)
	10 A	0.1 million
	8 A	0.15 million
	6 A	0.2 million
	4 A	0.3 million
	2 A	0.5 million
	1 A	1.0 million
• For lamp load	Power	Number of switching cycles (typ.)
	100 W	0.12 million
Contact protection (internal)	Internal readback circuit	
• Between PP relay output and M	39 V suppressor diode	
Wire break monitoring	No	
Parallel connection of 2 outputs	Not possible	
Control of a digital input	Possible	
Switching frequency		
• With resistive load	2 Hz symmetrical, maximum	
• With inductive load in accordance with IEC 60947-5-1, DC13	0.1 Hz symmetrical, maximum	
• With lamp load	2 Hz symmetrical, maximum	
Short-circuit protection of output	No, 10 A external circuit-breaker, "B" characteristics required	
Time, Frequency		
Internal processing times	See *"Response Times"*	
Acknowledgment time in safety mode	4 ms minimum/8 ms maximum	
Protection against Overvoltage		
Protection of power supply L+ from surge in accordance with IEC 61000-4-5 with external protection elements only		
• Symmetrical (L+ to M)	+ 1 kV; 1.2/50 µs	
• Asymmetrical (L+ to PE, M to PE)	+ 2 kV; 1.2/50 µs	
Protection of outputs from surge in accordance with IEC 61000-4-5 with external protection elements only		
Symmetrical (DO to M)	+ 1 kV; 1.2/50 µs	
Asymmetrical (DO to PE, M to PE)	+ 1 kV; 1.2/50 µs	
*: For more information on the requirements for sensors and actuators see *"Wiring and Fitting Modules"*. **: Operating below the permissible supply voltage is only permissible for the repair time. See chapter "Introduction (Page 61)."		

7.4 PM-D F DC24V PROFIsafe Power Module

7.4.1 Properties of the PM-D F DC24V PROFIsafe Power Module

Order Number

3RK1903-3BA02

Properties

The PM-D F DC24V PROFIsafe power module disposes of the following properties:

- 6 shutdown groups, SG 1 through SG 6
- Output current of SG 1 through SG 6, each 3 A (total current 5 A)
- Rated load voltage 24 VDC per shutdown group
- Suitable for supplying:
  - Fail-safe motor starters F-DS1e-x, F-RS1e-x
  - Fail-safe frequency converters F-FU
  - Fail-safe connection multipliers F-CM
  - Fail-safe power/expansion modules PM-D F X1
  - Brake control expansion modules xB1, xB2, xB3 and xB4
- Group fault display (SF; red LED)
- Status display per shutdown group (SG 1 through SG 6; green LED)
- Status display for load current power supply (PWR; green LED)
- Status display for electronic power supply (U1; green LED)
- achievable safety class SIL3/Category 4/PLe

Switching the Voltage Buses SG 1 through SG 6 and U 1

The power module can shut down voltage buses SG 1 through SG 6 over 6 digital outputs complying with safety class SIL2/Category 3/PLd or SIL3/Category 4/PLe. The outputs are implemented with two P switches. There is a main switch for all 6 shutdown groups and 6 individual switches connected in series per shutdown group.

The voltage bus U 1 (electronics power supply for the motor starters) is supplied with 24 VDC. **When overvoltage or undervoltage occurs,** U 1 is switched off by two P switches and the downstream motor starters are passivated. **In the event of a safety shutdown** of motor starters, U 1 is not switched off.

Conditions for Achieving Safety Class

The conditions for achieving the various safety classes are summarized in the table below.

Table 7- 11 PM-D F DC24V PROFIsafe: Conditions for SIL/Categories/PL

Condition	Achievable SIL/Category/PL
Fail-safe motor starters are expanded with the expansion modules: • Brake control xB3 and xB4	SIL2/Category 3/PLd
Power supply of: • Exclusively fail-safe motor starters F-DS1e-x and F-RS1e-x • Fail-safe frequency converters F-FU • Fail-safe connection multipliers F-CM • Fail-safe power/expansion modules PM-D F X1 Fail-safe motor starters are expanded with the expansion modules: • Brake Control xB1 and xB2	SIL3/Category 4/PLe

Note

The safety classes SIL2/Category 3/PLd or SIL3/Category 4/PLe listed in the table above can only be achieved with the modules specified in the "Condition" column. Configurations with other modules (e.g. motor starter DS1-x/RS1x, DS1e-x/RS1e-x, DSS1e-x) are not permitted for safety-related applications.

7.4.2 Terminal Assignment of the PM-D F DC24V PROFIsafe

Front View

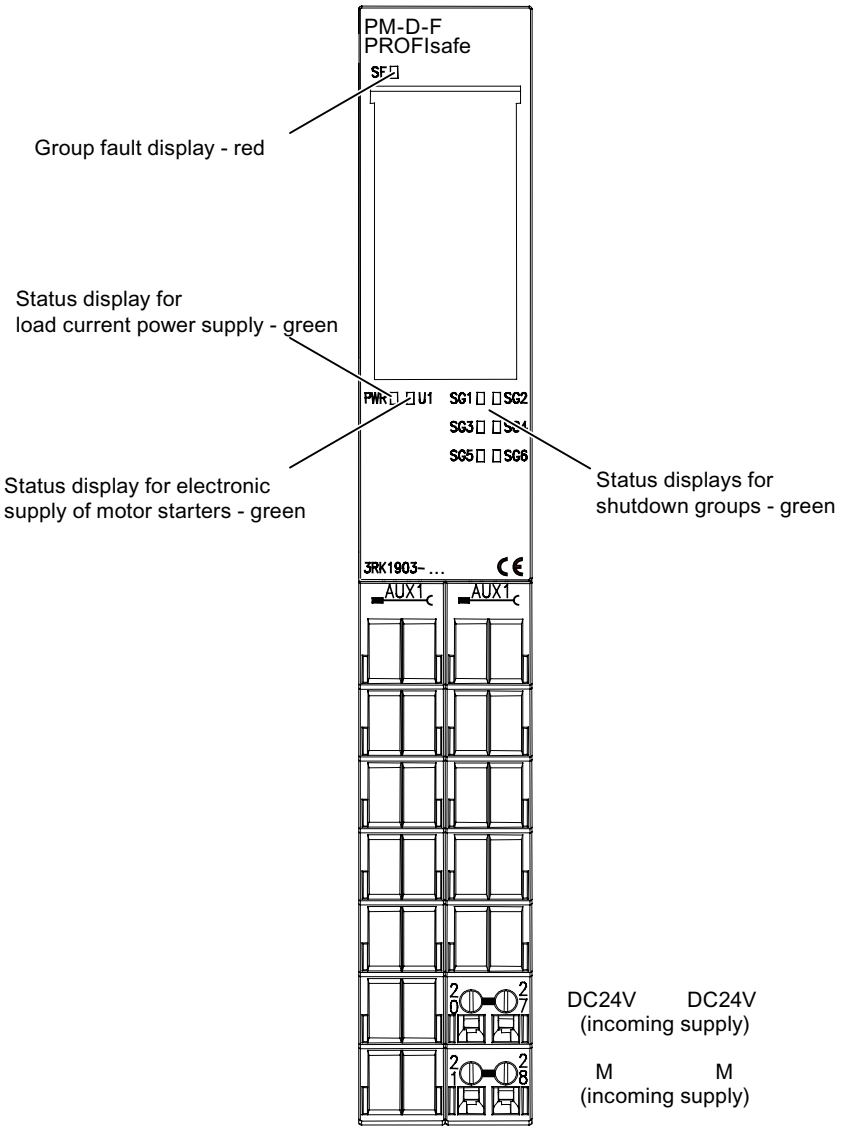


Figure 7-13 Front View of PM-D F DC24V PROFIsafe

WARNING

The SF LED and the status displays of the inputs/outputs are not designed for safety-related functions and may therefore not be evaluated for safety-related activities.

Terminal assignment

On the PM-D F DC24V PROFIsafe, you connect only the 24 V DC load voltage power supply and chassis. Wire the power module using the special terminal module.

The following table shows the terminal assignment of the PM-D F DC24V PROFIsafe for the supported terminal module TM-PF30S47-F1 (order number 3RK1 903-3AA00).

Table 7- 12 Terminal Assignment of the TM-PF30S47-F1

Terminal		Designation
20	24 VDC	24 VDC rated load voltage for: • Inserted power module and • Voltage buses SG 1 through SG 6 and U1
21	M	Ground
27	24 VDC	24 VDC rated load voltage for: • Inserted power module and • Voltage buses SG 1 through SG 6 and U1
28	M	Ground

7.4.3 Wiring of the PM-D F DC24V PROFIsafe

Block Diagram

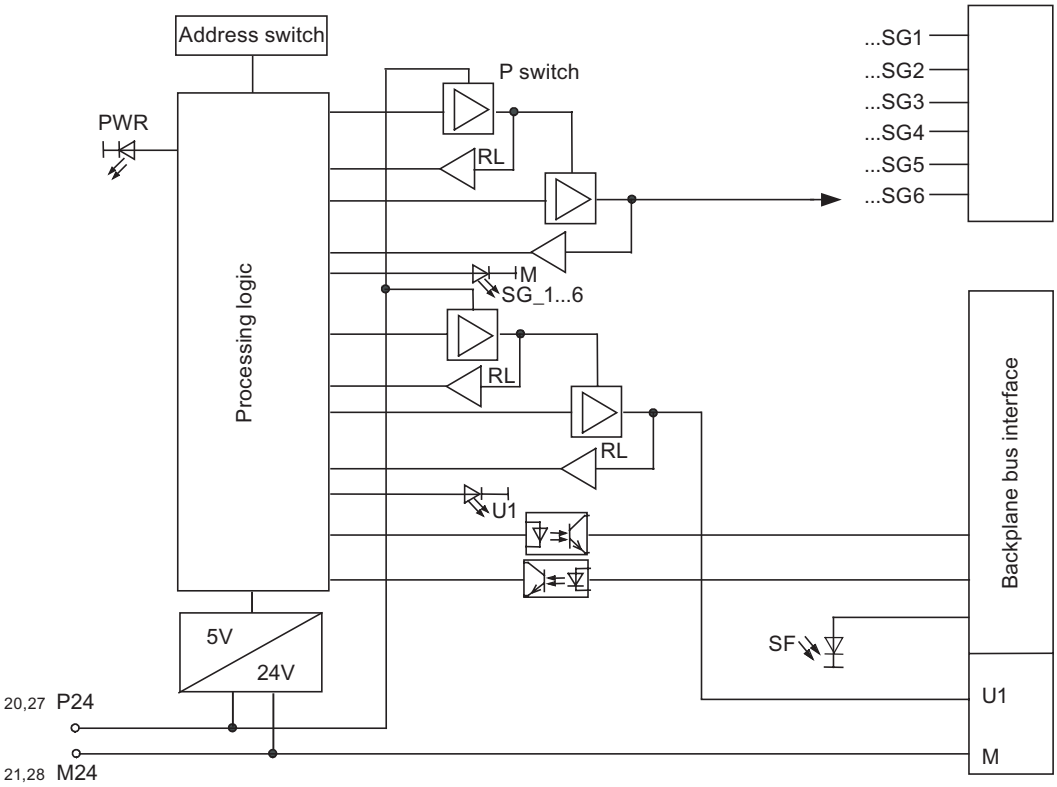


Figure 7-14 Block diagram of the PM-D F DC24V PROFIsafe

7.4.4 Parameters of the PM-D F DC24V PROFIsafe

Parameters in STEP 7

The table below lists the parameters that can be assigned for the PM-D F DC24V PROFIsafe.

Table 7- 13 Parameters of the PM-D F DC24V PROFIsafe

Parameter	Range	Default	Type of Parameter	Effective Range
F-Parameters:				
F_destination_address	1 to 1022	Assigned by STEP 7	Static	Module
F monitoring time	10 to 10000 ms	150 ms	Static	Module

7.4.5 Diagnostic Functions of PM-D F DC24V PROFIsafe

Behavior in Case of Supply Voltage Failure

The failure of the PM-D F DC24V PROFIsafe power supply is always indicated by the PWR LED on the module (light off). The failure of the electronics power supply is indicated by the U1 LED of the module (light off). This information is also provided on the module (entry in diagnostics data). Either all shutdown groups of the module (SG 1 through SG 6) are passivated or, in the case of channel-specific passivation, only the relevant shutdown groups are passivated.

In the case of a voltage dip in the external auxiliary voltage, the SF LED lights up, the module is passivated.

With the subsequent supply recovery (level must remain above the specified value for at least 1 minute (refer to the technical specifications: voltages, currents, electrical potentials)) the SF LED goes out again, the module remains passivated. The SF LED flashes if there are no other errors, until the error is acknowledged.

Diagnostic functions

The table below provides an overview of the diagnostic functions of the PM-D F DC24V PROFIsafe. The diagnostic functions are assigned either to a channel or the entire module.

Table 7- 14 Diagnostic functions of the PM-D F DC24V PROFIsafe

Diagnostic Function*	Fault Number	LED	Effective Range of Diagnostics	Can be assigned parameters
Short circuit	1_H	SF	Channel	No
Overtemperature	5_H	SF	Module	No
Internal error	9_H	SF	Module	No
Parameter assignment fault	10_H	SF	Module	No
Sensor voltage or load voltage missing	11_H	SF	Module	No
Communication problem	13_H	SF	Module	No
*: Specially for F-modules; display in *STEP 7*, see "Channel-Specific Diagnostics, Fault Types of Fail-Safe Modules" table				

Causes of Faults and Corrective Measures

The following table contains the possible causes of the faults described for the individual diagnostic messages of the PM-D F DC24V PROFIsafe and remedies.

Table 7- 15 Diagnostic messages of the PM-D F DC24V PROFIsafe, causes of errors and remedies

Diagnostics Message	Fault Detection	Possible Causes	Corrective Measures
Short circuit	Always	Short circuit in the actuator	Eliminate short-circuit/cross-circuit; once the fault has been eliminated, the module must be removed and inserted, or the power switched OFF and ON
		Cross circuit in the actuator	
		Internal error	Replace module
Overtemperature	Always	Shutdown due to violation of upper or lower temperature limit in the module case.	Check load wiring, check ambient temperature. Once the fault has been eliminated, the module must be removed and inserted, or the power switched off and on.
Internal error	Always	Internal module fault has occurred	Replace module
Parameter assignment error	Always	Inserted module does not match configuration. Incorrect parameter assignment	Correct the configuration (compare actual and preset configuration), and check communication paths. Correct the parameter assignment.
		PROFIsafe address set incorrectly in the F-module	Check whether the PROFIsafe address on the module matches the configuration in *HW Config*
external auxiliary supply missing	Always	No supply voltage or supply voltage is too low.	Check module for correct contact
Communication error	Always	Error in communication between F-CPU and module due to defective PROFIBUS connection or higher than permissible EMI, for example	Test PROFIBUS/PROFINET connection. Correct faults
		PROFIsafe monitoring time set too low	Set a greater value for the "F monitoring time" parameter for the module in *HW Config*

Generally Applicable Information on Diagnostics

For information on diagnostics that pertains to all fail-safe modules (for reading out diagnostic functions, passivating channels, for example), refer to *Diagnostics* chapter in this manual.

See also

Fault Diagnostics (Page 43)

7.4.6 Technical Specifications of the PM-D F DC24V PROFIsafe

Overview

Technical Specifications	
Dimensions and Weight	
Dimensions W x H x D (mm)	30 x 196.5 x 117.5
Weight	Approx. 112 g
Data for Specific Module	
Number of outputs (P/P switching)	6 shutdown groups (SG 1 through SG 6)
Internal power supply for bus	U 1
Assigned address area	
• In the I/O area for inputs	5 bytes
• In the I/O area for outputs	5 bytes
Maximum achievable safety class	
• according to IEC 61508, according to EN 954, according to ISO 13849	SIL3, category 4, PLe
Fail-safe performance characteristics	SIL3
• Low demand mode (average probability of failure on demand)	< 1.00E-05
• High demand/continuous mode (probability of a dangerous failure per hour)	< 1.00E-10
• Acceptance ID	CE, UL, CSA
Voltages, Currents, Potentials	
Rated supply voltage L+	24 VDC
• permissible range *	21.6 V to 26.4 V
• Power loss ride-through of L+	None
• Power loss ride-through of internal P5	5 ms
• Reverse polarity protection	No
Total current of outputs	
• Horizontal installation – Up to 40 °C – Up to 60 °C	Brief/permanent 10 A/5 A 10 A/4 A
• Vertical installation – Up to 40 °C	Brief/permanent 10 A/4 A
Electrical isolation	
• Between channels and backplane bus	Yes
• Between channels and power supply	No
• Between channels	No
• Between channels/power supply and shield	Yes
Permissible potential difference between	

Technical Specifications	
• Shield and ET 200S bus connection	75 VDC/60 VAC
• Shield and I/O (SGs, U 1 bus)	75 VDC/60 VAC
• ET 200S bus connection and I/O (SGs, U 1 bus)	250 VAC
Isolation in the series tested with	
• Shield and ET 200S bus connection	500 VDC/1 min or 600 VDC/1 s
• Shield and I/O (SGs, U 1 bus)	500 VDC/1 min or 600 VDC/1 s
• ET 200S bus connection and I/O (SGs, U 1 bus)	1500 VAC/1 min or 2545 VDC/1 s
Isolation in the type test tested with	
• Shield and ET 200S bus connection	350 VAC/1 min
• Shield and I/O (SGs, U 1 bus)	350 VAC/1 min
• ET 200S bus connection and I/O (SGs, U 1 bus)	2830 VAC/1 min
• Surge voltage test between ET 200S bus connection and I/O (SGs, U1 bus)	6000 VDC/5 positive and 5 negative pulses
Current consumption	
• From backplane bus	28 mA, maximum
• From load voltage L+ (without load)	100 mA, typical
Power dissipation of the module	4 W, typical
Status, Interrupts, Diagnostics	
Status display	• Green LED per SG • Green LED for electronic power supply • Green LED for the load voltage
Diagnostic functions	
• Group fault display	Red LED (SF)
• Diagnostic information can be displayed	Possible
Time, Frequency	
Internal processing times	See *"Response Times"*
Acknowledgment time in safety mode	4 ms minimum/8 ms maximum
Protection against Overvoltage	
Protection of power supply L+ from surge in accordance with IEC 61000-4-5 with external protection elements only	
• Symmetrical (L+ to M)	+ 1 kV; 1.2/50 µs
• Asymmetrical (L+ to PE, M to PE)	+2 kV; 1.2/50 µs
*: Operating below the permissible supply voltage is only permissible for the repair time. See chapter "Introduction (Page 61)."	

7.5 4/8 F-DI DC24V PROFIsafe Digital Electronic Module

7.5.1 Properties of the 4/8 F-DI 24 VDC PROFIsafe Digital Electronic Module

Order Number

6ES7138-4FA04-0AB0

Properties

The 4/8 F-DI DC24V PROFIsafe digital electronic module possesses the following properties:

- 8 inputs (SIL2/Category 3/PLd) or 4 inputs (SIL3/Category 3 or Category 4/PLe)
- 24 VDC rated input voltage
- Suitable for switches and 3/4-wire proximity switches (BEROs)
- 2 short circuit-proof sensor supplies, each one for four inputs
- External sensor supply possible
- Group fault display (SF; red LED)
- Status display for each input (green LED)
- one fault display for each sensor supply (1VsF and 2VsF; red LED)
- Assignable diagnostics

Power Modules Suitable for SIL2 or SIL3

Table 7- 16 EM 4/8 F-DI DC24V PROFIsafe: Power modules for SIL/Category/PL

Power module	achievable SIL/Category/PL
Supply through PM-E DC24V, PM-E DC24..48V/AC24..230V or PM-E DC24..48V	with 1oo1 sensor evaluation (8 F-DI) SIL2/Category 3/PLd with 1oo2 sensor evaluation (4 F-DI) SIL3/Category 3/PLe

Capacitive Crosstalk of Digital Input/Output Signals

refer to *"Characteristics of the power module PM-E F pm DC24V PROFIsafe"*

7.5.2 Terminal assignment of the EM 4/8 F-DI DC24V PROFIsafe

Front View

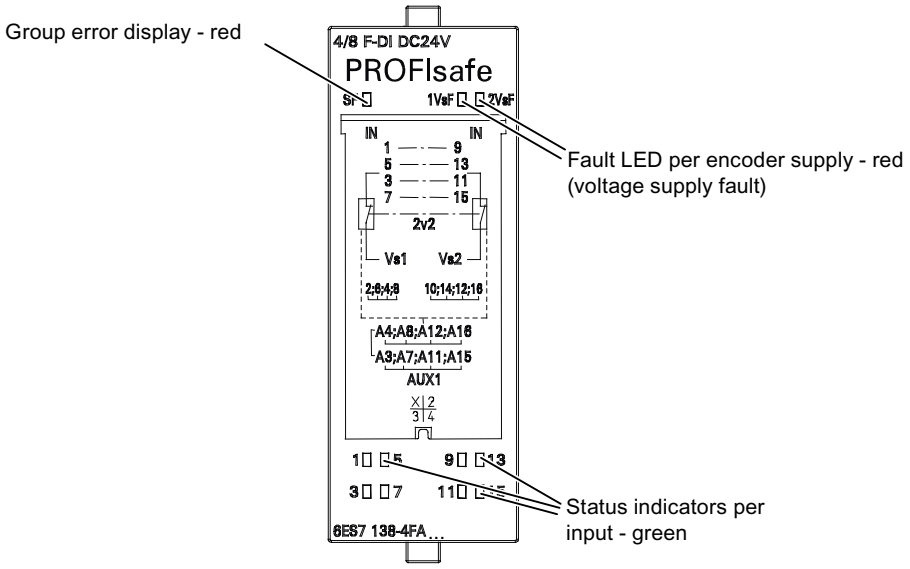
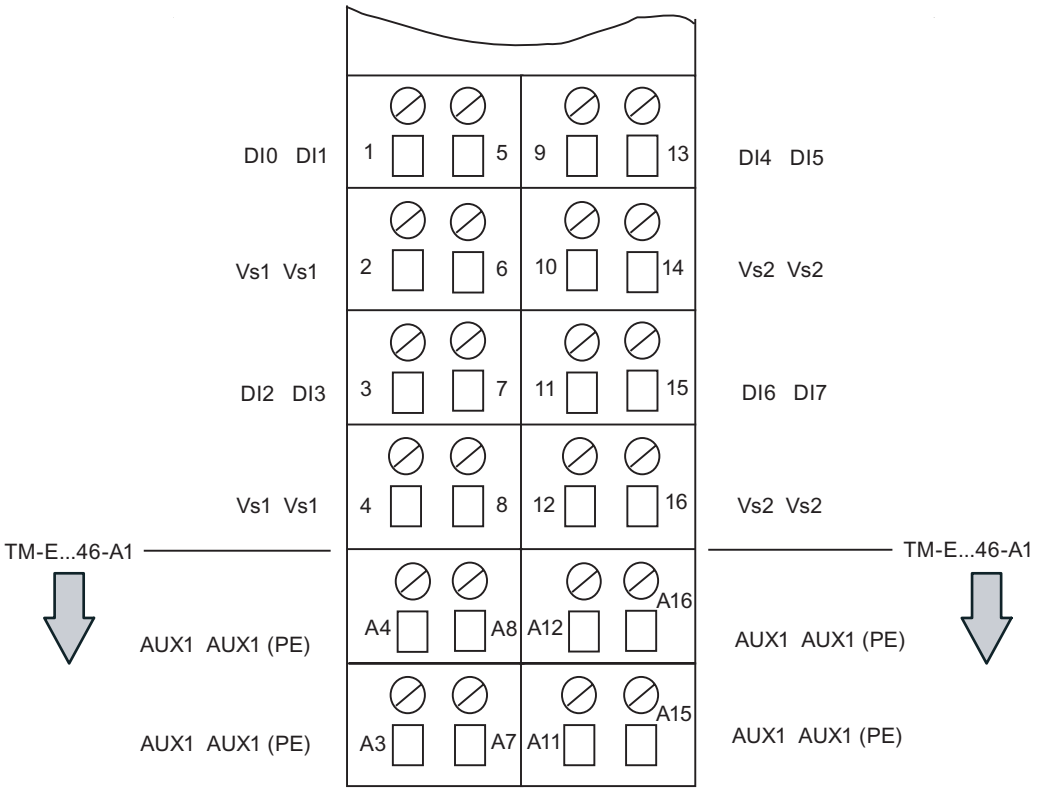


Figure 7-15 Front view EM 4/8 F-DI DC24V PROFIsafe

Terminal Assignment

The figure below shows the terminal assignment of the EM 4/8 F-DI DC24V PROFIsafe for the supported terminal module TM-E30S44-01, TM-E30C44-01, TM-E30S46-A1 and TM-E30C46-A1.



DI Fail-safe digital input

Vs1 Internal sensor power supply 1 for DI 0 to DI 3

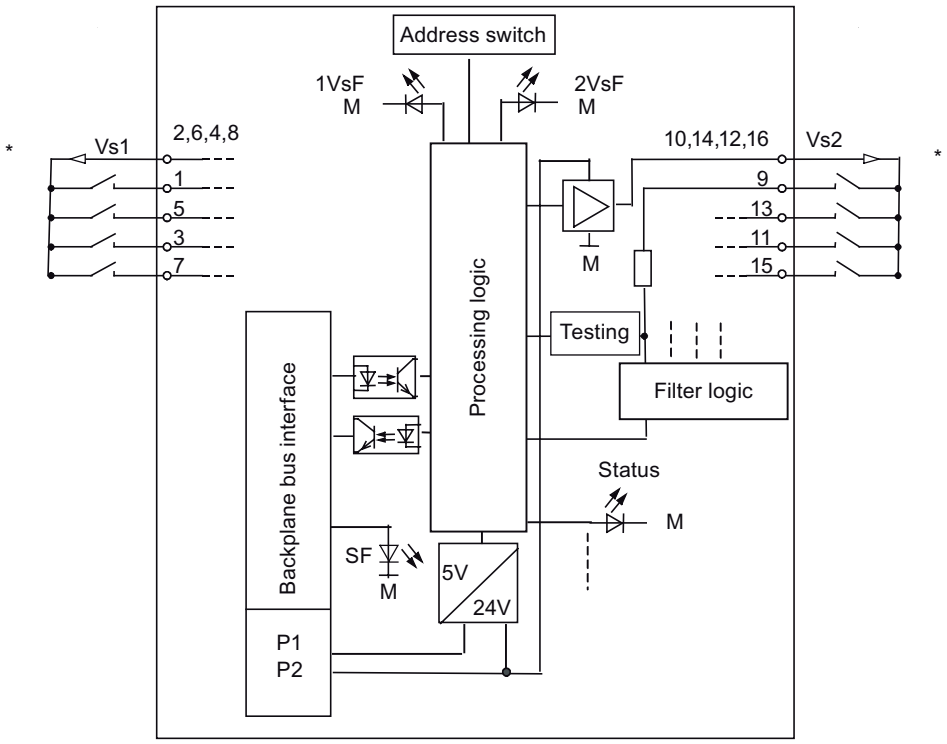
Vs2 Internal sensor power supply 2 for DI 4 to DI 7

For TM-E...46-A1 AUX 1 bus implemented. Connection to terminals A3 through A16 for any connection of PE (individual grouping of sensor supplies possible)

Figure 7-16 Terminal assignment TM-E...44-01/TM-E...46-A1 for EM 4/8 F-DI DC24V PROFIsafe

7.5.3 Wiring of the EM 4/8 F-DI DC24V PROFIsafe

Block diagram



* The notation of the NO contact corresponds to the module inscription. However, the encoder contacts must be NC contacts in general (because of the safe state of the process variables).

Figure 7-17 Block Diagram of EM 4/8 F-DI DC24V PROFIsafe

7.5.4 Parameters of the EM 4/8 F-DI DC24V PROFIsafe

Parameters in *STEP 7*

The table below lists the parameters that can be set for the EM 4/8 F-DI DC24V PROFIsafe.

Table 7- 17 Parameters of the EM 4/8 F-DI DC24V PROFIsafe

Parameter	Range	Default	Type of Parameter	Effective Range
F-Parameters:				
F_destination_address	1 to 1022	are assigned by *STEP 7*	Static	Module
F monitoring time	10 to 10,000 ms	150 ms	Static	Module
Module Parameters:				

Parameter	Range	Default	Type of Parameter	Effective Range
Input delay	0.5 ms, 3 ms, 15 ms	3 ms	Static	Module
Short-circuit test	Cyclic/disable	Cyclic	Static	Module
Behavior after channel faults*	Passivate the entire module/Passivate the channel	Passivate the entire module	Static	Module
Channel n, n+4	Activated/deactivated	Activated	Static	Channel group
Sensor supply	internal/external	internal	Static	Channel group
Sensor evaluation	1oo2 evaluation / 1oo1 evaluation	1oo2 evaluation	Static	Channel group
Type of sensor interconnection	1-channel; 2-channel equivalent; 2-channel, non-equivalent	2-channel equivalent	Static	Channel group
Behavior of discrepancy	Provide last valid value; provide 0 value	Provide last valid value	Static	Channel group
Discrepancy time	10 to 30,000 ms	10 ms	Static	Channel group
Reintegration after discrepancy error	Zero signal test not required/zero signal test required	Zero signal test not required	Static	Channel group
* This setting is only relevant when optional package *S7 Distributed Safety* V5.4 or higher is installed.				

Input Delay of 3 ms Parameter

Note

When operating with 3 ms input delay, you must always use shielded cables if there is a danger of overvoltage on the signal lines (see section "Electromagnetic Compatibility") to prevent possible passivation of the fail-safe digital inputs and shutdown of the sensor power supply.

If unshielded signal lines are used the safe behavior of the process variables is ensured.

Short-Circuit Test Parameter

This parameter can be used to activate short-circuit detection for channels set up for "internal sensor supply."

The short-circuit test parameter is used to activate or deactivate the cyclic short-circuit test. The short-circuit test is only useful for simple switches that do not have their own power supply. Always use the internal sensor power supplies if the short-circuit test has been activated (see also *"Applications for the 4/8 F-DI DC24V PROFIsafe electronic module"*).

Sensor supply parameter

This parameter can be used to activate the "Internal sensor supply" of the F-module. This setting is a prerequisite for using the short-circuit test.

Note

When there are different sensor supply parameter settings (internal/external) for the individual channel groups, the applications shown in the next chapter apply to specific channel groups.

Discrepancy behavior parameter

For "Behavior of Discrepancy," you assign the value that is to be made available to the safety program in the F-CPU during the time that a discrepancy exists between two input channels, i.e., during the discrepancy time. To program behavior of discrepancy:

- "Provide last valid value" or
- "Provide 0 value"

Requirements

Parameter settings:

- Sensor evaluation: "1oo2 evaluation"

"Provide last valid value"

The last valid value (old value) from before the discrepancy occurred is immediately made available to the safety program in the fail-safe CPU as soon as a discrepancy is detected between the signals of the two input channels involved. This value remains available until the discrepancy is cleared, or until the discrepancy time has expired and a discrepancy error is detected. The sensor-actuator response time is extended by this time.

As a result, the discrepancy time for sensors connected over two channels for high-speed reactions must be tuned to short response times. Thus, it makes no sense, for example, if sensors connected via 2 channels 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.

"Provide 0 value"

The "0" value is immediately made available to the safety program in the F-CPU as soon as discrepancy is detected between the signals of the two input channels involved.

If the "Provide 0 value" parameter is set, the sensor-actuator response time will not be influenced by the discrepancy time.

Discrepancy Time Parameter

You can define the discrepancy time for each channel pair with this parameter. The entered value is rounded to a multiple of 10 ms.

Requirements

Parameter settings:

- Sensor evaluation: "1oo2 evaluation"
- Type of sensor interconnection: "2-channel equivalent" or "2-channel non-equivalent"

Discrepancy Analysis and Discrepancy Time

When using a dual-channel, or non-equivalent sensor, or two single-channel sensors which measure the same physical process variable, the sensors will interact with a slight time delay because of precision limitations in their arrangement.

The discrepancy analysis for equality/non-equality is used at fail-safe inputs to detect errors based on the timing of two signals with the same functionality. Discrepancy analysis is initiated when different levels (when testing for nonequivalence: same voltage levels) are detected at two associated input signals. A test is conducted to determine whether the difference in levels (when testing for nonequivalence: the match) has disappeared after expiration of a specified time known as the discrepancy time. If not, this means that a discrepancy error exists.

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

Select a discrepancy time of sufficient length so that in case of no error, the difference between the two signals (when checking for nonequivalence: the consistency) has definitely disappeared before the discrepancy time expires.

Response During Discrepancy Time

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 of discrepancy.

Response During Discrepancy Time

If the input signals are not equivalent following expiration of the specified discrepancy time (when checking for nonequivalence: no inequality), for example due to wire break at a sensor line, the system detects a discrepancy error and generates a "discrepancy" diagnostic message in the diagnostic buffer of the F-I/O module to identify the faulty channels.

Reintegration After Discrepancy Error Parameter

With this parameter you can define the criteria for clearing discrepancy errors which, when fulfilled, facilitate reintegration of the relevant input channels. Programming options:

- "Zero signal test required" or
- "Zero signal test not required"

Requirements

Parameter settings:

- Sensor evaluation: "1oo2 evaluation"

"Zero signal test required"

When "Zero signal test required" is set, a discrepancy error is not considered cleared until a zero signal is set at both input channels.

When using nonequivalent sensors, that is, "2-channel nonequivalent" is set at the "Type of sensor interconnection" parameter, the zero signal must again be set at the channel which provides the wanted signal.

"Zero signal test not required"

When "Zero signal test not required" is set, a discrepancy error is considered cleared when a discrepancy no longer exists between the two input channels.

SIMATIC S7 F-modules, for which you cannot program the "Reintegration after discrepancy error" parameter, also behave in this way.

7.5.5 Applications for the 4/8 F-DI DC24V PROFIsafe Electronic Module

Selecting the Application

The diagram below supports you in selecting an application which suits your fail-safe requirements. The following chapters provide information for each application on wiring the F-module, and which specific parameters you must program in *STEP 7*.

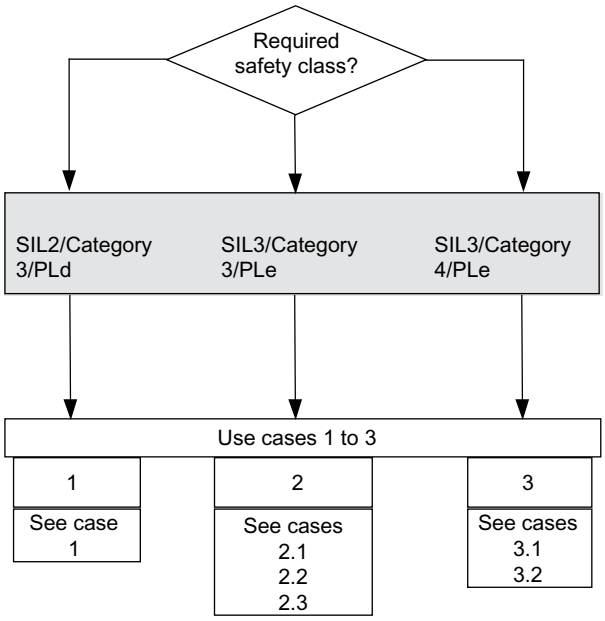


Figure 7-18 Use case selection - 4/8 F-DI DC24V PROFIsafe electronic module

WARNING

The achievable safety class is determined by the sensor quality and the length of the proof-test interval in accordance with IEC 61508 standard. If the sensor quality does not meet the requirements of the safety class, wire it to two channels for redundant operation.

Conditions for achieving SIL/Category/PL

The table below lists the conditions which have to be met for achieving the various safety categories.

Table 7- 18 EM 4/8 F-DI DC24V PROFIsafe: Conditions for achieving SIL/Category/PL

Application	Sensors	Sensor Evaluation	Sensor Supply	achievable SIL/Category/ PL
1	1-channel	1oo1	Internal, with short-circuit test	2 / 3 / d
			Internal, without short-circuit test	
			External	
2.1	1-channel	1oo2	Internal, with short-circuit test	3 / 3 / e
			Internal, without short-circuit test	
			External	
2.2	2-channel equivalent	1oo2	Internal, without short-circuit test	
			External	
2.3	2-channel, nonequivalent	1oo2	Internal, without short-circuit test	
			External	
3.1	2-channel equivalent	1oo2	Internal, with short-circuit test	3 / 4 / e
3.2	2-channel, nonequivalent			

Note

You can operate the various inputs of an F-DI module simultaneously in SIL2/Category 3/PLd **and** SIL3/Category 3 or 4/PLe. You only have to connect the inputs and assign the parameters as shown in the following chapters.

Sensor Requirements

Please note the information in section *"Requirements for Sensors and Actuators"* when using sensors for safety-related applications.

See also

Requirements for Sensors and Actuators (Page 37)

Using ET 200S Fail-Safe Modules (Page 14)

7.5.6 Application 1: SIL2/Category 3/PLd safety mode

Sensor supply

The EM 4/8 F-DI DC24V PROFIsafe provides sensor supply Vs1 for Inputs 0 to 3 and sensor supply Vs2 for Inputs 4 to 7. The sensor supply can be powered internally or externally.

Wiring Diagram for Application 1 – Connecting One Sensor to One Channel

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

The wiring is carried out on the appropriate terminal module.

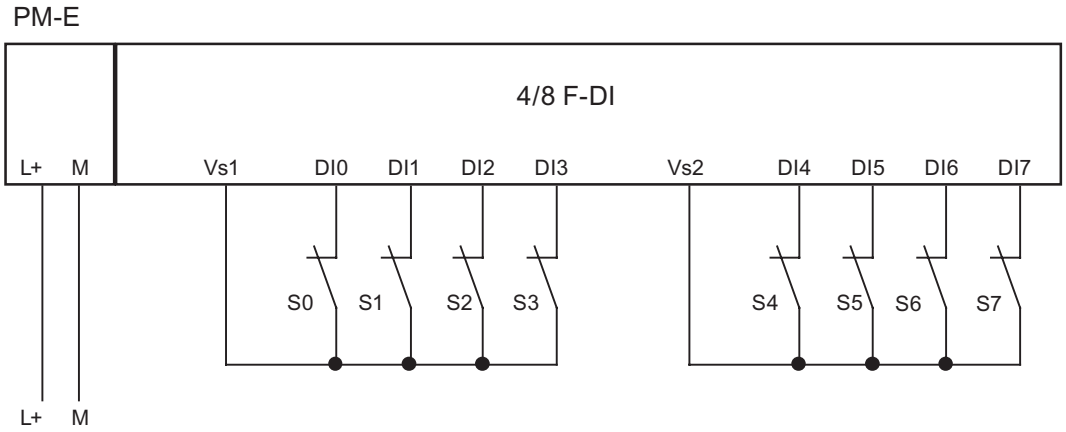


Figure 7-19 Wiring diagram EM 4/8 F-DI DC24V PROFIsafe - one sensor connected via one channel, internal sensor supply

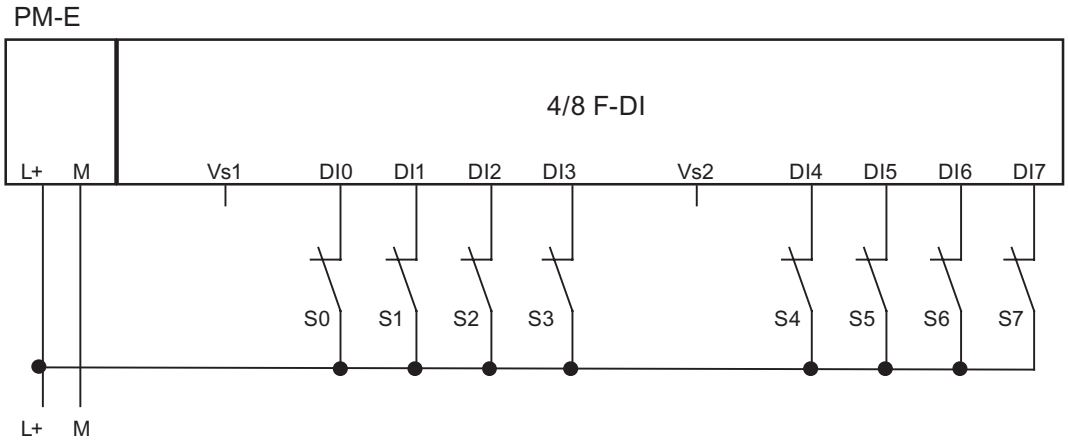


Figure 7-20 Wiring diagram EM 4/8 F-DI DC24V PROFIsafe - one sensor connected via one channel, internal sensor supply

WARNING

To achieve SIL2/Category 3/PLd using this wiring, you must use a suitably qualified sensor.

Assignable Parameters for Application 1

Set the "Sensor evaluation" parameter to "1oo1" for the corresponding input.

You can activate or deactivate the "short-circuit test" parameter. For digital inputs connected to an external supply, set the "Sensor supply" parameter for the corresponding digital input to "external". The program will otherwise report a "short circuit" diagnostics event if the "short-circuit test" is activated.

Special Features of Fault Detection (Application 1)

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

Table 7- 19 EM 4/8 F-DI DC24V PROFIsafe: Fault Detection (Application 1)

Example of Fault	Fault detection if ...		
	internal sensor supply and short-circuit test activated	internal sensor power supply and short-circuit test are deactivated	external sensor supply
Short circuit in DI 0 with DI 1	No	No	No
Short circuit in DI 0 with DI 4	Yes*	No	No
P-short circuit in DI 0	Yes	No	No
M-short circuit in DI 0	Yes*	Yes*	No
Discrepancy error	-	-	-
P-short circuit in sensor supply 1	Yes	no	No
M-short circuit in sensor supply 1, or sensor supply 2 defective	Yes	Yes	Yes
Short circuit in sensor supply 1 with sensor supply 2	Yes	no	no
Fault in read/test circuit	Yes	Yes	Yes
Supply voltage fault	Yes	Yes	Yes
*: Fault detection only if signals are corrupted. That is, the signal reading differs compared to 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", the wiring between the sensor and the input channel must be short circuit-proof.

7.5.7 Application 2: Safety mode SIL3/Category 3/PLe

Assigning Inputs to Each Other

The EM 4/8 F-DI DC24V PROFIsafe has 8 fail-safe inputs, DI 0 through DI 7 (SIL2). A pair of these inputs can each be used as one input (SIL3). The following assignment applies:

- DI 0 with DI 4
- DI 1 with DI 5
- DI 2 with DI 6
- DI 3 with DI 7

Sensor supply

The EM 4/8 F-DI DC24V PROFIsafe provides sensor supply Vs1 for Inputs 0 to 3 and sensor supply Vs2 for Inputs 4 to 7. The sensors can be powered internally or externally.

Wiring Diagram for Application 2.1 - Connecting one channel of one sensor to two inputs

Single-channel connection of a sensor to two inputs of the F-module for each process signal (1oo2 evaluation).

Note

If you power the sensors from the F-DI module, you must use the internal sensor supply Vs1. Connection to Vs2 is not possible.

The wiring is carried out on the appropriate terminal module.

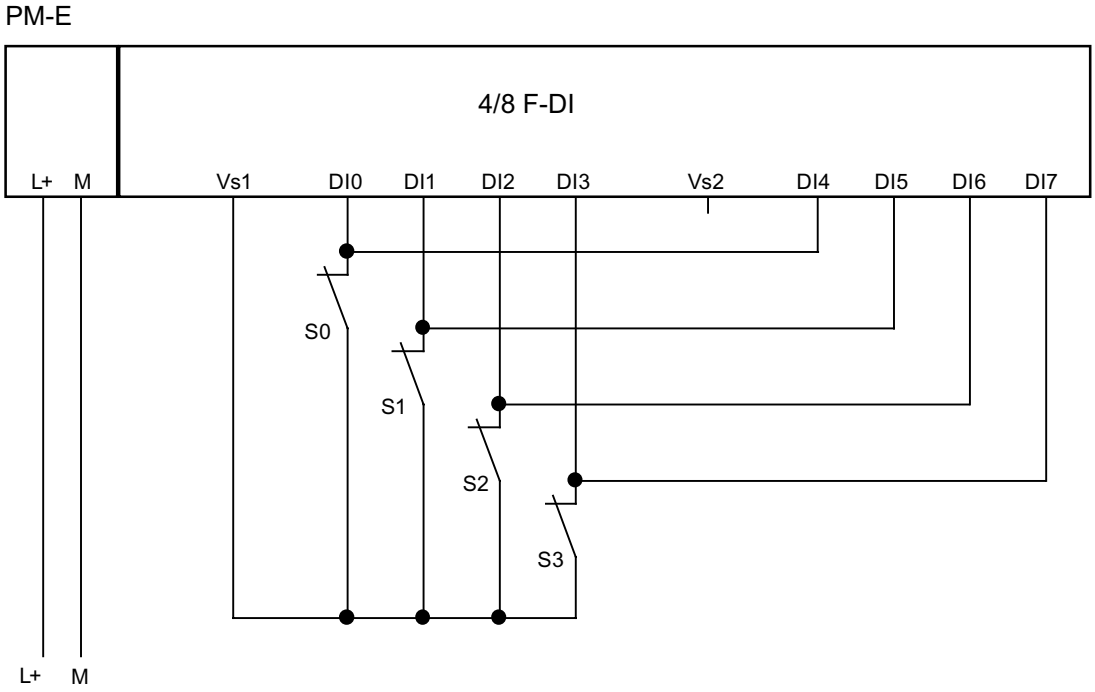


Figure 7-21 Wiring diagram EM 4/8 F-DI DC24V - one sensor connected via one channel to two inputs, internal sensor supply

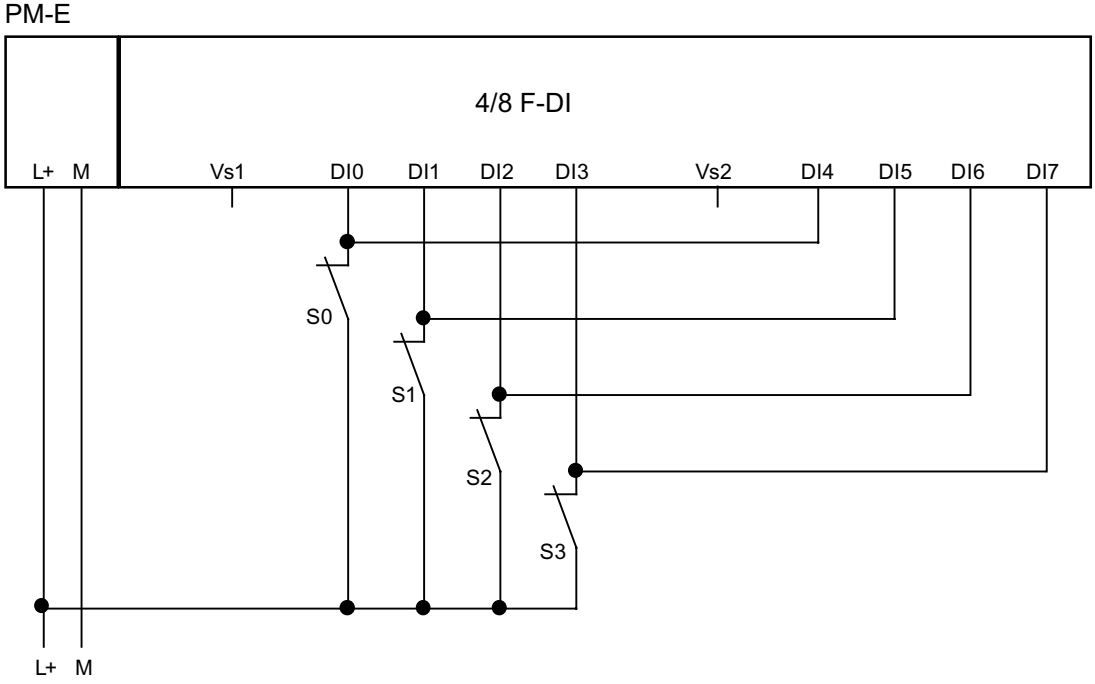


Figure 7-22 Wiring diagram EM 4/8 F-DI DC24V - one sensor connected via one channel to two inputs, external sensor supply

WARNING

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

Assignable Parameters for Application 2.1

Set the "1oo2 evaluation" at the corresponding input, and "Single-channel" at the "Type of sensor interconnection" parameter. The default discrepancy time of 10 ms cannot be modified.

You can activate or deactivate the "short-circuit test" parameter. For digital inputs connected to an external supply, set the "Sensor supply" parameter for the corresponding digital input to "external". The program will otherwise report a "short circuit" diagnostics event if the "short-circuit test" is activated.

Specific Features of Fault Detection (Application 2.1)

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

Table 7- 20 EM 4/8 F-DI DC24V PROFIsafe: Fault detection (application 2.1)

Example of fault	Fault detection if ...		
	Internal sensor supply and short-circuit test are activated	Internal sensor supply and short-circuit test are deactivated	External sensor supply
Short circuit in DI 0 with DI 1	no	no	no
Short circuit in DI 0 with DI 5	no	no	no
P-short circuit in DI 0	Yes	no	no
M-short circuit in DI 0	Yes*	Yes*	no
Discrepancy error	Yes	Yes	Yes
P-short circuit in sensor supply 1	Yes	no	no
M-short circuit in sensor supply 1, or sensor supply 2 defective	Yes	Yes	Yes
Short circuit in sensor supply 1 with sensor supply 2	Yes	no	no
Fault in read/test circuit	Yes	Yes	Yes
Supply voltage fault	Yes	Yes	Yes

*: Fault is detected only in case of signal corruption. In other words, the signal read 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.

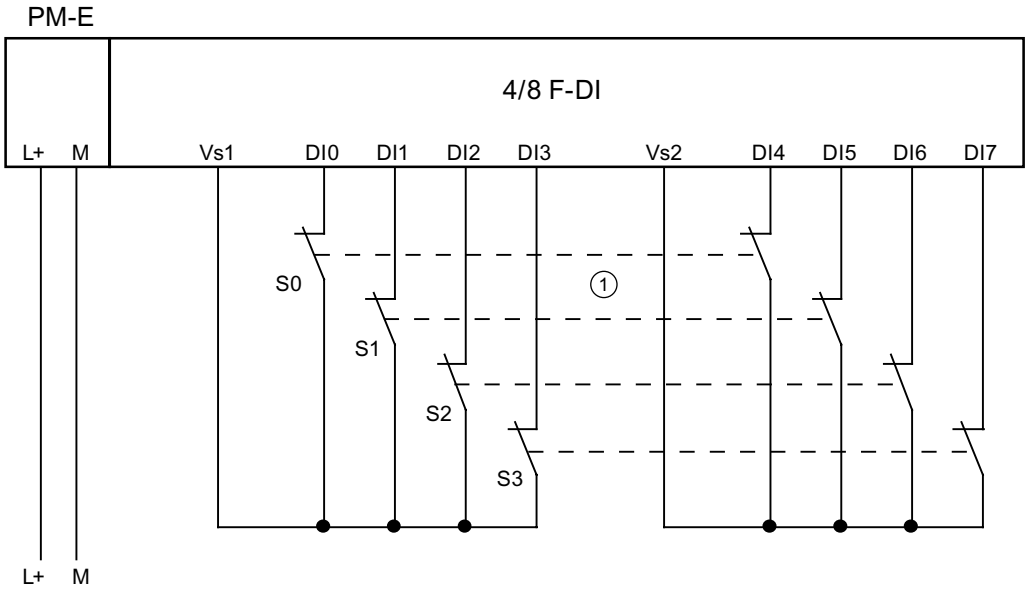
WARNING

If the short-circuit test is disabled or cannot be enabled, the wiring between the sensor and input channel must be short circuit-proof.

Wiring Diagram for Application 2.2 - Connecting a Two-Channel Sensor to Two Channels

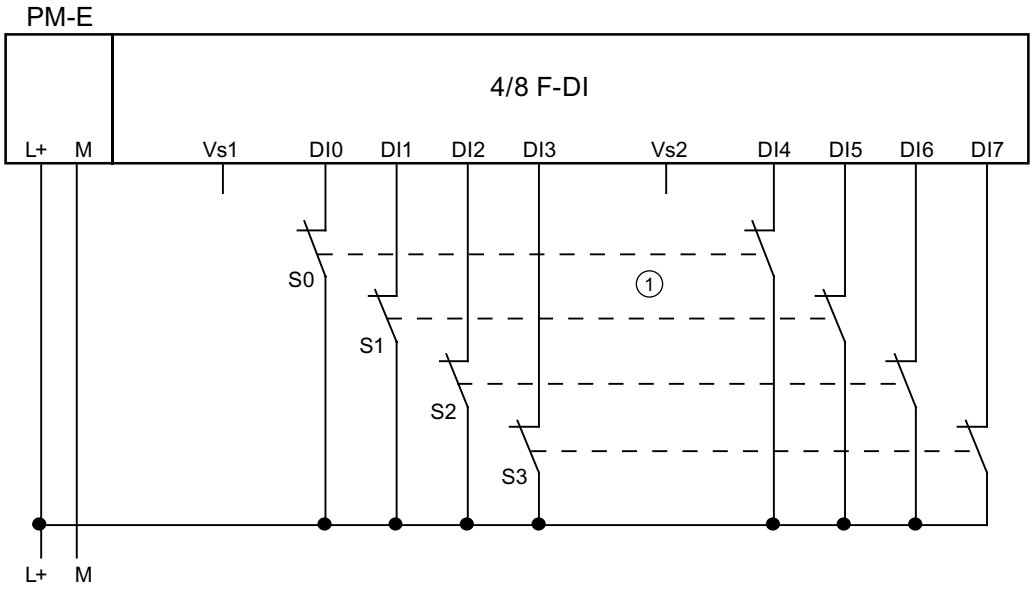
A 2-channel sensor is connected to two inputs of the F-module for each process signal (1oo2 evaluation).

The wiring is carried out on the appropriate terminal module.



① Encoder contacts are coupled mechanically

Figure 7-23 Wiring diagram EM 4/8 F-DI DC24V - a 2-channel sensor connected via two channels, internal sensor supply



① Encoder contacts are coupled mechanically

Figure 7-24 Wiring diagram EM 4/8 F-DI DC24V - a 2-channel sensor connected via two channels, external sensor supply

Wiring Diagram for Application 2.2 – Connecting Two Single-Channel Sensors to Two Channels

Two single-channel sensors are connected via two channels to two inputs of the F-module for each process signal (1oo2 evaluation). The sensors can also be connected to an external sensor supply.

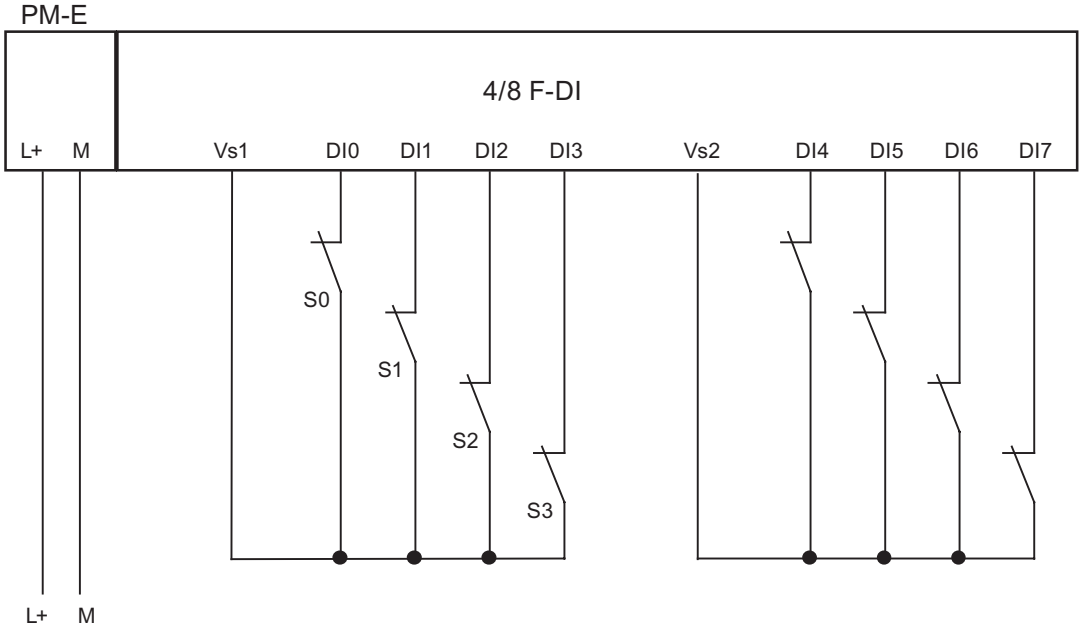


Figure 7-25 Wiring diagram EM 4/8 F-DI DC24V - two 1-channel sensors connected via two channels, internal sensor supply

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

Assignable Parameters for Application 2.2

Set the "sensor evaluation" to "1oo2 evaluation" at the corresponding input, and "2-channel equivalent" at the "Type of sensor interconnection" parameter. Disable the "short-circuit test" parameter.

Specific Features of Fault Detection (Application 2.2)

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

Table 7- 21 EM 4/8 F-DI DC24V PROFIsafe: Fault Detection (Application 2.2)

Example of fault	Fault detection if ...	
	Internal sensor supply and short-circuit test are deactivated	External sensor supply
Short circuit in DI 0 with DI 1	Yes*	Yes*
Short circuit in DI 0 with DI 4	no	no
Short circuit in DI 0 with DI 5	Yes*	Yes*
P-short circuit in DI 0	Yes*	Yes*
M-short circuit in DI 0	Yes*	Yes*
Discrepancy error	Yes	Yes
P-short circuit in sensor supply 1	no	no
M-short circuit in sensor supply 1, or sensor supply 2 defective	Yes	Yes
Short circuit in sensor supply 1 with sensor supply 2	no	no
Fault in read/test circuit	Yes	Yes
Supply voltage fault	Yes	Yes
*: Fault is detected only in case of signal corruption. In other words, the signal read 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.		

Wiring Diagram for Application 2.3 - Connecting a Nonequivalent Sensor to Two Nonequivalent Channels

A nonequivalent connection of a 2-channel sensor is connected to two inputs of the F-module for each process signal (1oo2 evaluation).

Alternatively, two one-channel sensors can be connected via two channels non-equivalently (see figure "Wiring diagram EM 4/8 F-DI DC24V - two one-Channel sensors connected via two channels nonequivalently, internal sensor supply"). In this case, the same process variable is acquired with two mechanically separate sensors.

The left-hand channels on the F-module (DI0 through DI3) supply the wanted signals. If no faults are detected, these signals will be available in the process image for inputs on the F-CPU.

Note

If you power the sensors from the F-DI module, you must use the internal sensor supply Vs1. Connection to Vs2 is not possible.

The wiring is carried out on the appropriate terminal module.

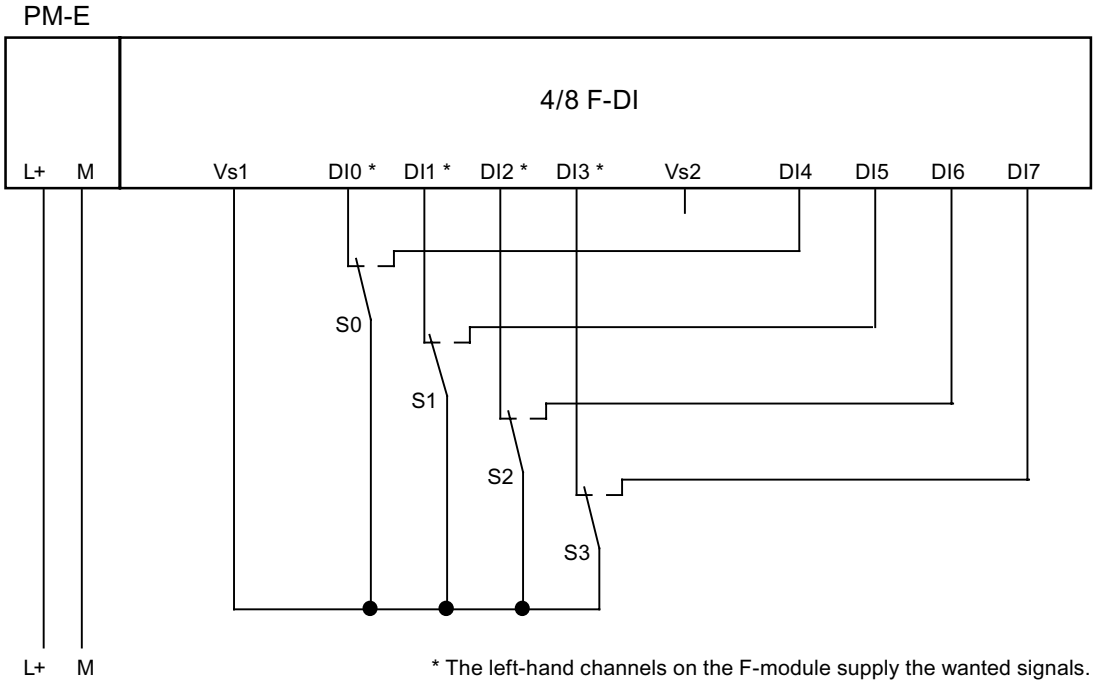


Figure 7-26 Wiring diagram EM 4/8 F-DI DC24V - a nonequivalent 2-channel sensor connected via two channels non-equivalently, internal sensor supply

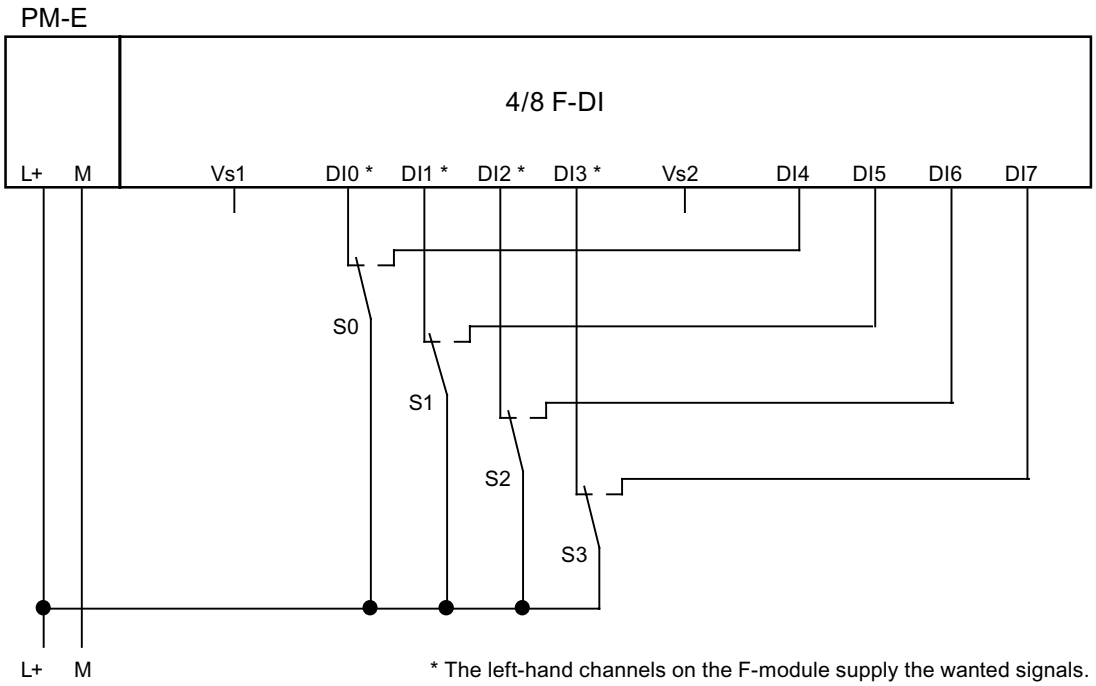


Figure 7-27 Wiring diagram EM 4/8 F-DI DC24V - a non-equivalent sensor connected via two channels non-equivalently, external sensor supply

Wiring Diagram for Application 2.3 – Connecting Two Single-Channel Sensors Nonequivalently via Two Channels

The left-hand channels on the F-module (DI0 through DI3) supply the wanted signals. If no faults are detected, these signals will be available in the I/O area for inputs on the F-CPU.

The sensors can also be connected to an external sensor supply.

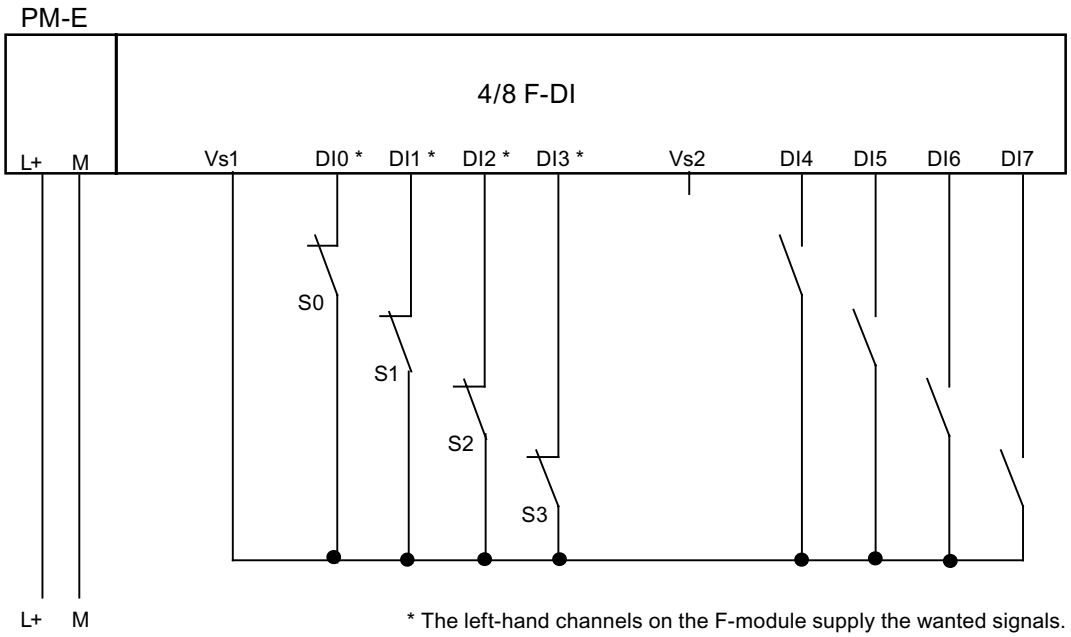


Figure 7-28 Wiring diagram EM 4/8 F-DI DC24V - two 1-channel sensors connected via two channels, internal sensor supply

⚠ WARNING

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

Assignable Parameters for Application 2.3

Set the "sensor evaluation" to "1oo2 evaluation" at the corresponding input, and "2-channel equivalent" at the "Type of sensor interconnection" parameter. Disable the "short-circuit test" parameter.

For digital inputs connected to an external supply, set the "Sensor supply" parameter for the corresponding digital input to "external".

Specific Features of Fault Detection (Application 2.3)

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

Table 7- 22 EM 4/8 F-DI DC24V PROFIsafe: Fault Detection (Application 2.3)

Example of fault	Fault detection if ...	
	Internal sensor supply and short-circuit test are deactivated	External sensor supply
Short circuit in DI 0 with DI 1	Yes*	Yes*
Short circuit in DI 0 with DI 4	Yes	Yes
Short circuit in DI 0 with DI 5	Yes*	Yes*
P-short circuit in DI 0	Yes*	Yes*
M-short circuit in DI 0	Yes*	Yes*
Discrepancy error	Yes	Yes
P-short circuit in sensor supply 1	no	no
M-short circuit in sensor supply 1, or sensor supply 2 defective	Yes	Yes
Short circuit in sensor supply 1 with sensor supply 2	no	no
Fault in read/test circuit	Yes	Yes
Supply voltage fault	Yes	Yes
*: Fault is detected only in case of signal corruption. In other words, the signal read 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.		

7.5.8 Application 3: Safety mode SIL3/Category 4/PLe

Assigning Inputs to Each Other

The EM 4/8 F-DI DC24V PROFIsafe has 8 fail-safe inputs, DI 0 through DI 7 (SIL2). A pair of these inputs can each be used as one input (SIL3). The following assignment applies:

- DI 0 with DI 4
- DI 1 with DI 5
- DI 2 with DI 6
- DI 3 with DI 7

Sensor supply

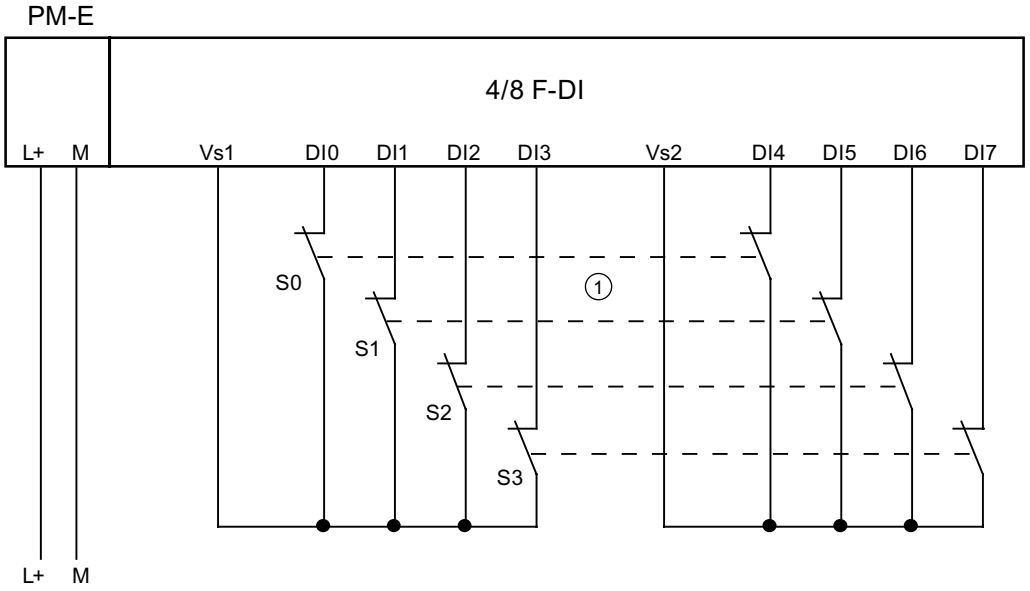
The EM 4/8 F-DI DC24V PROFIsafe provides sensor supply Vs1 for Inputs 0 to 3 and sensor supply Vs2 for Inputs 4 to 7. The sensor must be supplied internally.

Wiring Diagram for Application 3.1 - Connecting a Two-Channel Sensor to Two Channels

A 2-channel sensor is connected to two inputs of the F-module for each process signal (1oo2 evaluation).

Wiring diagram of the connection of two single-channel sensors to two channels. In this case, the same process variable is acquired with two mechanically separate sensors.

The wiring is carried out on the appropriate terminal module.



① Encoder contacts are coupled mechanically

Figure 7-29 Wiring diagram EM 4/8 F-DI DC24V - a 2-channel sensor connected via two channels, internal sensor supply

Alternatively, two one-channel sensors can be connected via two channels (see figure *"Wiring diagram EM4/8 F-DI DC24V - two one-channel sensors connected via two channels, internal sensor supply"*). In this case, the same process variable is acquired with two mechanically separate sensors.

⚠ WARNING

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

Assignable Parameters for Application 3.1

Set the "sensor evaluation" to "1oo2 evaluation" at the corresponding input, and "2-channel equivalent" at the "Type of sensor interconnection" parameter. Activate the "short-circuit test" parameter and set "internal" at the "sensor supply" parameter.

Wiring Diagram for Application 3.2 - Connecting a Nonequivalent Sensor to Two Nonequivalent Channels

4 process signals can be connected to an EM 4/8 F-DI DC24V PROFIsafe. A sensor is nonequivalently connected via 2 channels to two inputs of the F-module for each process signal (1oo2 evaluation).

Alternatively, two one-channel sensors can be connected via two channels (see figure "Wiring diagram EM 4/8 F-DI DC24V - two one-channel sensors connected via two channels nonequivalently, internal sensor supply"). In this case, the same process variable is acquired with two mechanically separate sensors.

The left-hand channels on the F-module (DI0 through DI3) supply the wanted signals. If no faults are detected, these signals will be available in the I/O area for inputs on the F-CPU.

Note

You must use the internal sensor supply Vs1 to supply voltage to the sensor. Connection to Vs2 is not possible.

The wiring is carried out on the appropriate terminal module.

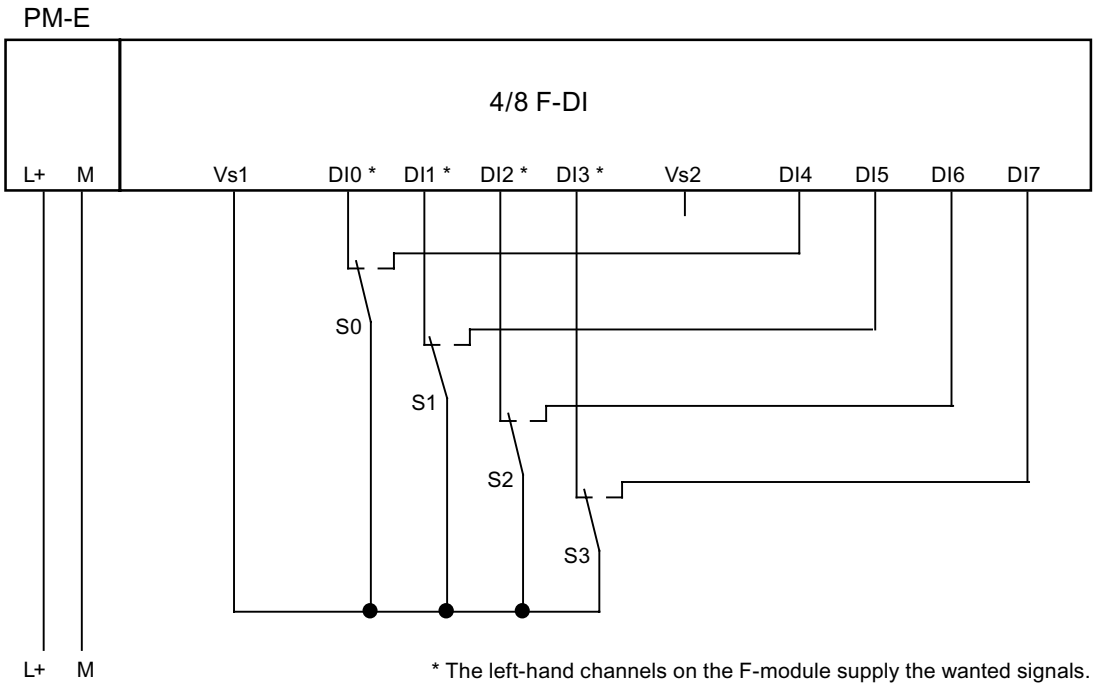


Figure 7-30 Wiring diagram EM 4/8 F-DI DC24V - a nonequivalent sensor connected via two channels non-equivalently, internal sensor supply

WARNING

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

Wiring Diagram for Application 3.2 – Connecting Two Single-Channel Sensors Nonequivalently via Two Channels

The left-hand channels on the F-module (DI0 through DI3) supply the wanted signals. If no faults are detected, these signals will be available in the I/O area for inputs on the F-CPU.

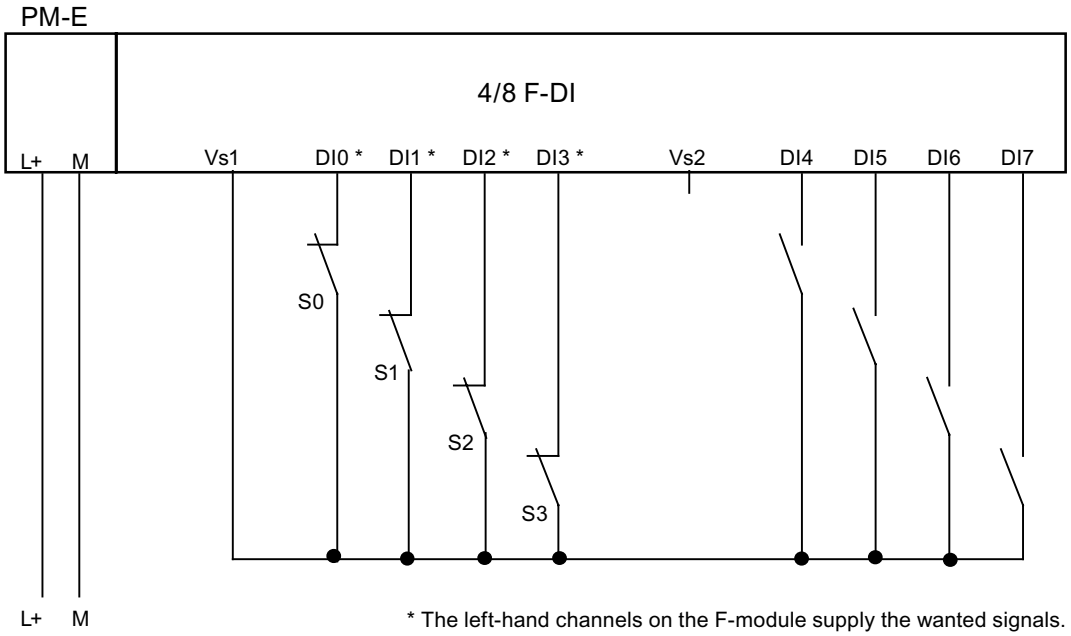


Figure 7-31 Wiring diagram EM 4/8 F-DI DC24V - two 1-channel sensors connected via two channels, internal sensor supply

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

Assignable Parameters for Application 3.2

Set the "sensor evaluation" to "1oo2 evaluation" at the corresponding input, and "2-channel equivalent" at the "Type of sensor interconnection" parameter. Activate the "short-circuit test" parameter and set "internal" at the "sensor supply" parameter.

Special Features of Fault Detection (Application 3.1 and 3.2)

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

Table 7- 23 EM 4/8 F-DI DC24V PROFIsafe: Fault Detection (Application 3.1 and 3.2)

Example of fault	Fault detection with internal sensor power supply and activated short-circuit test for...	
	Sensor 2-channel equivalent	Sensor 2-channel non-equivalent
Short circuit in DI 0 with DI 1	Yes*	Yes*
Short circuit in DI 0 with DI 4	Yes*	Yes
Short circuit in DI 0 with DI 5	Yes*	Yes*
P-short circuit in DI 0	Yes	Yes
M-short circuit in DI 0	Yes*	Yes*
Discrepancy error	Yes	Yes
P-short circuit in sensor supply 1	Yes	Yes
M-short circuit in sensor supply 1, or sensor supply 2 defective	Yes	Yes
Short circuit in sensor supply 1 with sensor supply 2	Yes	Yes
Fault in read/test circuit	Yes	Yes
Supply voltage fault	Yes	Yes
*: Fault is detected only in case of signal corruption. In other words, the signal read 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.		

Requirements for Machine Protection Applications with Category 4

The following requirements apply for applications in machine protection with category 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
- All short circuits listed in the above table are covered. It is sufficient to locate a short circuit, because two faults are required for it to occur (both signal lines in short circuit have an insulation fault). A multiple short circuit analysis is not required.

Procedures for locating all short circuits are also permissible if single short circuits are not located,

- provided these do not cause corruption of read signals compared to the sensor signals or
- provided they cause corruption of read signals compared to sensor signals in the direction that ensures safety.

7.5.9 Diagnostic Functions of the EM 4/8 F-DI DC24V PROFIsafe

Behavior in Case of Supply Voltage Failure

Failure of the Vs1 and Vs2 sensor power supply of the EM 44/8 F-DI DC24V PROFIsafe is indicated by the 1VsF and 2VsF LED on the F-module. This information is also provided in the module (diagnostic entry). Either all channels of the module are passivated or, in case of channel-specific passivation, the relevant channels are passivated.

In the case of a voltage dip in the external auxiliary voltage, the SF LED lights up, the module is passivated.

With the subsequent supply recovery (level must remain above the specified value for at least 1 minute (refer to the technical specifications: voltages, currents, electrical potentials)) the SF LED goes out again, the module remains passivated. The SF LED flashes if there are no other errors, until the error is acknowledged.

Behavior in Case of Cross-Circuit/Short-Circuit at the Sensor Supply

When operating with programmed external sensor supply and blocked short-circuit test, you enable the detection of short-circuits to M at the sensor supplies and signaling at the corresponding VsFLED. No entries are made in the diagnostics data of the module.

When operating with a configured external sensor supply and cyclic short-circuit test, you enable the detection of cross-circuits between 1Vs and 2Vs and short-circuits to M and P at the sensor supplies and signaling at the corresponding VsF LED. No entries are made in the diagnostics data of the module.

Diagnostic functions

The table below provides an overview of the diagnostic functions of the EM 4/8 F-DI DC24V PROFIsafe. The diagnostic functions are assigned either to one channel or to the entire module.

Table 7- 24 Diagnostic functions of the EM 4/8 F-DI DC24V PROFIsafe

Diagnostic Function*	Fault Number	LED	Signaled in Application	Effective Range of Diagnostics	Can be Assigned Parameters
Short circuit	1_H	SF 1VsF 2VsF	1, 2, 3	Channel	Yes
Overtemperature	5_H	SF	1, 2, 3	Module	No
Internal error	9_H	SF	1, 2, 3	Module	No
Parameter assignment error	10_H	SF	1, 2, 3	Module	No
Sensor voltage or load voltage missing	11_H	SF	1, 2, 3	Module	No
Communication error	13_H	SF	1, 2, 3	Module	No

Diagnostic Function*	Fault Number	LED	Signaled in Application	Effective Range of Diagnostics	Can be Assigned Parameters
Discrepancy error (1oo2 evaluation) safety-oriented tripping	19_H	SF	2,3	Channel	No
*: Specially for F-modules; display in *STEP 7*, see "Channel-Specific Diagnostics, Fault Types of Fail-Safe Modules" table					

Note

If you have activated the **short-circuit test** for the F-DI module in *STEP 7* and are using only one of the two internal sensor supplies of the module (Vs1 or Vs2), a channel M-short circuit is then detected for each of the four channels with a sensor supply that is not used. Four "short-circuit" diagnostic functions are generated in the diagnostic buffer of the F-module.

Special Features of 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 in *"Application 1: Safety mode SIL2/Category 3/PLd" to "Use case 3: Safety mode SIL3/Category 4/PLe"*.

Causes of Faults and Corrective Measures

The following table contains the possible causes of the faults described for the individual diagnostic messages of the EM 4/8 F-DI DC24V PROFIsafe and remedies.

Table 7- 25 Diagnostic messages of the EM 4/8 F-DI DC24V PROFIsafe, causes of errors and remedies

Diagnostic Message	Possible Causes	Corrective Measures
Short circuit	Short circuit in the sensor	Eliminate short circuit/cross circuit Check the sensor supply
	Cross circuit in the sensor	
	Encoder supply short-circuit	
	Internal error	Replace module
Overtemperature	Shutdown due to violation of upper or lower temperature limit value in the module case.	Check load wiring, check ambient temperature, check whether permissible output current is exceeded for the ambient temperature. Once the fault has been eliminated, the module must be removed and inserted or the power switched OFF and ON.
Internal error	Internal module fault has occurred	Replace module

Diagnostic Message	Possible Causes	Corrective Measures
Parameter assignment error	Inserted module does not match configuration Faulty parameter assignment	Correct configuration (compare actual and preset configuration) Check communication paths Correct configuration
	PROFIsafe address set incorrectly in the F-module	Check whether the PROFIsafe address on the module matches the configuration in *HW Config*
Sensor voltage or load voltage missing	No supply voltage or supply voltage is too low	Check the supply voltage on the interconnected PM Check module for correct contact
Communication error	Error in communication between F-CPU and module due to defective PROFIBUS connection or higher than permissible EMI, for example	Check the PROFIBUS/PROFINET connection Eliminate the interference
	PROFIsafe monitoring time set too low	Set a greater value for the "F monitoring time" parameter for the module in *HW Config*
	Configuration of the F-module does not match safety program	Generate safety program again; then load configuration and safety program into F-CPU again
Discrepancy error (1oo2 evaluation)	Faulty process signal Defective sensor	Check process signal, replace sensor if necessary
	Short circuit between unconnected sensor cable and the sensor supply cable	Eliminate short circuit
	Wire break in connected sensor cable or the sensor supply cable	Eliminate broken wire
	Assigned discrepancy time too short	Check the assigned discrepancy time
		Once the fault is eliminated, the F-module must be reintegrated in the safety program

Detailed information on F I/O access can be found under *"Diagnostics"* in the *S7 Distributed Safety, Configuring and Programming* manual or the *S7 F/FH Systems, Configuring and Programming* manual.

Generally Applicable Information on Diagnostics

For information on diagnostics that affects all fail-safe modules (such as readout of diagnostic functions; passivation of channels) see this manual in *"Diagnostics"* and the *S7 Distributed Safety, Configuration and Programming* manual or *S7 F/FH Systems, Configuring and Programming*.

See also

Fault Diagnostics (Page 43)

7.5.10 Technical Specifications of the EM 4/8 F-DI DC24V PROFIsafe

Overview

Technical Specifications		
Dimensions and Weight		
Dimensions W x H x D (mm)	30 x 81 x 52	
Weight	Approx. 78 g	
Data for Specific Module		
Number of inputs		
• 1-channel	8, maximum	
• 2-channel	4, maximum	
Assigned address area		
• I/O area for inputs	6 bytes	
• I/O area for outputs	4 bytes	
Length of cable		
• Unshielded *	Max. 200 m (at input delay 3 ms * and 15 ms)	
• Shielded *	Max. 200 m (at input delay 0.5 ms, 3 ms and 15 ms)	
Maximum achievable safety class	1-channel	2-channel
• In accordance with IEC 61508	SIL2	SIL3
• In accordance with EN 954	Category 3	Category 4
• according to ISO 13849	PLd	PLe
Fail-safe performance characteristics	SIL2	SIL3
• Low demand mode (average probability of failure on demand)	< 1.00E-03	< 1.00E-05
• High demand/continuous mode (probability of dangerous failure per hour)	< 1.00E-08	< 1.00E-10
• Acceptance ID	FM, cULus, ATEX, CE, C-Tick	
Voltages, Currents, Potentials		
Rated supply voltage L+	24 VDC	
• permissible range **	20.4 V to 28.8 V	
• Power loss ride-through of L+	None	
• Power loss ride-through of internal P5	5 ms	
• Reverse polarity protection	No	
Number of simultaneously controllable inputs		
• Horizontal installation – Up to 55°C – Up to 60°C – Up to 60°C	 8 (with 28.8 V) 8 (with 24 V) 6 (with 28.8 V)	
• Vertical installation – Up to 40 °C	 8	
Electrical isolation		
• Between channels and backplane bus	Yes	
• Between channels and power supply	No	

Technical Specifications	
• Between channels	No
• Between channels/power supply and shield	Yes
Permissible potential difference between	
• Shield and ET 200S bus connection	75 VDC/60 VAC
• Shield and I/O (DIs, P1/P2 buses)	75 VDC/60 VAC
• ET 200S bus connection and I/O (DIs, P1/P2 buses)	250 VAC
Isolation in the series tested with	
• Shield and ET 200S bus connection	500 VDC/1 min or 600 VDC/1 s
• Shield and I/O (DIs, P1/P2 buses)	500 VDC/1 min or 600 VDC/1 s
• ET 200S bus connection and I/O (DIs, P1/P2 buses)	1500 VAC/1 min or 2545 VDC/1 s
Isolation in the type test tested with	
• Shield and ET 200S bus connection	350 VAC/1 min
• Shield and I/O (DIs, P1/P2 buses)	350 VAC/1 min
• ET 200S bus connection and I/O (DIs, P1/P2 buses)	2830 VAC/1 min
• Surge voltage test between ET 200S bus connection and I/O (DIs, P1/P2 bus)	6000 VDC/5 positive and 5 negative pulses
Current consumption	
• From backplane bus	28 mA, typical
• From load voltage L+ (without load)	120 mA, typical
Power dissipation of the module	4 W, typical
Status, Interrupts, Diagnostics	
Status display	
Inputs	Green LED per channel
Sensor supply	Red LED per channel
Diagnostic functions	
• Group fault display	Red LED (SF)
• Diagnostic information can be displayed	Possible
Sensor Supply Outputs	
Number of outputs	2
Output voltage	
• Loaded	Minimum L+ (-1.5 V)
Output current	
• Rated value	300 mA
• Permissible range	0 mA to 300 mA
Permissible total current of outputs	600 mA
Short-circuit protection	Yes, electronic
• Operating value	0.7 A to 1.8 A
Data for selecting a sensor ***	
Input voltage	
• Rated value	24 VDC
• For "1" signal	15 V to 30 V
• For "0" signal	-30 V to 5 V

Technical Specifications		
Input current		
• For "1" signal	3.7 mA, typical	
Input delay *	Assignable (for all inputs together)	
• For "0" after "1"	Typically 0.5 ms	(0.3 ms to 0.7 ms)
	Typically 3 ms	(2.6 ms to 3.4 ms)
	Typically 15 ms	(13 ms to 17 ms)
• bei "1" nach "0"	Typically 0.5 ms	(0.3 ms to 0.7 ms)
	Typically 3 ms	(2.6 ms to 3.4 ms)
	Typically 15 ms	(13 ms to 17 ms)
Input characteristic	In accordance with IEC 61131-2 Type 1	
Connection of 2-wire proximity switch (BERO)	Not possible	
• Permissible quiescent current	0.6 mA, maximum	
Time, Frequency		
Internal processing times	See *"Response Times"*	
Acknowledgment time in safety mode		
• Short-circuit test activated With input delay of 0.5 ms: With input delay of 3 ms: With input delay of 15 ms:	 Min. 4 ms / max. 7 ms Min. 4 ms / max. 12 ms Min. 4 ms / max. 9 ms	
• Short-circuit test deactivated	Min. 4 ms / max. 6 ms	
Minimum sensor signal duration	See *"Minimum Duration of Sensor Signals to Allow Correct Detection by the F-DI Module"* table in *"Wiring and Fitting Modules"*	
Protection against Overvoltage		
Protection of power supply L+ from surge in accordance with IEC 61000-4-5 with external protection elements only		
• Symmetrical (L+ to M)	1 kV; 1.2/50 µs	
• Asymmetrical (L+ to PE, M to PE)	+2 kV; 1.2/50 µs	
Protection of inputs and outputs from surge in accordance with IEC 61000-4-5 with external protection elements only		
• Symmetrical (Vs, DI to M)	+1 kV; 1.2/50 µs	
• Asymmetrical (Vs, DI to PE, M to PE)	+1 kV; 1.2/50 µs	

*: With an input delay of 0.5 ms, shielded cables must be used for the digital inputs and the sensor supply.
With 3 ms input delay, shielded cables must be used if there is a danger of overvoltage on the signal lines (see section "Electromagnetic Compatibility") to prevent possible passivation of the fail-safe digital inputs and the sensor power supply switching off. If unshielded signal lines are used, the safe behavior of the process variables is ensured.
**: Operating below the permissible supply voltage is only permissible for the repair time. See chapter "Introduction (Page 61)."
***: For more information on the requirements for sensors and actuators, see "Wiring and Fitting Modules".

7.6 EM 4 F-DI/3 F-DO DC24V PROFIsafe digital electronic module

7.6.1 Properties of the 4 F-DI/3 F-DO DC24V PROFIsafe Digital Electronic Module

Order Number

6ES7138-4FC01-0AB0

Properties

The 4 F-DI/3 F-DO DC24V PROFIsafe digital electronic module possesses the following properties:

- Achievable safety class SIL2/Category 3/PLd
- Inputs
  - Four inputs
  - 24 VDC rated input voltage
  - Suitable for switches and 3/4-wire proximity switches (BEROs)
  - 1 short circuit-proof sensor supply for four inputs
  - External sensor supply possible
  - The fault display for the sensor supply (VsF) is mapped to VsF and to the associated channels
  - Only 1oo2 evaluation possible
- Outputs
  - 3 outputs, P/M-switching
  - Output current 2 A
  - Rated load voltage 24 VDC
  - Suitable for solenoid valves, DC contactors and indicator lights
- Group fault display (SF; red LED)
- Status and fault LEDs for each input/output (two-color green/red LED)
- Only supported in safety mode

Supported Interface Modules

Refer to chapter "Using ET 200S Fail-Safe Modules (Page 14)" for the supported interface modules.

The EM 4 F-DI/3 F-DO DC24V PROFIsafe can be used centrally with IM 151-7 F-CPU 6ES7151-7FA20-0AB0 V2.6 or higher or IM 151-8 PN/DP F-CPU 6ES7151-8FB00-0AB0.

Supported Power Modules

Table 7- 26 EM 4F-DI/3F-DO DC24V PROFIsafe: Power module for SIL/Category/PL

Power Module	achievable SIL/Category/PL
Supply through PM-E DC24V, PM-E DC24..48V/AC24..230V or PM-E DC24..48V	with 1oo2 sensor evaluation of the SIL2/Category 3/PLd sensor

Switching Grounded Loads

If the EM 4 F-DI/3 F-DO DC24V PROFIsafe switches loads that have a chassis-ground connection (for example to improve EMC characteristics) **and** if chassis and ground are connected at the power supply being used, a "short-circuit" is detected.

From the perspective of the F-module, the M-switch is bridged by the chassis-ground connection (refer to the diagram below as an example of an EM 4 F-DI/3 F-DO DC24V PROFIsafe).

Remedy:

- Using the PM-E F pp DC24V PROFIsafe
- The value of the resistance between chassis and ground at the load end must be greater than 100 kΩ

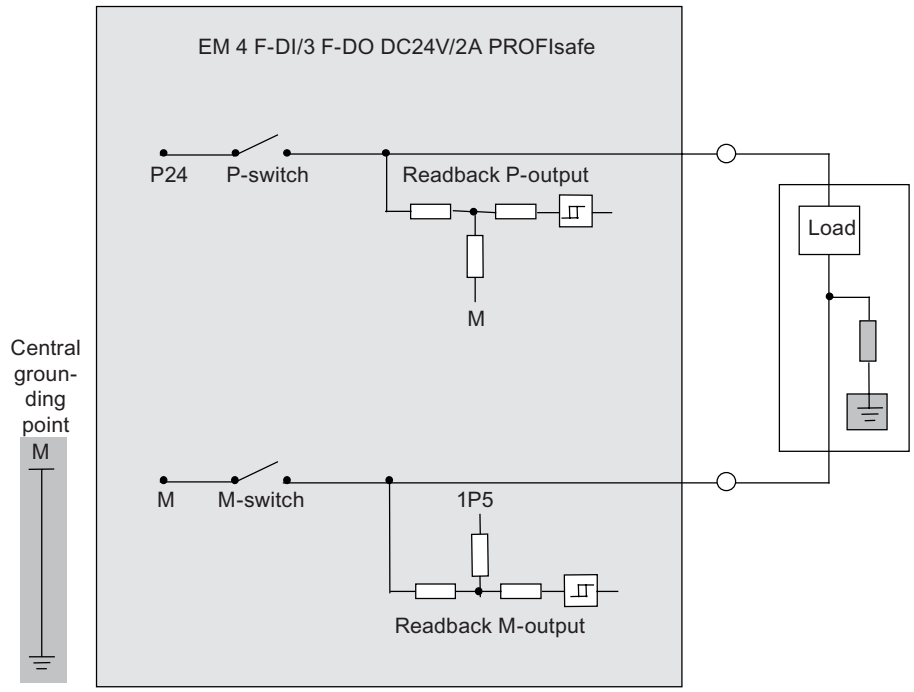


Figure 7-32 Switching Grounded Loads (resistance exists between chassis and ground)

Capacitive Crosstalk of Digital Input/Output Signals

refer to *"Properties of the power module PM-E F pm DC24V PROFIsafe"*.

Magnetic capacitance with inductive loads

Note

Note that an inductive load connected to the DO channels can induce voltages in the case of electromagnetic interference of a strong magnetic field. This can cause a short-circuit error message.

Remedy:

- Spatially disconnect the inductive loads or shield against the magnetic field.
- Set the parameters for the readback time to 50 ms or higher.

SIL mode in grounded configuration

WARNING

The bridging resistance between the M-output and PE may not be less than 100 kΩ for SIL2 operation in grounded configurations. The bridging impedance must be sufficiently high for underflow of the relay release voltage, in order to maintain the proper functioning of both shutdown circuits (P and M-switch).

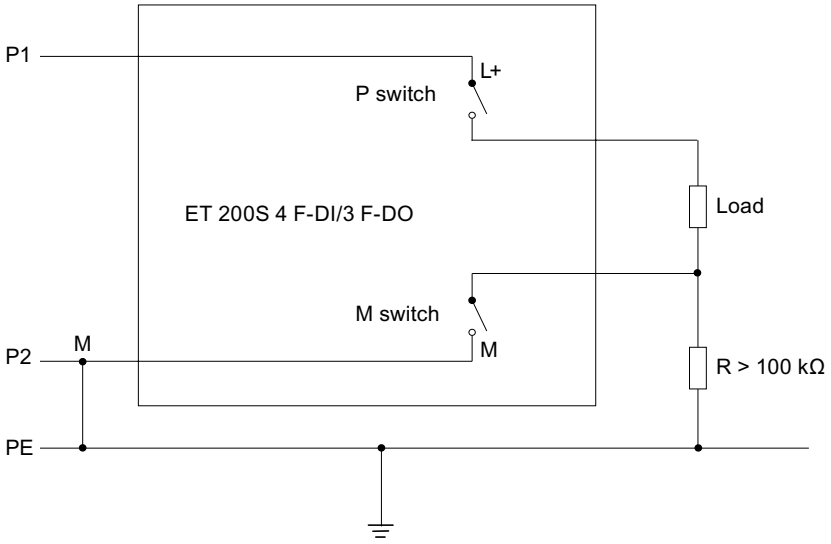


Figure 7-33 SIL2 mode in grounded configuration

7.6.2 Terminal assignment of the EM 4 F-DI/3 F-DO DC24V PROFIsafe

Front view

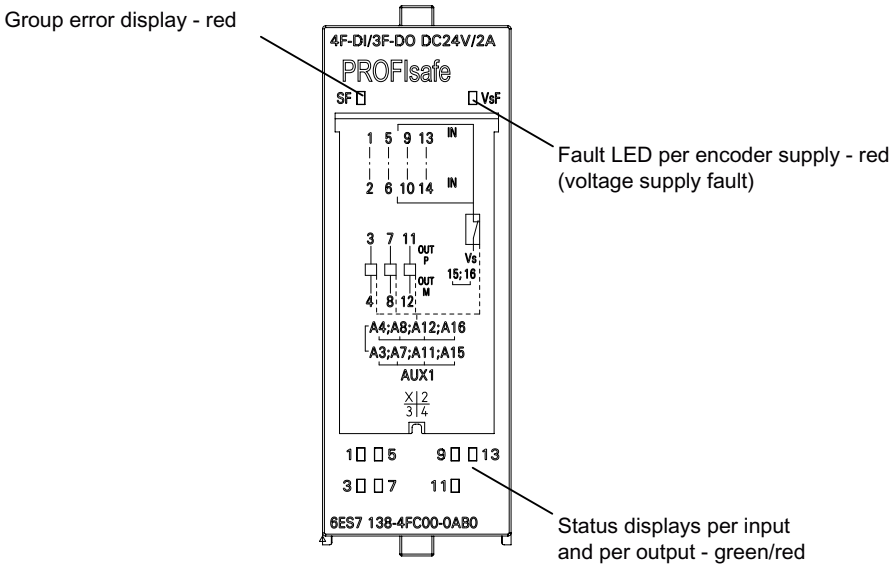


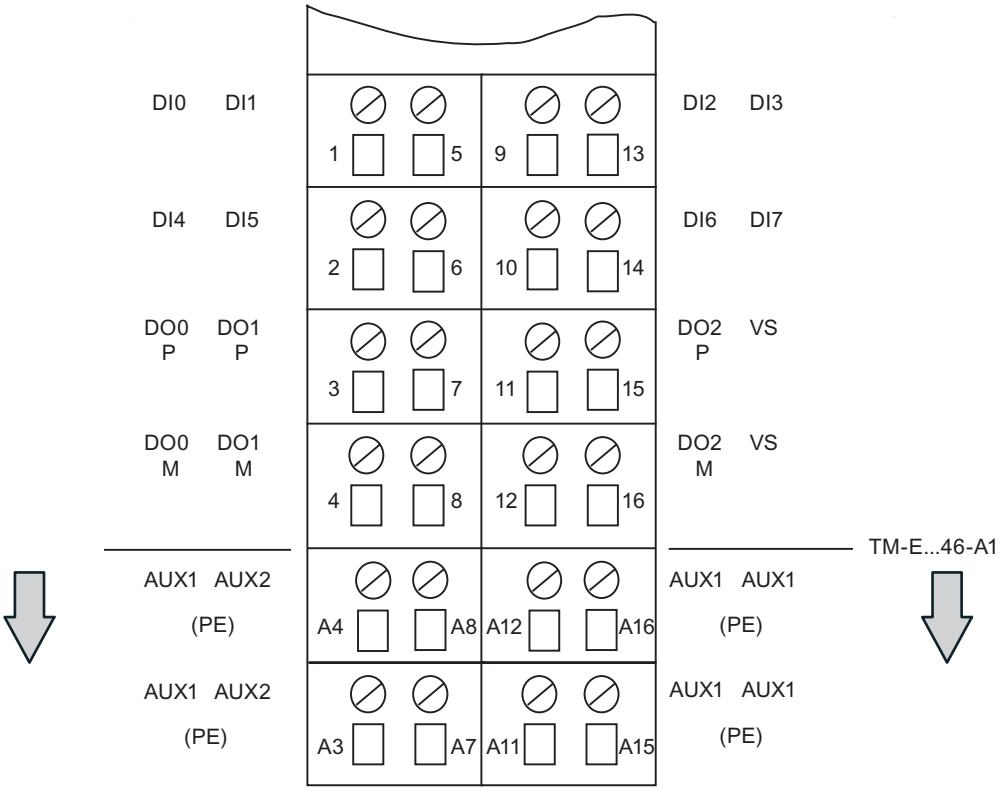
Figure 7-34 Front view 4F-DI/3F-DO

WARNING

The SF LED and the status displays of the inputs/outputs are not designed for safety-related functions and may therefore not be evaluated for safety-related activities.

Terminal assignment

The figure below shows the terminal assignment of the EM 4 F-DI/3 F-DO DC24V PROFIsafe for the terminal module TM-E30S44-01, TM-E30C44-01, TM-E30S46-A1 and TM-E30C46-A1.



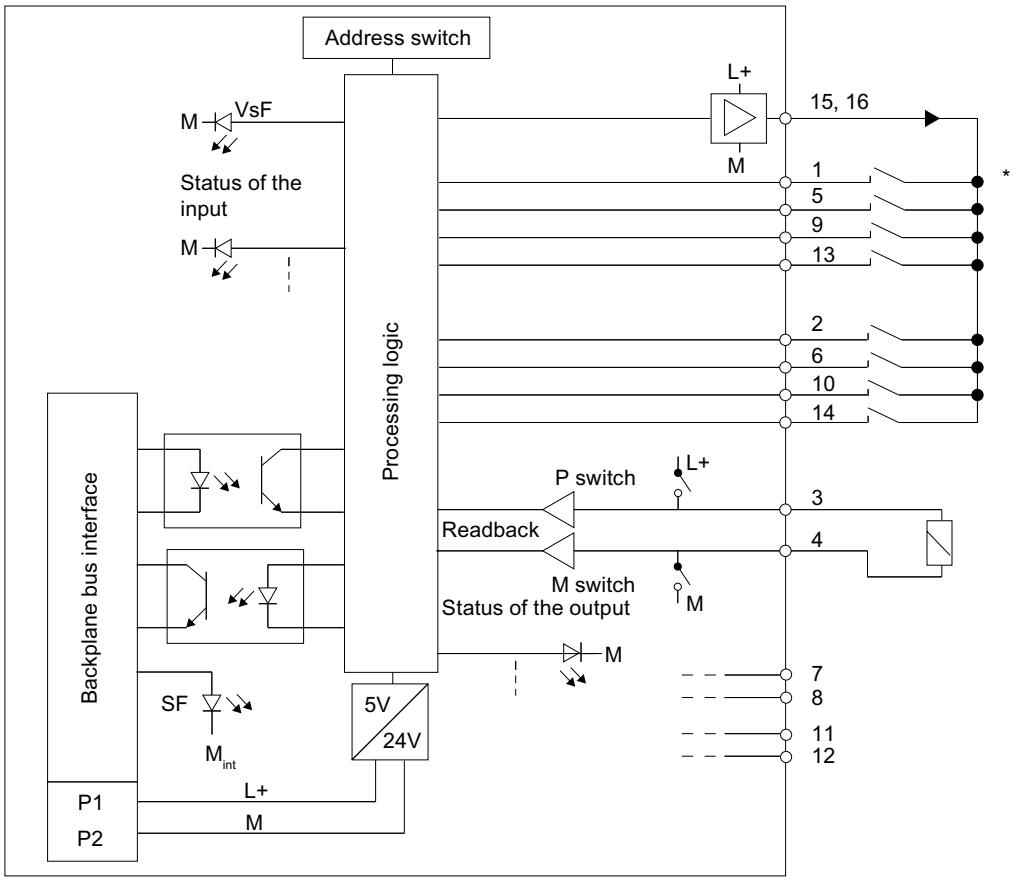
DI	Fail-safe digital input
VS	Internal sensor supply for DI0 to DI7
DOx P	Terminal for fail-safe digital output (P/M-switching)
DOx M	Terminal for fail-safe digital output (P/M-switching)

For TM-E...46-A1 AUX1 bus carried out. Connection to terminals A3 to A16 for any connection of PE (individual grouping of load current power supplies possible)

Figure 7-35 Terminal assignment TM-E...44-01/TM-E...46-A1 for EM 4 F-DI/3 F-DO DC24V PROFIsafe

7.6.3 Wiring of EM 4 F-DI/3 F-DO DC24V PROFIsafe

Block Diagram



* The notation of the NO contact corresponds to the module inscription. However, the encoder contacts must be NC contacts in general (because of the safe state of the process variables).

Figure 7-36 Block Diagram of the EM 4F-DI/3 F-DO DC24V PROFIsafe

7.6.4 EM 4 F-DI/3 F-DO DC24V PROFIsafe parameters

Parameters in *STEP 7*

The table below lists the parameters that can be set for the EM 4 F-DI/3 F-DO DC24V PROFIsafe.

Table 7- 27 Parameters of the EM 4 F-DI/3 F-DO DC24V PROFIsafe

Parameter	Range	Default	Type of Parameter	Effective Range
F-Parameters:				
F_destination_address	1 to 1022	is assigned by *STEP 7*	Static	Module
F monitoring time	10 to 10000 ms	150 ms	Static	Module
Module-specific input parameters				
Short-circuit test	Cyclic/disabled	Cyclic	Static	Module
Behavior after channel faults*	Passivate the entire module/Passivate the channel	Passivate the entire module	Static	Module
Channel n, n+4	Activated/deactivated	Activated	Static	Channel group
Sensor supply	internal/external	internal	Static	Channel group
Sensor evaluation	1oo2 evaluation	1oo2 evaluation	Static	Channel group
Type of sensor interconnection	1-channel 2-channel equivalent; 2-channel, non-equivalent	2-channel equivalent	Static	Channel group
Behavior of discrepancy	Provide last valid value; provide 0 value	Provide last valid value	Static	Channel group
Discrepancy time	10 to 30000 ms	10 ms	Static	Channel group
Reintegration after discrepancy error	Zero signal test not required/Zero signal test required	Zero signal test not required	Static	Channel group
Module-specific output parameters:				
Behavior after channel faults*	Passivate the entire module/Passivate the channel	Passivate the entire module	Static	Module
DO channel n	Activated/deactivated	Activated	Static	Channel
Readback time	1 to 400 ms	1 ms	Static	Channel
* This setting is only relevant when *S7 Distributed Safety* V5.4 or higher is installed.				

Short-circuit test parameter

This parameter can be used to activate short-circuit detection for channels set up for "internal sensor supply."

The short-circuit test is only useful when operating with simple switches which are not connected to their own power supply.
Short-circuit detection temporarily cuts off the sensor supply. The cut-off period equals the input delay (= 3 ms) (see also *"Applications for the 4 F-DI/3 F-DO DC24V PROFIsafe electronic module"*).

Sensor Supply Parameter

This parameter can be used to activate the "internal sensor supply" of the F-module. This setting is a prerequisite for using the short-circuit test.

Note

When there are different sensor supply parameter settings (internal/external) for the individual channel groups, the applications shown in the next chapter apply to specific channel groups.

Discrepancy behavior parameter

For "Behavior of Discrepancy" you assign the value that is to be made available to the safety program in the F-CPU during the time that a discrepancy exists between two input channels, i.e., when the discrepancy time is running. To program discrepancy behavior:

- "Provide last valid value" or
- "Provide 0 value"

"Provide last valid value"

The last valid value (old value) from before the discrepancy occurred is immediately made available to the safety program in the fail-safe CPU as soon as a discrepancy is detected between the signals of the two input channels involved. This value remains available until the discrepancy is cleared, or until the discrepancy time has expired and a discrepancy error is detected. The sensor-actuator response time is extended by this time.

As a result, the discrepancy time for sensors connected over two channels for high-speed reactions must be tuned to short response times. Thus, it makes no sense, for example, if sensors connected via 2 channels 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.

"Provide 0 value"

The "0" value is immediately made available to the safety program in the F-CPU as soon as discrepancy is detected between the signals of the two input channels involved.

If the "Provide 0 value" parameter is set, the sensor-actuator response time will not be influenced by the discrepancy time.

Discrepancy Time Parameter

You can define the discrepancy time for each channel pair with this parameter. The entered value is rounded to a multiple of 10 ms.

Requirements

Parameter settings:

- Type of sensor interconnection: "2-channel equivalent" or "2-channel nonequivalent"

Discrepancy Analysis and Discrepancy Time

When using a dual-channel or non-equivalent sensor 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 equality/non-equality is used at fail-safe inputs to detect errors based on the timing of two signals with the same functionality. Discrepancy analysis is initiated when different levels (when testing for nonequivalence: same levels) are detected for two associated input signals. A test is conducted to determine whether the difference in levels (when testing for nonequivalence: the consistency) disappears after a programmable period of time known as the discrepancy time. If not, this means that a discrepancy error exists.

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

Select a discrepancy time of sufficient length so that in case of no error, the difference between the two signals (when checking for nonequivalence: the consistency) has definitely disappeared before the discrepancy time expires.

Response During Discrepancy Time

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 of discrepancy.

Response During Discrepancy Time

If the input signals are not equivalent following expiration of the specified discrepancy time (when checking for nonequivalence: no inequality), for example due to wire break at a sensor line, the system detects a discrepancy error and generates a "discrepancy" diagnostic message in the diagnostic buffer of the F-I/O module to identify the faulty channels.

Reintegration After Discrepancy Error Parameter

With this parameter you can define the criteria for clearing discrepancy errors which, when fulfilled, facilitate reintegration of the relevant input channels. Programming options:

- "Zero signal test required" or
- "Zero signal test not required"

"Zero signal test required"

When "Zero signal test required" is set, a discrepancy error is not considered cleared until a zero signal is set at both input channels.

When using nonequivalent sensors, that is, "2-channel nonequivalent" is set at the "Type of sensor interconnection" parameter, the zero signal must again be set at the channel which provides the wanted signal.

"Zero signal test not required"

When "Zero signal test not required" is set, a discrepancy error is considered cleared when a discrepancy no longer exists between the two input channels.

SIMATIC S7 F-modules, for which you cannot program the "Reintegration after discrepancy error" parameter, also behave in this way.

Readback Time Parameter

Each output channel has its own selectable readback time. This time specifies the maximum duration of the turn off test for the corresponding channel and therefore also the readback time for turning off the channel.

The following readback times can be set: 1 ms, 5 ms, 10 ms, 50 ms, 100 ms, 200 ms and 400 ms.

You should set an adequately high readback time if the channel involved switches high capacitive loads. If the readback time for a controlled capacitive load is set too low, the output channel is passivated because the discharge of the capacitance does not take place within the turn off test.

If the readback signals are incorrect, the "short circuit" fault only causes passivation of the output channel after the readback time elapses.

⚠ WARNING

With a configured readback time of ≥ 50 ms, short-circuits (cross-circuits) can be suppressed with an interference signal with a frequency > 10 Hz (50:50 duty cycle).

Short-circuits (cross-circuits) on an output of the same module will be detected.

7.6.5 Input applications of EM 4 F-DI/3 F-DO DC24V PROFIsafe

Conditions for achieving SIL/Category/PL

The table below lists the conditions which have to be met for achieving the various safety categories.

Table 7- 28 EM 4 F-DI/3 F-DO DC24V PROFIsafe: Conditions for achieving SIL/Category/PL

Application	Sensors	Sensor evaluation	Sensor supply	achievable SIL/Category/ PL
1.1	1-channel	1oo2	Internal, with/without short-circuit test	2 / 3 / d
			external	
1.2	2-channel equivalent	1oo2	Internal, with/without short-circuit test	
			external	
1.3	2-channel, nonequivalent	1oo2	Internal, with/without short-circuit test	
			external	

Sensor Requirements

Please note the information in section *"Requirements for Sensors and Actuators"* when using sensors for safety-related applications.

Assigning Inputs to Each Other

The EM 4 F-DI/3 F-DO DC24V PROFIsafe has 8 fail-safe inputs, DI 0 through DI 7 (SIL2). Each pair of these inputs can be operated as one input (SIL2). The following assignment applies:

- DI0 with DI4
- DI1 with DI5
- DI2 with DI6
- DI3 with DI7

Sensor Supply

The 4 F-DI/3 F-DO DC24V PROFIsafe EM makes available the VS sensor supply for the Inputs 0 to 7.

The sensors can be powered internally or externally.

Application 1.1: Wiring diagram for connecting single-channel sensor to two inputs

Single-channel connection of a sensor to two inputs of the F-module for each process signal (1oo2 evaluation).

The wiring is carried out on the appropriate terminal module.

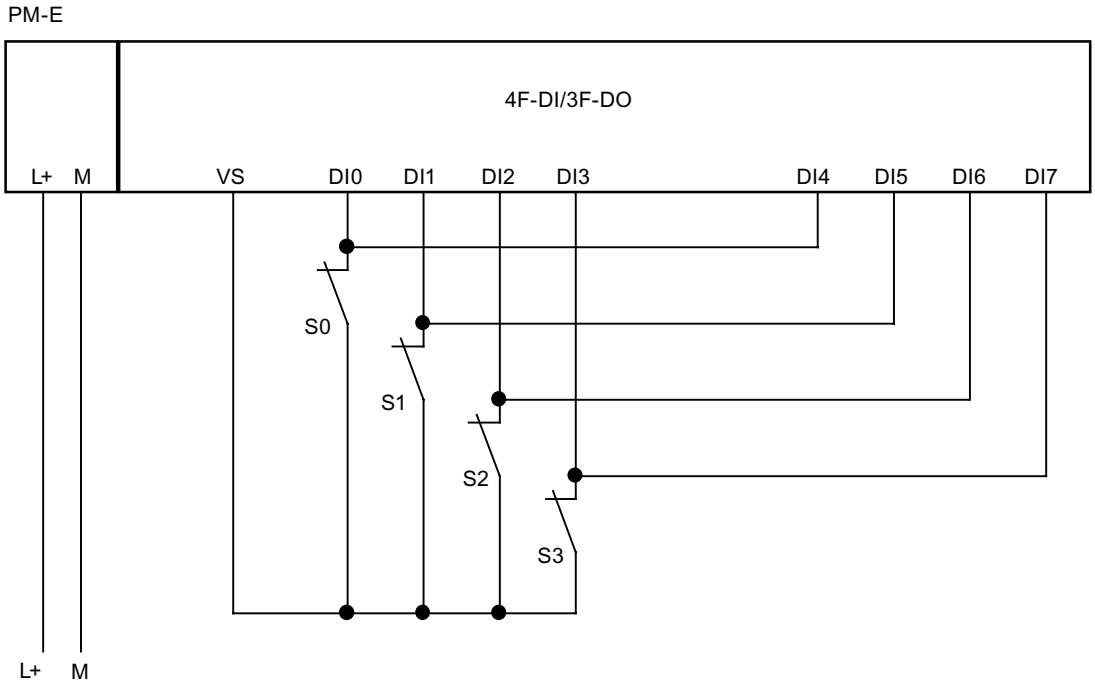


Figure 7-37 Wiring diagram EM 4 F-DI/3 F-DO DC24V - one sensor connected via one channel to two inputs, internal sensor supply

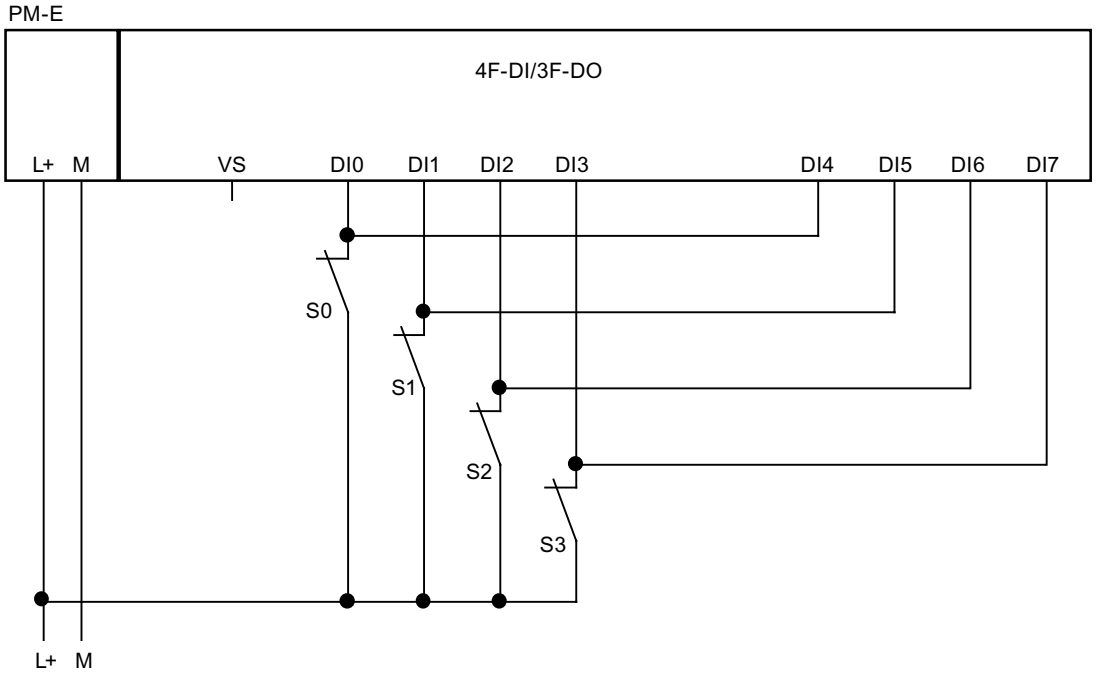


Figure 7-38 Wiring diagram EM 4 F-DI/3 F-DO DC24V - one sensor connected via one channel to two inputs, external sensor supply

WARNING

To achieve SIL2/Category 3/PLd using this wiring, you must use a suitably qualified sensor.

Assignable Parameters for Application 1.1

You can activate or deactivate the "short-circuit test" parameter. For digital inputs connected to an external supply, set the "Sensor supply" parameter for the corresponding digital input to "external". The program will otherwise report a "short circuit" diagnostics event if the "short-circuit test" is activated.

Special Features of Fault Detection in Application 1.1

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

Table 7- 29 EM 4 F-DI/3 F-DO DC24V PROFIsafe: Fault detection

Example of fault	Fault detection if ...		
	internal sensor supply and short-circuit test activated	internal sensor power supply and short-circuit test are deactivated	external sensor supply
Short-circuit DI0 with DI1	No	No	No

	Fault detection if ...		
Short-circuit DI0 with DI5	No	No	No
P short-circuit DI0	Yes	No	No
M short-circuit DI0	Yes*	Yes*	No
Discrepancy error	Yes	Yes	Yes
P-short circuit in sensor supply	Yes	No	No
M-short-circuit in sensor supply or defective	Yes	Yes	Yes
Short-circuit SS with DI0	No	No	No
Supply voltage fault	Yes	Yes	Yes

***:** Fault is detected only in case of signal corruption. In other words, the signal read 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.

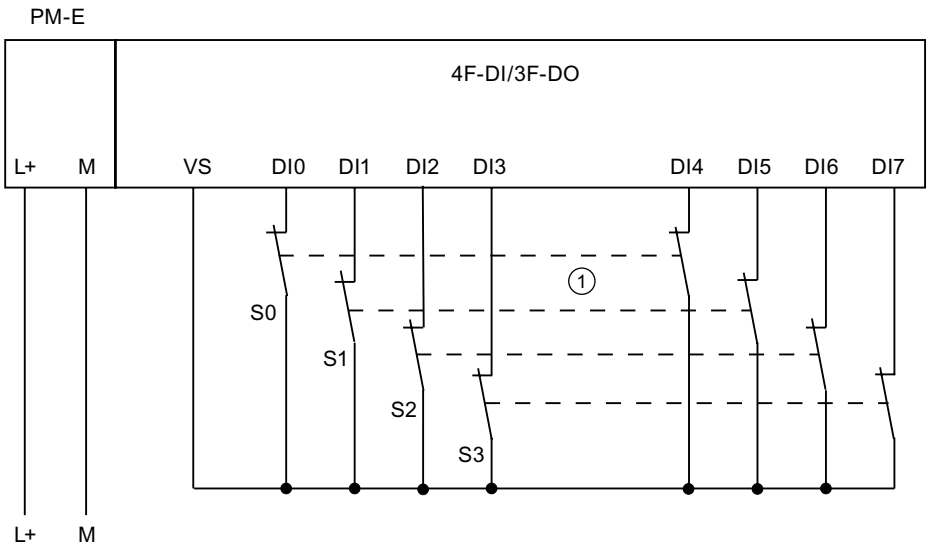
WARNING

If the short-circuit test is disabled or cannot be enabled, the wiring between the sensor and input channel must be short circuit-proof.

Application 1.2: Wiring diagram for connecting a 2-channel sensor to two channels

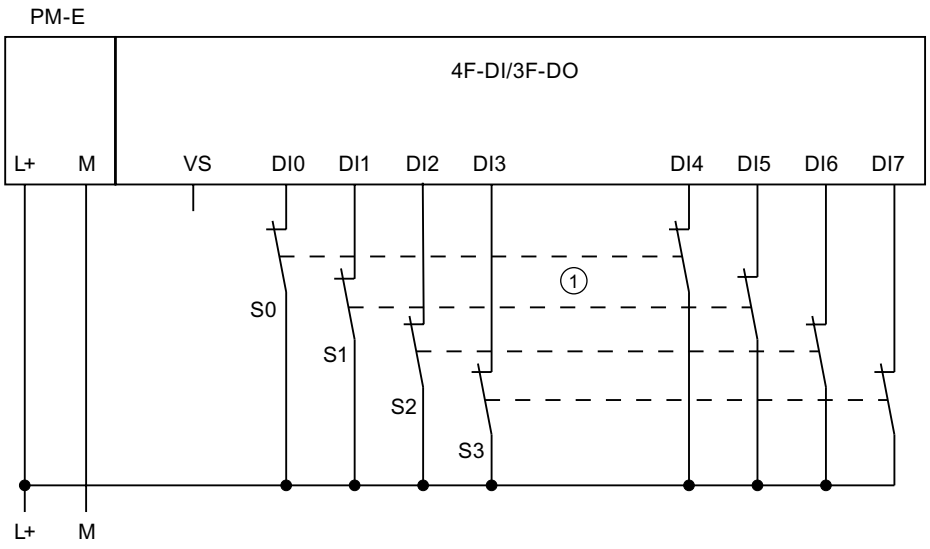
A 2-channel sensor is connected to two inputs of the F-module for each process signal (1oo2 evaluation).

The wiring is carried out on the appropriate terminal module.



① Encoder contacts are coupled mechanically

Figure 7-39 Wiring diagram EM 4 F-DI/3 F-DO DC24V - a 2-channel sensor connected via two channels, internal sensor supply



① Encoder contacts are coupled mechanically

Figure 7-40 Wiring diagram EM 4 F-DI/3 F-DO DC24V - a 2-channel sensor connected via two channels, external sensor supply

Wiring diagram of the connection of two single-channel sensors to two channels

Two single-channel sensors are connected via two channels to two inputs of the F-module for each process signal (1oo2 evaluation). The sensors can also be connected to an external sensor supply.

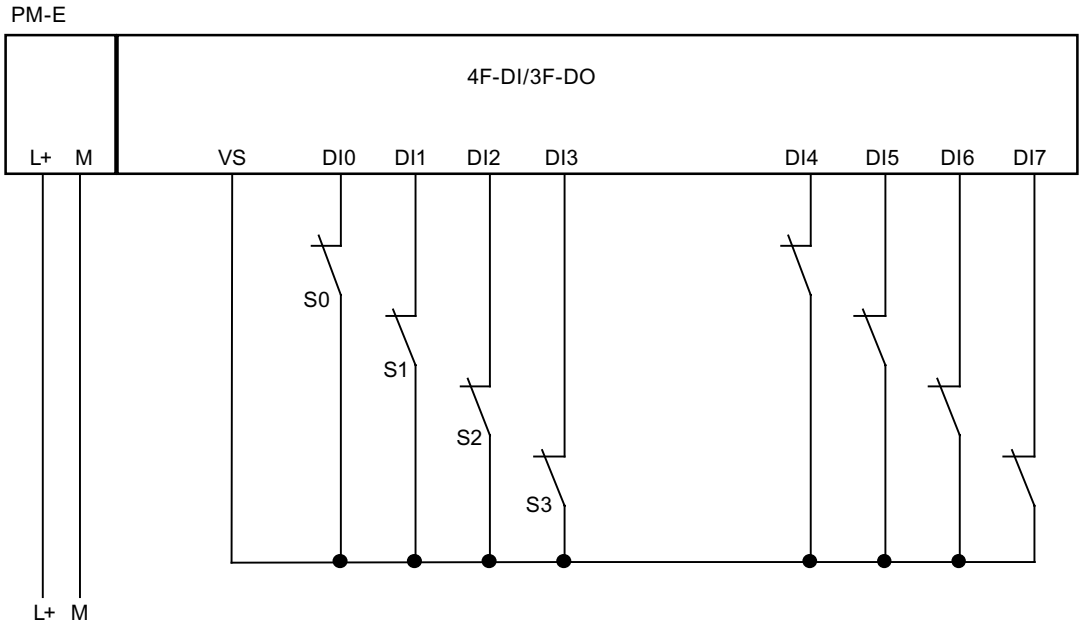


Figure 7-41 Wiring diagram EM 4 F-DI/3 F-DO DC24V - two 1-channel sensors connected via two channels, internal sensor supply

WARNING

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

Assignable Parameters for Application 1.2

Set the "Type of sensor interconnection" parameter to "2-channel equivalent" for the corresponding input.

You can activate or deactivate the "short-circuit test" parameter. For digital inputs connected to an external supply, set the "Sensor supply" parameter for the corresponding digital input to "external". The program will otherwise report a "short circuit" diagnostics event if the "short-circuit test" is activated.

Special Features of Fault Detection in Application 1.2

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

Table 7- 30 EM 4 F-DI/3 F-DO DC24V PROFIsafe: Fault detection

Example of fault	Error detection condition ...		
	Internal sensor supply and short-circuit test are activated	Internal sensor supply and short-circuit test are deactivated	external sensor supply
Short-circuit DI0 with DI1	Yes*	Yes*	Yes*
Short-circuit DI0 with DI4	No	No	No
Short-circuit DI0 with DI5	Yes*	Yes*	Yes*
P short-circuit DI0	Yes*	Yes*	Yes*
M short-circuit DI0	Yes*	Yes*	Yes*
Discrepancy error	Yes	Yes	Yes
P-short circuit in sensor supply	Yes	No	No
M-short circuit in sensor supply or defective	Yes	Yes	Yes
Short-circuit SS with DI0	Yes*	Yes*	Yes*
Supply voltage fault	Yes	Yes	Yes
*: Fault is detected only in case of signal corruption. In other words, the signal read 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.			

WARNING

If the short-circuit test is not activated or the sensor supply to digital inputs is set to "external", the wiring between the sensor and the input channel must be short circuit-proof.

Application 1.3: Wiring diagram of the nonequivalent connection of a nonequivalent sensor to two channels

A nonequivalent connection of a 2-channel sensor is connected nonequivalently to two inputs of the F-I/O module for each process signal (1oo2 evaluation).

The left-hand channels on the F-module (DI0 through DI3) supply the wanted signals. If no faults are detected, these signals will be available in the I/O area for inputs on the F-CPU.

The wiring is carried out on the appropriate terminal module.

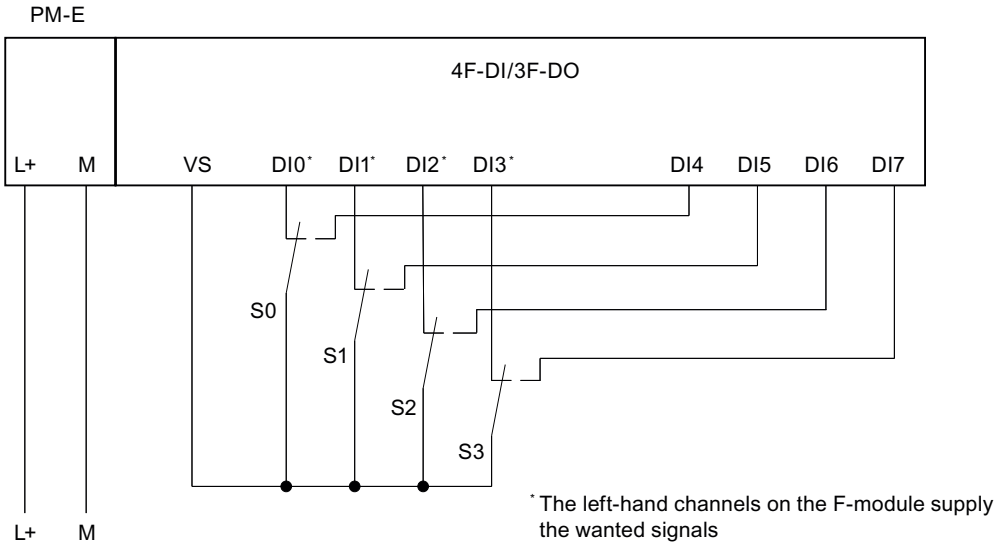


Figure 7-42 Wiring diagram EM 4 F-DI/3 F-DO DC24V - a nonequivalent 2-channel sensor connected via two channels non-equivalently, internal sensor supply

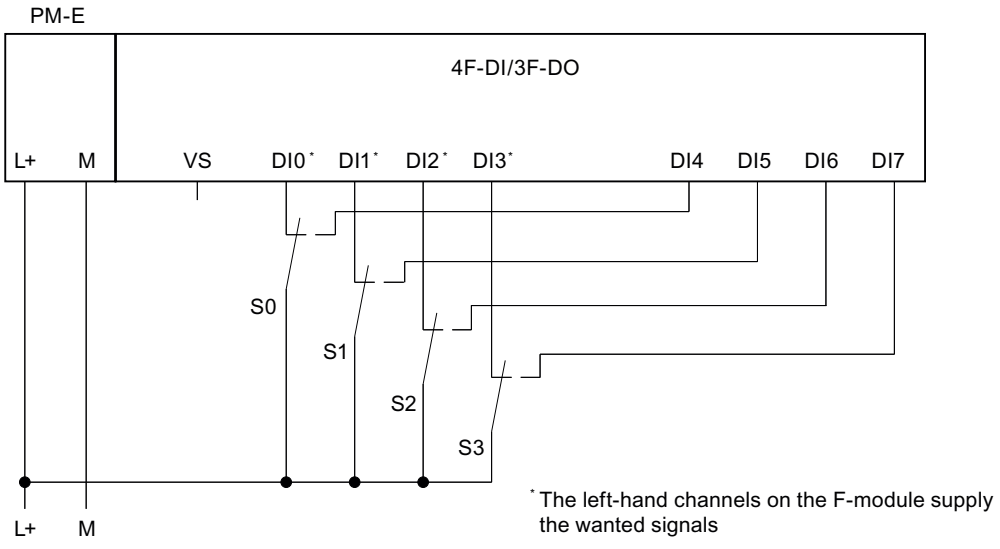


Figure 7-43 Wiring diagram EM 4 F-DI/3 F-DO DC24V - a non-equivalent sensor connected via two channels non-equivalently, external sensor supply

Wiring Diagram for Nonequivalent Connection of Two Single-Channel Sensors to Two Channels

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

The left-hand channels on the F-module (DI0 through DI3) supply the wanted signals. If no faults are detected, these signals will be available in the I/O area for inputs on the F-CPU.

The sensors can also be connected to an external sensor supply.

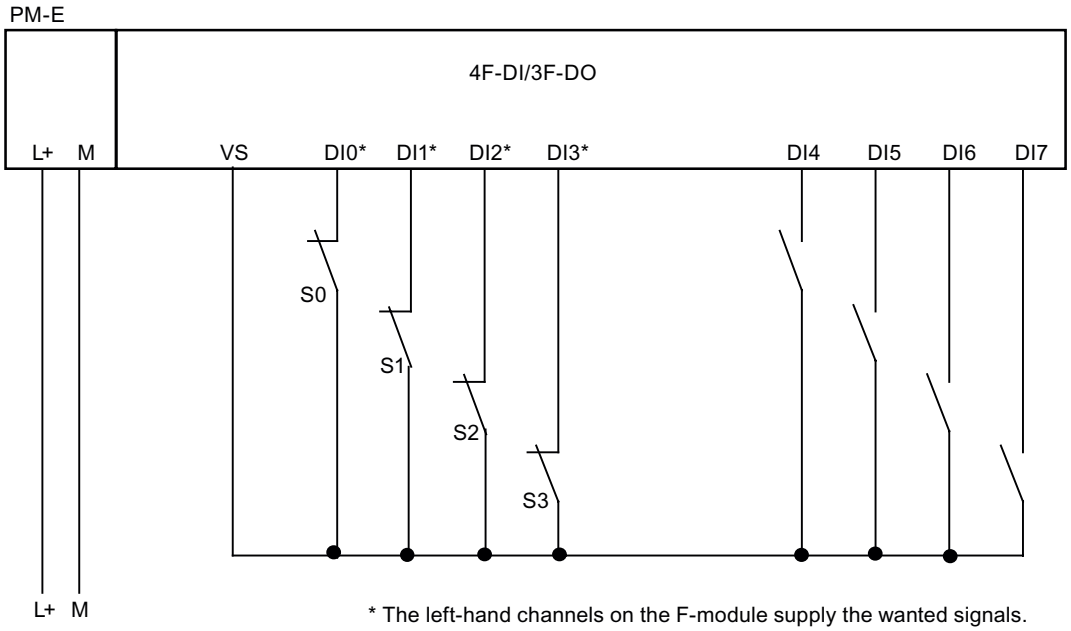


Figure 7-44 Wiring diagram EM 4 F-DI/3 F-DO DC24V - two 1-channel sensors connected via two channels, internal sensor supply

⚠ WARNING

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

Assignable Parameters for Application 1.3

You can activate or deactivate the "short-circuit test" parameter. For digital inputs connected to an external supply, set the "Sensor supply" parameter for the corresponding digital input to "external". The program will otherwise report a "short circuit" diagnostics event if the "short-circuit test" is activated.

Special Features of Fault Detection in Application 1.3

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

Table 7- 31 EM 4 F-DI/3 F-DO DC24V PROFIsafe: Fault Detection (Application 1.3)

Example of fault	Fault detection if ...		
	Internal sensor supply and short-circuit test are activated	Internal sensor supply and short-circuit test are deactivated	external sensor supply
Short-circuit DI0 with DI1	Yes*	Yes*	Yes*
Short-circuit DI0 with DI4	Yes	Yes	Yes
Short-circuit DI0 with DI5	Yes*	Yes*	Yes*
P short-circuit DI0	Yes*	Yes*	Yes*
M short-circuit DI0	Yes*	Yes*	Yes*
Discrepancy error	Yes	Yes	Yes
P-short circuit in sensor supply	Yes	No	No
M-short circuit in sensor supply or sensor supply defective	Yes	Yes	Yes
Short-circuit SS with DI0	Yes*	Yes*	Yes*
Supply voltage fault	Yes	Yes	Yes
*: Fault is detected only in case of signal corruption. In other words, the signal read 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

Requirements for Sensors and Actuators (Page 37)

Using ET 200S Fail-Safe Modules (Page 14)

7.6.6 Output applications of EM 4 F-DI/3 F-DO DC24V PROFIsafe

Application 1: Wiring a load to each digital output

Each of the three fail-safe digital outputs consists of one DOx P P-switch and one DOx M M-switch. You connect the load between P and M-switches. The two switches are always activated so that voltage is applied to the load.

The wiring is carried out on an appropriate terminal module.

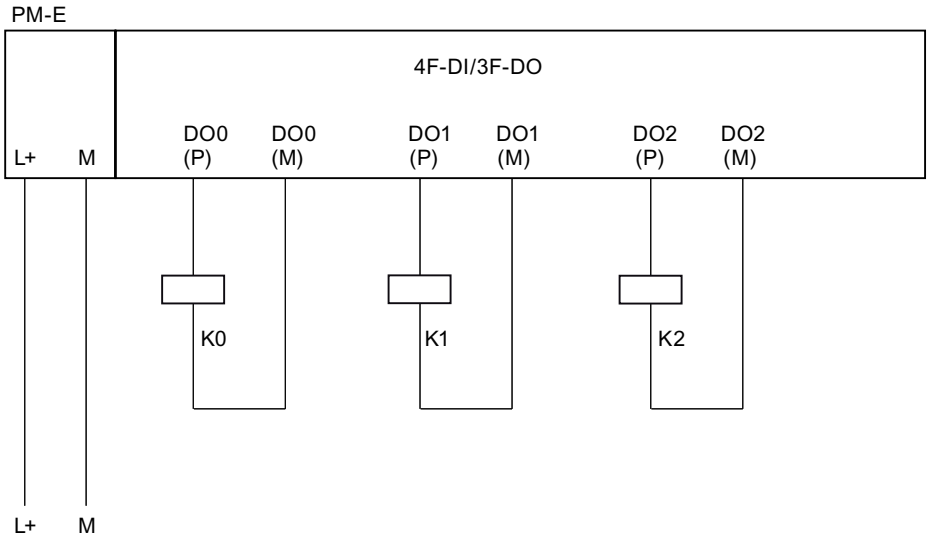


Figure 7-45 Wiring Diagram EM 4 F-DI/3 F-DO DC24V - Output Circuit

Note

In order to achieve SIL2/Category 3/PLd with this wiring, you must install a suitably-qualified actuator, for example in accordance with IEC 60947.

Application 2: Wiring loads to L+ and M at each digital output

Not allowed.

Application 3: Wiring Two Loads in Parallel to each Digital Output

Avoiding/Managing Cross-Circuits:

To protect against cross circuits between P and M-switches in fail-safe digital outputs, we recommend the following wiring scheme:

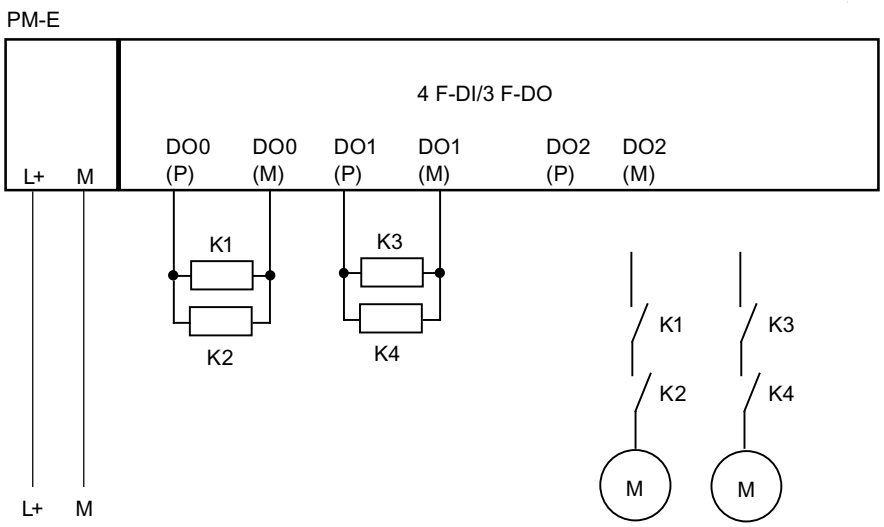


Figure 7-46 Diagram of Two Relays Wired in Parallel to 1 F-DO of EM 4 F-DI/3 F-DO DC24V

7.6.7 Diagnostic functions of EM 4 F-DI/3 F-DO DC24V PROFIsafe

Behavior in Case of Supply Voltage Failure

Failure of the Vs sensor power supply of the EM 4 F-DI/3 F-DO DC24V PROFIsafe is indicated by the VsF LED on the F-module. This information is also provided in the module (diagnostic entry). Either all channels of the module are passivated or, in the case of channel-specific passivation, the relevant channels are passivated.

In the case of a voltage dip in the external auxiliary voltage, the SF LED lights up, the module is passivated.

With the subsequent supply recovery (level must remain above the specified value for at least 1 minute (refer to the technical specifications: voltages, currents, electrical potentials)) the SF LED goes out again, the module remains passivated. The SF LED flashes if there are no other errors, until the error is acknowledged.

Behavior in Case of Cross-Circuit/Short-Circuit at the Sensor Supply

When operating with programmed external sensor supply and blocked short-circuit test, you enable the detection of M-short circuits to M at the sensor supply and signaling at the corresponding VsF LED. No entries are made in the diagnostics data of the module.

When operating with external sensor supply and cyclic short-circuit test, you enable the detection of M and P-short circuits at the sensor supply and signaling at the corresponding VsF LED. No entries are made in the diagnostics data of the module.

Diagnostic Functions

The table below provides an overview of the diagnostic functions of the EM 4 F-DI/3 F-DO DC24V PROFIsafe. The diagnostic functions are assigned either to one channel or to the entire module.

Table 7- 32 Diagnostic functions of the EM 4 F-DI/3 F-DO DC24V PROFIsafe

Diagnostic function*	Fault number	LED	is signaled in application	Effective range of diagnostic	programmable
Short-circuit	1_H	SF	1.1 - 1.3	Channel	No
Short circuit (on the encoder supply)	1_H	VsF SF	1.1 - 1.3	Channel	Yes
Internal error	9_H	SF	1.1 - 1.3	Module	No
Parameter assignment error	10_H	SF	1.1 - 1.3	Module	No
Sensor voltage or load voltage missing	11_H	SF	1.1 - 1.3	Module	No
Communication error	13_H	SF	1.1 - 1.3	Module	No
Safety-related shutdown	19_H	SF	1.1 - 1.3	Channel	No
Discrepancy error	19_H	SF	1.1 - 1.3	Channel	No
*: Specially for F-modules; display in *STEP 7*, see "Channel-Specific Diagnostics, Fault Types of Fail-Safe Modules" table					

WARNING

Before acknowledging the short-circuit diagnosis, remedy the respective error and validate your safety function. In this case, follow the steps described in chapter "Reactions to Faults (Page 41)".

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 in *"Application 1.1"* to *"Application 1.3"*.

Causes of Faults and Corrective Measures

The following table contains the possible causes of the faults described for the individual diagnostic messages of the EM 4 F-DI/3 F-DO DC24V PROFIsafe and remedies.

Table 7- 33 Diagnostic messages of the EM 4 F-DI/3 F-DO DC24V PROFIsafe, causes of errors and remedies

Diagnostic Message	Fault detection	Possible Causes	Corrective Measures
Short-circuit	Depends on parameter settings	Short circuit in the sensor/actuator	Eliminate the short-circuit.
		Cross-circuit at the sensor/actuator	Eliminate the cross-circuit within 100 hours after the error has occurred.
		Encoder supply short circuit	Eliminate the short-circuit.
		Internal error	Replace module
Internal error	Always	Internal module fault has occurred	Replace module
Parameter assignment error	Always	Inserted module does not match configuration Faulty parameter assignment	Correct configuration (compare actual and preset configuration) Check communication paths Correct configuration
		PROFIsafe address set incorrectly in the F-module	Check whether the PROFIsafe address on the module matches the configuration in *HW Config*
Sensor voltage or load voltage missing	Always	No supply voltage or supply voltage is too low	Check the supply voltage on the interconnected PM, Check module for correct contact
Communication error	Always	Error in communication between F-CPU and module due to defective PROFIBUS connection or higher than permissible EMI, for example	Check the PROFIBUS/PROFINET connection Eliminate the interference
		PROFIsafe monitoring time set too low	Set a greater value for the "F monitoring time" parameter for the module in *HW Config*
		Configuration of the F-module does not match safety program	Generate safety program again; then load configuration and safety program into F-CPU again
Safety-related shutdown	Always	Faulty process signal Defective sensor	Check process signal, replace sensor if necessary
		Short circuit between unconnected sensor cable and the sensor supply cable	Eliminate short circuit
		Wire break in connected sensor cable or the sensor supply cable	Eliminate broken wire
		Assigned discrepancy time too short	Check the assigned discrepancy time
		Switching frequency exceeded	Reduce the switching frequency
			Once the fault is eliminated, the F-module must be reintegrated in the safety program

Detailed information on F I/O access can be found under *"Diagnostics"* in the *S7 Distributed Safety, Configuring and Programming* manual or the *S7 F/FH Systems, Configuring and Programming* manual.

Generally applicable information on diagnostics

For information on diagnostics that affects all fail-safe modules (such as readout of diagnostic functions; passivation of channels) see this manual in *"Diagnostics"* and the *S7 Distributed Safety, Configuration and Programming* manual or *S7 F/FH Systems, Configuring and Programming*.

See also

Fault Diagnostics (Page 43)

7.6.8 Technical specifications of the EM 4 F-DI/3 F-DO DC24V PROFIsafe

Overview

Technical Specifications	
Dimensions and Weight	
Dimensions W x H x D (mm)	30 x 81 x 52
Weight	Approx. 73 g
Data for Specific Module	
Number of inputs	
• 2-channel	4, maximum
Number of outputs (P/M switching)	3, maximum
Assigned address area	
• I/O area for inputs	7 bytes
• I/O area for outputs	5 bytes
Length of cable	
• Unshielded *	30 m, maximum
• Shielded *	30 m, maximum
Maximum achievable safety class	
• In accordance with IEC 61508	SIL2
• In accordance with EN 954	Category 3
• In accordance with ISO 13849	PLd
Fail-safe performance characteristics	SIL2
• Low demand mode (average probability of failure on demand)	< 1.00E-04
• High demand/continuous mode (probability of a dangerous failure per hour)	< 1.00E-08
• Acceptance ID	cULus, FM, ATEX, CE, C-Tick
Voltages, Currents, Potentials	
Rated supply voltage L+	24 VDC
• permissible range **	20.4 V to 28.8 V

Technical Specifications	
• Power loss ride-through of L+	None
• Power loss ride-through of internal P5	5 ms
• Reverse polarity protection	No
Number of simultaneously controllable inputs	
• Horizontal installation – Up to 60°C	 8 (with 28.8 V)
• Vertical installation – Up to 40 °C	 8
Total current of outputs	
• Horizontal installation – Up to 40 °C – Up to 60°C	 6 A 4 A
• Vertical installation – Up to 40 °C	 4 A
Electrical isolation	
• Between channels and backplane bus	Yes
• Between channels and power supply	No
• Between channels	No
• Between channels/power supply and shield	Yes
Permissible potential difference between	
• Shield and ET 200S bus connection	75 VDC/60 VAC
• Shield and I/O (DIs, P1/P2 buses)	75 VDC/60 VAC
• ET 200S bus connection and I/O (DIs, P1/P2 buses)	250 VAC
Isolation in the series tested with	
• ET 200S bus connection and I/O (DIs, P1/P2 buses)	1500 VAC/1 min or 2545 VDC/1 s
Isolation in the type test tested with	
• Shield and ET 200S bus connection	370 VAC/1 min
• Shield and I/O (DIs, P1/P2 buses)	370 VAC/1 min
• ET 200S bus connection and I/O (DIs, P1/P2 buses)	2830 VAC/1 min
Current consumption	
• From backplane bus	< 20 mA
• From load voltage L+ (without load)	70 mA, typical
Power dissipation of the module	3.5 W, typical
Status, Interrupts, Diagnostics	
Status display	
Inputs	Red/green LED per channel
Outputs	Red/green LED per channel

Technical Specifications		
Sensor supply	Red VsF LED and display at channel LED	
Diagnostic functions		
• Group fault display	Red LED (SF)	
• Diagnostic information can be displayed	Possible	
Sensor Supply Outputs		
Number of outputs	1	
Output voltage		
• Loaded	Minimum L+ (-1.5 V)	
Output current		
• Rated value	400 mA	
• Permissible range	0 mA to 400 mA	
Short-circuit protection	Yes, electronic	
• Operating value	4 A to 9 A	
Specifications for sensor selection *		
Input voltage		
• Rated value	24 VDC	
• For "1" signal	15 V to 30 V	
• For "0" signal	-30 V to 5 V	
Input current		
• For "1" signal	3.5 mA, typical	
Input delay *		
• For "0" after "1"	Typically 3 ms	(2.6 ms to 3.4 ms)
• For "1" after "0"	Typically 3 ms	(2.6 ms to 3.4 ms)
Input characteristic	In accordance with IEC 61131-2 Type 1	
Connection of 2-wire proximity switch (BERO)	Not possible	
Data for Selecting an Actuator*		
Output voltage		
• For "1" signal	• Minimum L+ (-2 V) • P-switch: Minimum L+ (-1.5 V); voltage drop in M-switch: 0.5 V, maximum	
Output current for "1" signal		
• Rated value	2 A	
• Permissible range	20 mA to 2.4 A	
For "0" signal (residual current)	0.5 mA, maximum	
Indirect control of load by means of interface relay:		
For "0" signal (residual current)	0.5 mA, maximum	
Load resistance range	12 Ω to 1 kΩ	
Lamp load	10 W, maximum	
Parallel connection of 2 outputs	Not possible	

Technical Specifications	
Control of a digital input	Not possible
Switching frequency	
• With resistive load	30 Hz, maximum
• With inductive load in accordance with IEC 60947-5-1, DC13	0.1 Hz, maximum
• With lamp load	10 Hz, maximum
Voltage induced on current interruption limited to	L+ (-2×47 V), typical
Short-circuit protection of output	Yes, electronic
• Response threshold (short circuit)	5 A to 12 A
• Response threshold (external M-short circuit)	5 A to 12 A
• Response threshold (external P-short circuit)	4 A to 12 A
Time, Frequency	
Internal processing times	See *"Response Times"*
Minimum sensor signal duration	See *"Minimum Duration of Sensor Signals to Allow Correct Detection by the F-DI Module"* table in *"Wiring and Fitting Modules"*
Protection against Overvoltage	
Protection of power supply L+ from surge in accordance with IEC 61000-4-5 with external protection elements only	
• Symmetrical (L+ to M)	+ 1 kV; 1.2/50 µs
• Asymmetrical (L+ to PE, M to PE)	+ 2 kV; 1.2/50 µs
*: For more information on the requirements for sensors and actuators, see "Wiring and Fitting Modules".	
**: Operating below the permissible supply voltage is only permissible for the repair time. See chapter "Introduction (Page 61)."	

7.7 4 F-DO DC24V/2A PROFIsafe digital electronic module

7.7.1 Properties of the 4 F-DO DC24V/2A PROFIsafe digital electronic module

Order Number

6ES7138-4FB03-0AB0

Properties

The 4 F-DO DC24V/2A PROFIsafe digital electronic module possesses the following properties:

- Four outputs, P/M switching
- 2 A output current
- Rated load voltage 24 VDC
- Suitable for solenoid valves, DC contactors and indicator lights
- Group fault display (SF; red LED)
- Status display for each output (green LED)
- Assignable diagnostics
- Safety class SIL3 attainable

Power Modules Suitable for SIL2 or SIL3

Table 7- 34 EM 4 F-DO DC24V/2A PROFIsafe: Power module for SIL/Category/PL

Power Module	achievable SIL/Category/PL
Supply through PM-E DC24V, PM-E DC24V/AC120/230V or PM-E DC24..48V	SIL3/Category 4/PLe

Switching Grounded Loads

If the EM 4 F-DO DC24V/2A PROFIsafe switches loads that have a chassis-ground connection (for example to improve EMC characteristics) **and** if chassis and ground are connected at the power supply being used, a "short circuit" is detected.

From the perspective of the F-module, the M-switch is bridged by the chassis-ground connection (refer to the diagram below as an example of an EM 4 F-DO DC24V/2A PROFIsafe).

Remedy:

- Using the PM-E F pp DC24V PROFIsafe
- The value of the resistance between chassis and ground at the load end must be greater than 100 kΩ

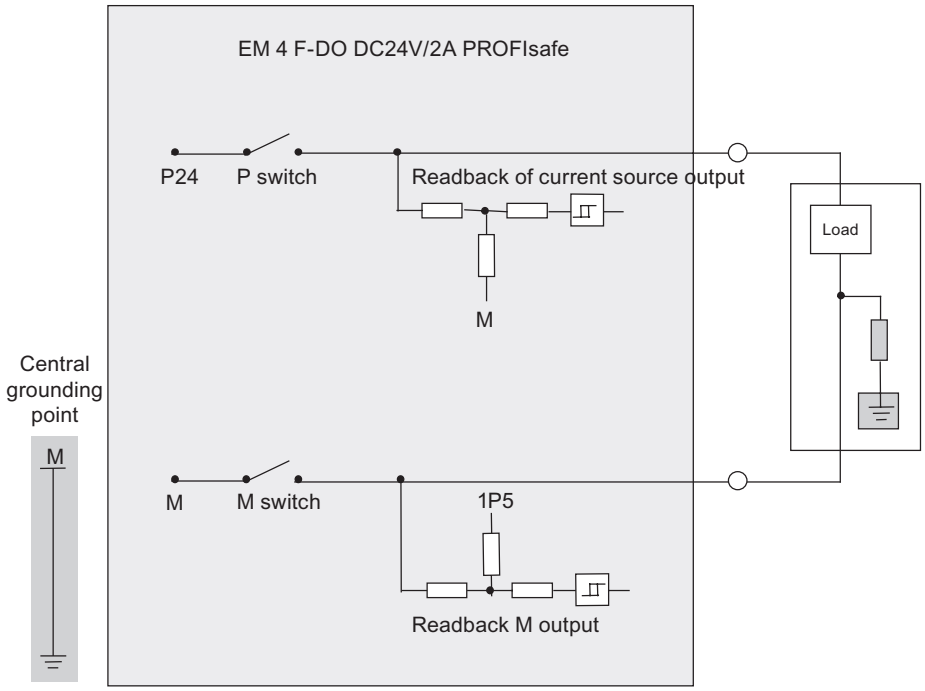


Figure 7-47 Switching Grounded Loads (with resistance between chassis and ground)

Capacitive Crosstalk of Digital Input/Output Signals

Refer to *"Properties of the power module PM-E F pm DC24V PROFIsafe"*.

Magnetic capacitance with inductive loads

Note

Note that an inductive load connected to the DO channels can induce voltages in the case of electromagnetic interference of a strong magnetic field. This can cause a short-circuit error message.

Remedy:

- Spatially disconnect the inductive loads or shield against the magnetic field.
- Set the parameters for the readback time to 50 ms or higher.

7.7.2 Terminal assignment of the EM 4 F-DO DC24V/2A PROFIsafe

Front View

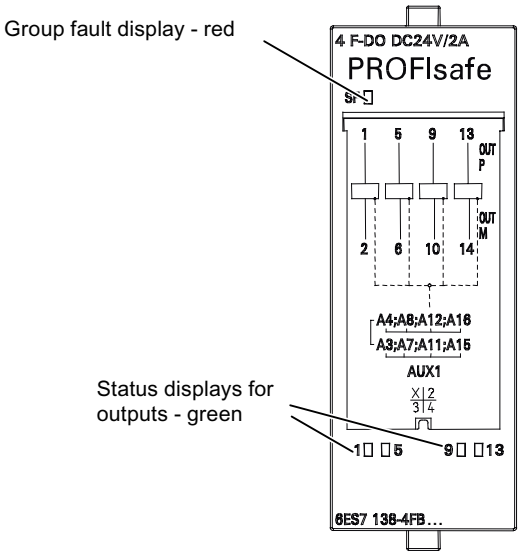


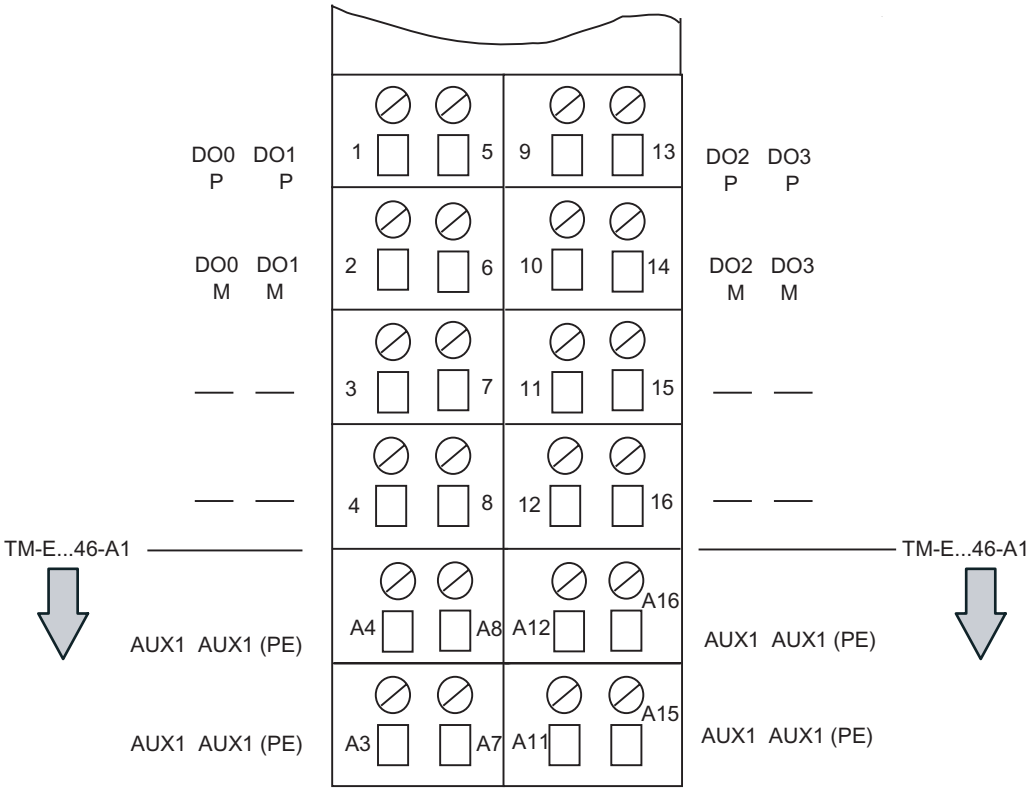
Figure 7-48 Front view EM 4 F-DO DC24V/2A PROFIsafe

WARNING

The SF LED and the status displays of the inputs/outputs are not designed for safety-related functions and may therefore not be evaluated for safety-related activities.

Terminal Assignment

The diagram below shows the terminal assignment of the EM 4 F-DO DC24V/2A PROFIsafe for the supported terminal modules TM-E30S44-01, TM-E30C44-01, TM-E30S46-A1 and TM-E30C46-A1.



DOx P: Terminal for fail-safe digital output (P/M switching)

DOx M: Terminal for fail-safe digital output (P/M switching)

At TM-E...46-A1: AUX 1 bus implemented. Connection to terminals A3 to A16 for any connection of PE (individual grouping of load current power supplies possible)

Figure 7-49 Terminal Assignment of TM-E...44-01/TM-E...46-A1 for EM 4 F-DO DC24V/2A PROFIsafe

See also

Properties of the PM-E F pm DC24V PROFIsafe Power Module (Page 62)

7.7.3 Wiring diagram of the EM 4 F-DO DC24V/2A PROFIsafe

Block Diagram

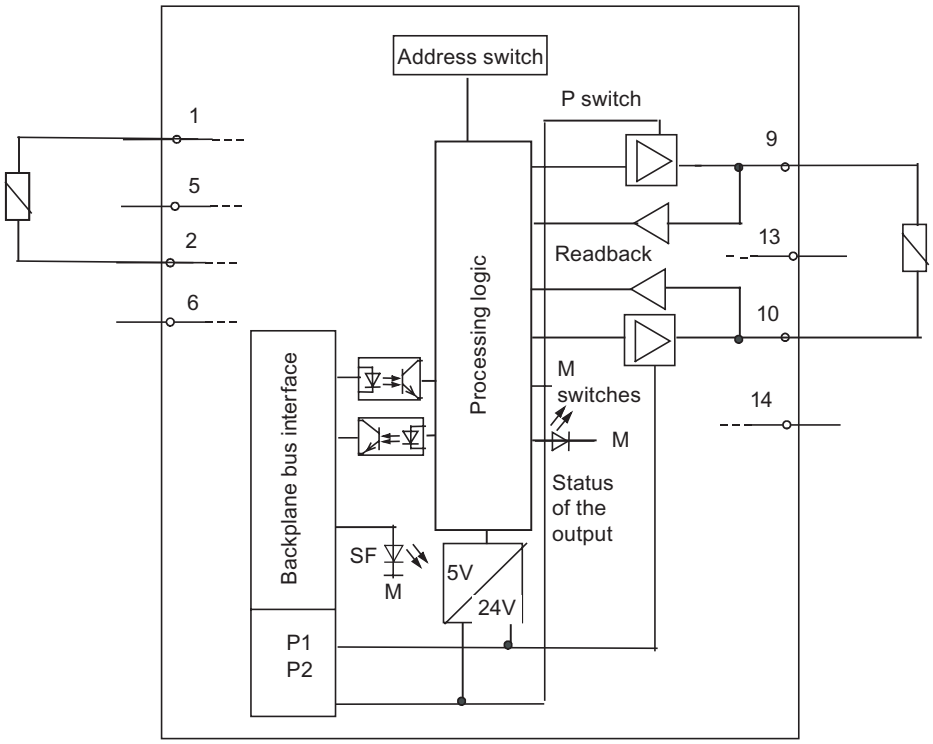


Figure 7-50 Block diagram of the EM 4 F-DO DC24V/2A PROFIsafe

Application 1: Wiring a load to each digital output

Each of the four fail-safe digital outputs consists of a DOx P P-switch and a DOx M M-switch. You connect the load between the P and M-switches. The two switches are always activated so that voltage is applied to the load. This configuration achieves safety class SIL3/Category 4/PLe.

The wiring is carried out on an appropriate terminal module.

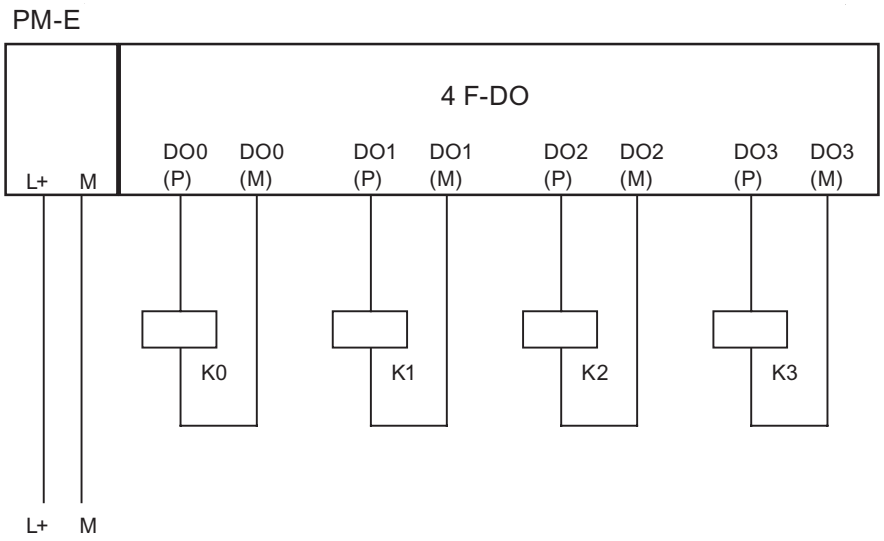


Figure 7-51 Wiring diagram of the EM 4 F-DO DC24V/2A PROFIsafe

WARNING

In order to achieve SIL3/Category 4/PLe with this wiring, you must install a suitably-qualified sensor, for example in accordance with IEC 60947.

Application 2: Wiring loads to L+ and M at each digital output

You can connect two relays using one fail-safe digital output. The following conditions should be kept in mind:

- L+ and M of the relays must be connected with L+ and M of the F-DO module (reference potential must be equal).
- The normally open contacts of the two relays must be connected in series.

A connection to each of the four digital outputs is possible. The figure below shows an example of the connection to DO0. This configuration achieves safety class SIL3/Category 4/PLe (process status readback required).

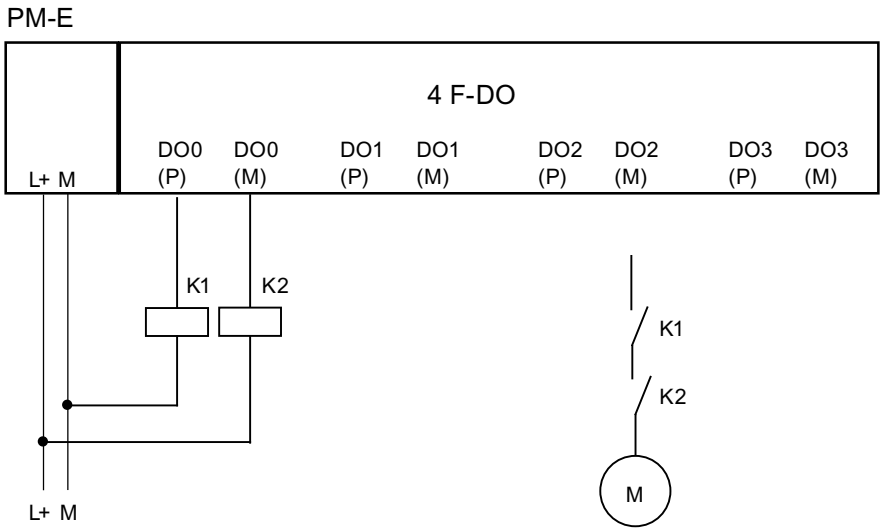


Figure 7-52 Wiring diagram for in each case 2 relays on 1 F-DO of the EM 4 F-DO DC24V/2A PROFIsafe

WARNING

When connecting two relays on one digital output, (as shown in the figure above), the errors "wire break" and "overload" are detected only at the P-switch (not at the M-switch).

WARNING

The controlled actuator can no longer be switched off should a cross circuit occur between the P and M-switches of the output. To avoid cross circuits between the P and M-switches of a fail-safe digital output, you should always wire the relay connection to the P and M-switches separately, in order to prevent any cross circuits (for example with separately-sheathed cables or using separate cable ducts).

Note

The EM 4 F-DO DC24V/2A PROFIsafe carries out a bit pattern test every 15 minutes or so. The module then sends an impulse for max. 4 ms. This test is run with a time offset between the P and M-switches in order to prevent the actuator from being activated. This impulse may cause the corresponding relay to tighten, which may reduce its service life.

We therefore recommend adhering to the wiring scheme detailed below.

Application 3: Wiring two loads in parallel to each digital output

Avoiding/Managing Cross Circuits:

To protect against cross-circuits between P and M-switches in fail-safe digital outputs, we recommend the following wiring scheme. This configuration achieves safety class SIL3/Category 4/PLe.

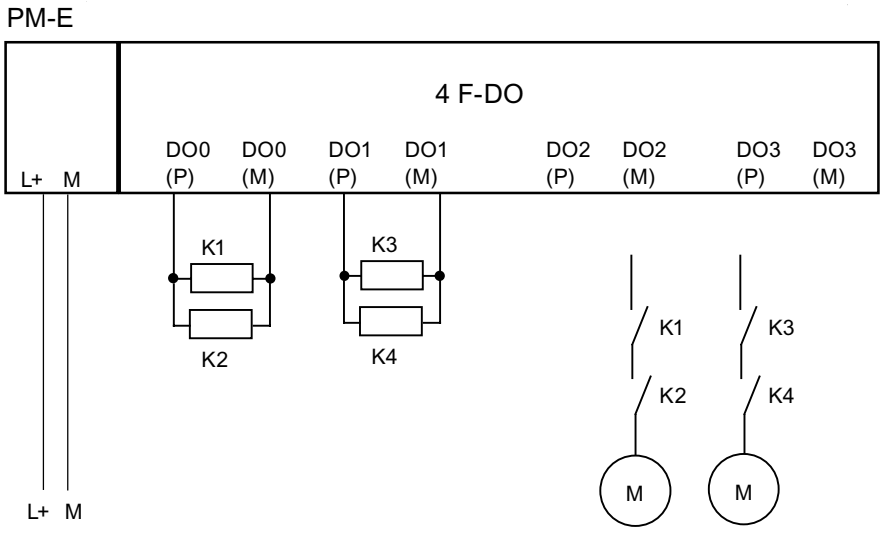


Figure 7-53 Wiring diagram for in each case 2 relays parallel on 1 F-DO of the EM 4 F-DO DC24V/2A PROFIsafe

Note

With a parallel connection of two relays on one digital output (as shown above) the "wire break" fault is only detected if the wire break disconnects both relays from P or M. This diagnosis is not safety-related.

7.7.4 Parameters for the EM 4 F-DO DC24V/2A PROFIsafe

Parameters in *STEP 7*

The table below lists the parameters that can be assigned for the F-DO module (see also *"Configuring and programming"*).

Table 7- 35 Parameters of the F-DO Module

Parameter	Range	Default	Type of Parameter	Effective Range
F Parameters:				
F_destination_address	1 to 1022	is assigned by *STEP 7*	Static	Module
F monitoring time	10 to 10000 ms	150 ms	Static	Module
Module Parameters:				
Behavior after channel faults*	Passivate the entire module/Passivate the channel	Passivate the entire module	Static	Module
DO channel n	Activated/deactivated	Activated	Static	Channel
Readback time	1 to 400 ms	1 ms	Static	Channel
Diagnostics: Wire break	Activated/deactivated	Deactivated	Static	Channel
* This setting is only relevant when *S7 Distributed Safety* V5.4 or higher is installed.				

Readback Time Parameter

Each output channel has its own selectable readback time. This time specifies the maximum duration of the turn off test for the corresponding channel and therefore also the readback time for turning off the channel.

The following readback times can be set: 1 ms, 5 ms, 10 ms, 50 ms, 100 ms, 200 ms and 400 ms.

You should set an adequately high readback time if the channel involved switches high capacitive loads. If the readback time for a controlled capacitive load is set too low, the output channel is passivated because the discharge of the capacitance does not take place within the turn off test.

If the readback signals are incorrect, the "short circuit" fault only causes passivation of the output channel after the readback time has elapsed.

⚠ WARNING

With a configured readback time of ≥ 50 ms, short-circuits (cross circuits) can be suppressed with an interference signal with a frequency > 10 Hz (50:50 duty cycle).

Short-circuits (cross-circuits) on an output of the same module will be detected.

7.7.5 Diagnostic Functions of the EM 4 F-DO DC24V/2 A PROFIsafe

Behavior in case of supply voltage failure

In the case of a voltage dip in the external auxiliary voltage, the SF LED lights up, the module is passivated.

With the subsequent supply recovery (level must remain above the specified value for at least 1 minute (refer to the technical specifications: voltages, currents, electrical potentials)) the SF LED goes out again, the module remains passivated. The SF LED flashes if there are no other errors, until the error is acknowledged.

Diagnostic functions

The table below provides an overview of the diagnostic functions of the EM 4 F-DO DC24V/2A PROFIsafe. The diagnostic functions are assigned either to one channel or to the entire module.

Table 7- 36 Diagnostic functions of the EM 4 F-DO DC24V/2A PROFIsafe

Diagnostic Function*	Fault Number	LED	Effective Range of Diagnostics	Can be Assigned Parameters
Short circuit	1_H	SF	Channel	No
Overload	4_H	SF	Channel	No
Overtemperature	5_H	SF	Module	No
Wire break	6_H	SF	Channel	Yes
Internal error	9_H	SF	Module	No
Parameter assignment error	10_H	SF	Module	No
Sensor voltage or load voltage missing	11_H	SF	Module	No
Communication error	13_H	SF	Module	No
Safety-related shutdown	19_H	SF	Channel	No
*: specially for F-modules; display in *STEP 7*, see "Channel-Specific Diagnostics, Fault Types of Fail-Safe Modules" table				

⚠ WARNING

Before acknowledging the short-circuit diagnosis, remedy the respective error and validate your safety function. In this case, follow the steps described in chapter "Reactions to Faults (Page 41)".

Causes of Faults and Corrective Measures

The following table contains the possible causes of the faults described for the individual diagnostic messages of the EM 4 F-DO DC24V/2A PROFIsafe and remedies.

Table 7- 37 Diagnostic messages of the EM 4 F-DO DC24V/2A PROFIsafe, causes of errors and remedies

Diagnostic Message	Fault Detection	Possible Causes	Corrective Measures
Short circuit	Always	Short circuit in the actuator	Eliminate the short-circuit
		Cross circuit in the actuator	Eliminate the cross-circuit within 100 hours after the error has occurred.
		Internal error	Replace module
Overload	For "1" output signal only	Output stage is overloaded and becomes too hot	Eliminate overload
Overtemperature	Always	Shutdown due to violation of upper or lower temperature limit value in the module case	Check load wiring, check ambient temperature, check whether permissible output current (total current) is exceeded for the ambient temperature. Once the fault has been eliminated, the module must be removed and inserted or the power switched off and on.
Wire break	For "1" output signal only	Line break	Eliminate broken wire, ensure specified minimum load (see Technical Specifications)
Internal error	Always	Internal module fault has occurred	Replace module
Parameter assignment error	Always	Inserted module does not match configuration. Incorrect parameter assignment.	Correct the configuration (compare actual and preset configuration), check communication paths Correct configuration
		PROFIsafe address set incorrectly in the F-module	Check whether the PROFIsafe address on the module matches the configuration in *HW Config*
Sensor voltage or load voltage missing	Always	No supply voltage or supply voltage is too low	Check the supply voltage on the interconnected PM, check the module for correct contact
Communication error	Always	Error in communication between F-CPU and module, e.g. due to defective PROFIBUS connection or higher than permissible EMI	Test PROFIBUS/PROFINET connection. Correct faults
		PROFIsafe monitoring time set too low	Set a greater value for the "F monitoring time" parameter for the module in *HW Config*
		Configuration of the F-module does not match safety program	Generate safety program again; then load configuration and safety program into F-CPU again
Safety-related shutdown	Always	Switching frequency exceeded	Reduce the switching frequency

Generally Applicable Information on Diagnostics

For information on diagnostics that pertains to all fail-safe modules (for example, for reading diagnostics functions, or passivating channels), refer to *"Diagnostics"* chapter in this manual.

See also

Fault Diagnostics (Page 43)

7.7.6 Technical Specifications of the EM 4 F-DO DC24V/2A PROFIsafe

Overview

Technical Specifications	
Dimensions and Weight	
Dimensions W x H x D (mm)	30 x 81 x 52
Weight	Approx. 85 g
Data for Specific Module	
Number of outputs (P/M switching)	4
Assigned address area	
• I/O area for inputs	5 bytes
• I/O area for outputs	5 bytes
Length of cable*	
• Unshielded	200 m, maximum
• Shielded	200 m, maximum
Maximum achievable safety class	
• In accordance with IEC 61508	SIL3
• In accordance with EN 954	Category 4
• In accordance with ISO 13849	PLe
Safety characteristics	SIL3
• Low demand mode (average probability of failure on demand)	< 1.00E-05
• High demand/continuous mode (probability of a dangerous failure per hour)	< 1.00E-10
• Acceptance ID	FM, cULus, ATEX, CE, C-Tick
Voltages, Currents, Potentials	
Rated supply voltage L+	24 VDC
• permissible range **	20.4 V to 28.8 V
• Power loss ride-through of L+	None
• Power loss ride-through of internal P5	5 ms
• Reverse polarity protection	No

Technical Specifications	
Total current of outputs	
• Horizontal installation – Up to 40 °C – Up to 55 °C – Up to 60 °C	 6 A 5 A 4 A
• Vertical installation – Up to 40 °C	 4 A
Electrical isolation	
• Between channels and backplane bus	Yes
• Between channels and power supply	No
• Between channels	No
• Between channels/power supply and shield	Yes
Permissible potential difference between	
• Shield and ET 200S bus connection	75 VDC/60 VAC
• Shield and I/O (DOs, P1/P2 buses)	75 VDC/60 VAC
• ET 200S bus connection and I/O (DOs, P1/P2 buses)	250 VAC
Isolation in the series tested with	
• Shield and ET 200S bus connection	500 VDC/1 min or 600 VDC/1 s
• Shield and I/O (DOs, P1/P2 buses)	500 VDC/1 min or 600 VDC/1 s
• ET 200S bus connection and I/O (DOs, P1/P2 buses)	1500 VAC/1 min or 2545 VDC/1 s
Isolation in the type test tested with	
• Shield and ET 200S bus connection	350 VAC/1 min
• Shield against I/O (DOs, P1/P2 buses)	350 VAC/1 min
• ET 200S bus connection against I/O (DOs, P1/P2 buses)	2830 VAC/1 min
• Surge voltage test between ET 200S bus connection and I/O (DOs, P1/P2 buses)	6000 VDC/5 positive and 5 negative pulses
Current consumption	
• From backplane bus	28 mA, maximum
• From load voltage L+ (without load)	100 mA, typical
Power dissipation of the module	3.5 W, typical
Status, Interrupts, Diagnostics	
Status display	
Outputs	Green LED per channel
Diagnostic functions	
• Group fault display	Red LED (SF)
• Diagnostic information can be displayed	Possible

Technical Specifications	
Data for selecting an actuator* **	
Output voltage	
• For "1" signal	• Minimum L+ (-2.0 V) • P-switch: Minimum L+ (-1.5 V); Voltage drop in M-switch: 0.5 V, maximum
Output current for "1" signal	
• Rated value	2 A
• Permissible range	20 mA to 2.4 A
For "0" signal (residual current)	0.5 mA, maximum
Indirect control of load by means of interface relay:	
For "0" signal (residual current)	
• P-switch	0.5 mA, maximum
• M-switch	4 mA, maximum
Load resistance range	12 Ω to 1 kΩ
Lamp load	10 W, maximum
Wire break monitoring (open load detection) and overload monitoring	
• Response threshold	I < 4 to 19 mA
• Fault detection time	depending on the selected readback time (see *"Response Times"*)
Parallel connection of 2 outputs	Not possible
Control of a digital input	Not possible
Switching frequency	
• With resistive load	30 Hz symmetrical, maximum
• With inductive load in accordance with IEC 60947-5-1, DC13	0.1 Hz symmetrical, maximum
• With lamp load	10 Hz symmetrical, maximum
Voltage induced on current interruption limited to	Typ. L+ (-2x 47 V)
Short-circuit protection of output	Yes, electronic
• Response threshold (short circuit)	5 A to 12 A
• Response threshold (external M-short circuit)	5 A to 12 A
• Response threshold (external P-short circuit)	25 A to 45 A
Overload protection	Yes
• Response threshold	I >2.6 A to 2.8 A
Time, Frequency	
Internal processing times	See *"Response Times"*
Acknowledgment time in safety mode	4 ms minimum/8 ms maximum
Protection against Overvoltage	
Protection of power supply L+ from surge in accordance with IEC 61000-4-5 with external protection elements only	

Technical Specifications	
• Symmetrical (L+ to M)	+ 1 kV; 1.2/50 µs
• Asymmetrical (L+ to PE, M to PE)	+2 kV; 1.2/50 µs
Protection of inputs and outputs from surge in accordance with IEC 61000-4-5 with external protection elements only	
• Symmetrical (L+ to M)	+1 kV; 1.2/50 µs
• Asymmetrical (L+ to PE, M to PE)	+2 kV; 1.2/50 µs
*: In order to achieve the specified cable length, you must route the P and M-signal lines in a cable or a sheathed cable. **: Operating below the permissible supply voltage is only permissible for the repair time. See chapter "Introduction (Page 61)." ***: For more information on the requirements for sensors and actuators see *"Wiring and Fitting Modules"*.	

7.8 1 F-RO DC24V/AC24..230V/5A Digital Electronic Module

7.8.1 Properties of the EM 1 F-RO DC24V/AC24..230V/5A

Order Number

6ES7138-4FR00-0AA0

Properties

The 1 F-RO DC24V/AC24..230V/5A digital electronic module disposes of the following properties:

- 1 relay output (2 2-channel contacts)
- Output current 5 A
- Rated load voltage 24 VDC and 24 VAC to 230 VAC
- Status display for output (green LED)
- safety class SIL3/Category 4/PLe can be achieved if the F-RO module is controlled by a fail-safe output (for example, by EM 4F-DO DC24V/2A PROFIsafe)

7.8.2 Terminal assignment of EM 1F-RO DC24V/AC24..230V/5A

Front view

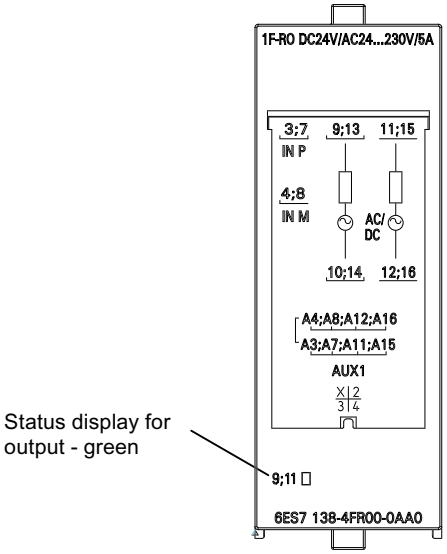


Figure 7-54 Front view EM 1 F-RO DC24V/AC24..230V/5A

WARNING

The status display of the output is not designed for safety-related functions and may therefore not be evaluated for safety-related activities.

Terminal assignment

The figure below shows the terminal assignment of the EM 1 F-RO DC24V/AC24..230V/5A for the supported terminal module TM-E30S44-01, TM-E30C44-01, TM-E30S46-A1 and TM-E30C46-A1.

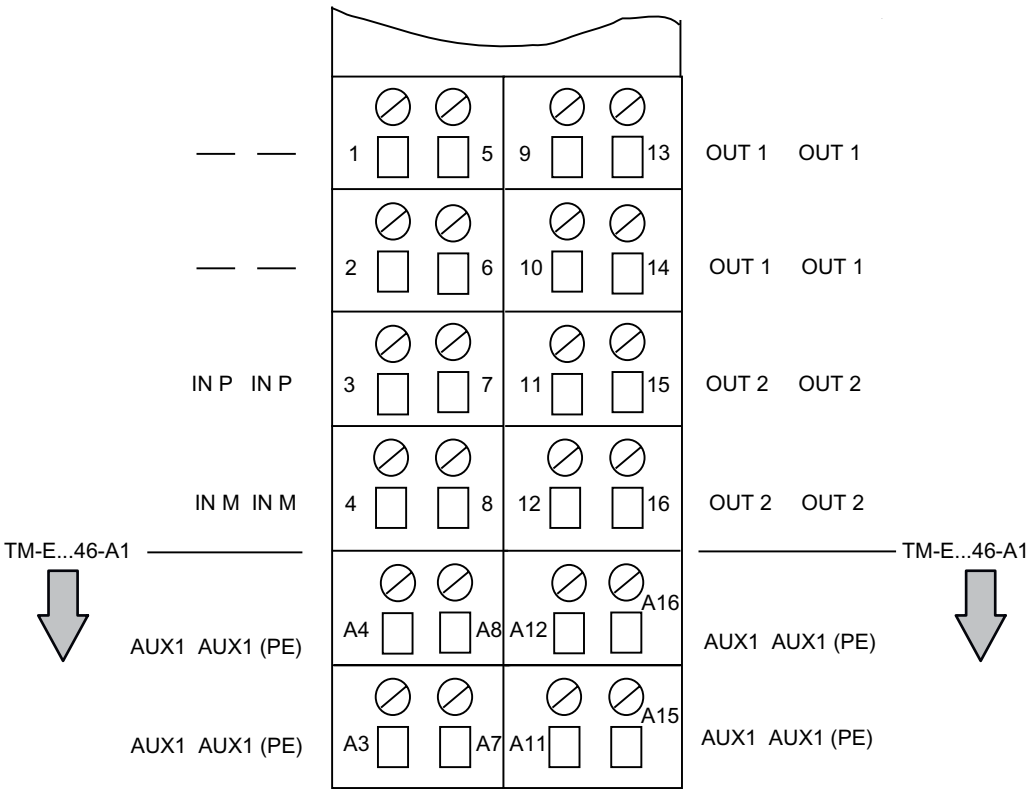


Figure 7-55 Terminal assignment TM-E...44-01/TM-E...46-A1 for EM 1 F-RO DC24V/AC24..230V/5A

Table 7- 38 Terminal assignment of the TM-E...44-01/TM-E...46-A1

Terminal		Designation
3	IN P	Terminal for 24 VDC control voltage
4	IN M	Terminal for control voltage ground
A4	AUX 1	At TM-E...46-A1: AUX 1 bus implemented. Connection to terminals A3 to A16 for any PE connection. Individual grouping of load current supplies is supported.
A3	AUX 1	At TM-E...46-A1: AUX 1 bus implemented. Connection to terminals A3 to A16 for any PE connection. Individual grouping of load current supplies is supported.
7	IN P	Terminal for 24 VDC control voltage
8	IN M	Terminal for control voltage ground
A8	AUX 1	At TM-E...46-A1: AUX 1 bus implemented. Connection to terminals A3 to A16 for any PE connection. Individual grouping of load current supplies is supported.
A7	AUX 1	At TM-E...46-A1: AUX 1 bus implemented. Connection to terminals A3 to A16 for any PE connection. Individual grouping of load current supplies is supported.

Terminal		Designation
9	OUT 1	NO contact, channel 0 for fail-safe switching of load 1
10	OUT 1	
11	OUT 2	NO contact, channel 1 for fail-safe switching of load 2
12	OUT 2	
A12	AUX 1	At TM-E...46-A1: AUX 1 bus implemented. Connection to terminals A3 to A16 for any PE connection. Individual grouping of load current supplies is supported.
A11	AUX 1	At TM-E...46-A1: AUX 1 bus implemented. Connection to terminals A3 to A16 for any PE connection. Individual grouping of load current supplies is supported.
13	OUT 1	NO contact, channel 0 for fail-safe switching of load 1
14	OUT 1	
15	OUT 2	NO contact, channel 1 for fail-safe switching of load 2
16	OUT 2	
A16	AUX 1	At TM-E...46-A1: AUX 1 bus implemented. Connection to terminals A3 to A16 for any PE connection. Individual grouping of load current supplies is supported.
A15	AUX 1	At TM-E...46-A1: AUX 1 bus implemented. Connection to terminals A3 to A16 for any PE connection. Individual grouping of load current supplies is supported.

⚠ CAUTION

Wire these terminals in parallel if high currents are generated at OUT 1 or OUT 2 (≥ 50% of the rated current of the respective output channel):

- For OUT 1: Terminals 9/10 and 13/14
- For OUT 2: Terminals 11/12 and 15/16

Otherwise, high current loads may cause the terminals to heat up.

7.8.3 Wiring of EM 1 F-RO DC24V/AC24..230V/5A

Block diagram

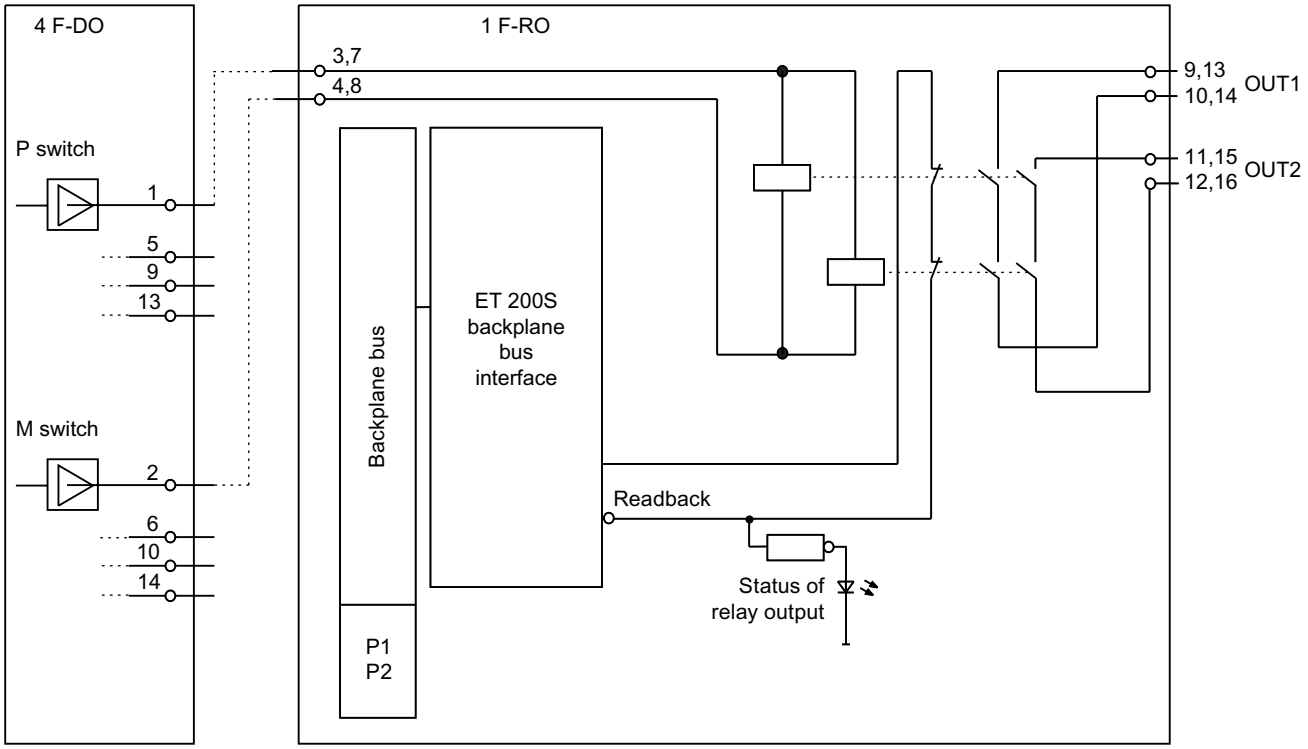


Figure 7-56 Block diagram of the EM 1 F-RO DC24V/AC24..230V/5A

Wiring Diagram

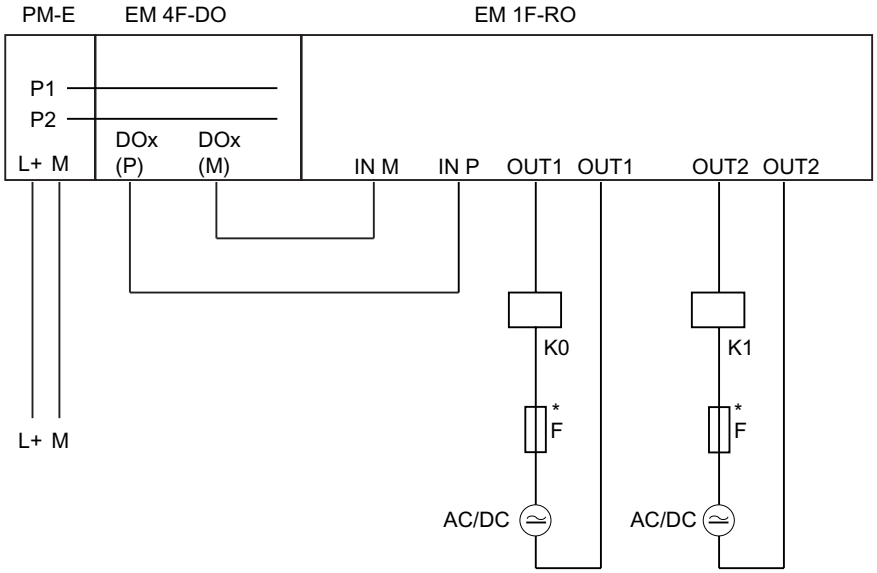


Figure 7-57 Wiring diagram of the EM 1 F-RO DC24V/AC24..230V/5A

WARNING

* Please always install an external fuse with the following properties in order to protect the relay contacts against overload and short-circuits: Fusible cut-out, 6 A, operating class gL/gG.

Note that for applications in accordance with EN 50156-1, the specified rated current of the overcurrent protective device must be multiplied by the safety factor 0.6 to rule out the error "non-opening of contact elements due to permanent contact welding".

Wiring the 24 VDC power supply

Apply the 24 VDC control voltage to IN P (terminals 3;7) and IN M (terminals 4;8). The 24 VDC line is usually connected via a PM-switching fail-safe output (e.g. EM 4 F-DO DC24V/2A PROFIsafe). Wire the P-output of F-DO to IN P and the M-output to IN M of the F-RO module.

You can also wire the circuit using a PP-switching fail-safe output. However, note that external short-circuits to P at the P input cannot be controlled. In this case IN M would be connected directly to the control voltage ground.

Wiring the Load Voltage and the Load

The connections of the relay output features electrically isolated NO contacts. This means that power must be fed to these contacts from an external source. Connect the load supply (supply 1) and the load (load 1) in series to the connections OUT 1 (terminals 9;13)/(terminals 10;14). This circuit ensures that the NO contacts of the relay reliably cut off power to the load voltage supply. This redundant series circuit of the relay contacts allows shutdown if one of the two relays fails.

The two circuits are not electrically interdependent. They are logically interconnected by way of common control. This means that the potential in the OUT 2 (terminals 11;15)/(terminals 12;16), supply 2 and load 2 electric circuit may be different.

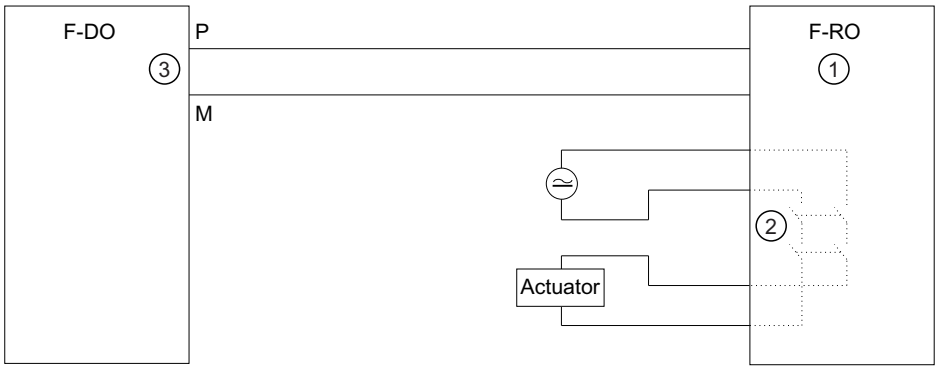
⚠ WARNING

If you have connected extra low voltage (SELV/PELV) to one channel, then the other channel of the F-RO module must also be connected to extra low voltage.

Information on the F-RO module and the current TÜV certificate report are available for download on the Internet from http://support.automation.siemens.com, "Product Support" pages.

Reading back the relay contacts

Always compare the readback value returned from the F-RO module with the control status in the safety program. The S7 Distributed Safety F-systems provide an F-application block FB 216 "F_FDBACK" for this purpose: You can use the "Feedback circuit monitoring" in your safety program (see the *S7 Distributed Safety, Configuring and Programming)* manual.



① F-RO with Integrated FEEDBACK input
② Relay contacts for switching the load
③ Output Q

Figure 7-58 Example of an interconnection with F-application block FB 216

If the 24 VDC control voltage falls below the required value for relay pick-up or the wire to the input connections breaks, the relays will be released and "0" will be read back instead of "1." This fault is only detected if the control voltage is switched on.

The value "1" is read back from the module if one of the two relays gets stuck (NO contacts remain closed). The fault is detected by comparing this readback value with the expected value "0" in the safety program. This fault is only detected if the control voltage is switched off.

Note

SIL3/Category 4/PLe requires the readback of process states and at least daily signal transitions.

7.8.4 Diagnostic functions of EM 1 F-RO DC24V/AC24..230V/5A

Output status display

Behavior of the output status display at the F-RO module:

- Relay not activated: LED is not lit
- Relay is activated: LED is lit
- Relay not activated and relay contact welded: LED is lit

Causes of Faults and Corrective Measures

In S7 Distributed Safety F-systems you can run diagnostics by evaluating output "DIAG" of FB 216 "F_FDBACK" when using this F-application block in your safety program to read back the relay contacts (refer to the *S7 Distributed Safety, Configuring and Programming* manual).

7.8.5 Technical specifications of the EM 1 F-RO DC24V/AC24..230V/5A

Overview

Technical Specifications	
Dimensions and Weight	
Dimensions W x H x D (mm)	30 x 81 x 52
Weight	Approx. 90 g
Data for Specific Module	
Number of outputs	
• Relay outputs	1 (2 channels)
Assigned address area	

Technical Specifications	
• In the I/O area for inputs	2 bits
• In the I/O area for outputs	--
Length of cable	
• Unshielded for load contact	200 m, maximum
• Shielded for load contact	200 m, maximum
• Control cable (input)	10 m, maximum
Maximum achievable safety class	
• In accordance with IEC 61508	SIL3
• In accordance with EN 954	Category 4
• In accordance with ISO 13849	PLe
Fail-safe performance characteristics	SIL3
• Low demand mode (average probability of failure on demand)	< 1.00E-05
• High demand/continuous mode (probability of a dangerous failure per hour)	< 1.00E-09
• Acceptance ID	cULus, CE, C-Tick
Voltages, Currents, Potentials	
Control voltage	20.4 to 28.8 VDC (supplied from fail-safe output of an F-DO)
Total current at both channels	
• Horizontal installation – Up to 40 °C – Up to 50 °C – Up to 60 °C	8 A 6 A 5 A at max. control voltage 24.8 VDC 3 A at max. control voltage 28.8 VDC
• Vertical installation – Up to 40 °C	6 A
Electrical isolation	
• Between channels and backplane bus	Yes
• Between channels and control voltage	Yes
• Between channels	Yes
• Between channels/control voltage and shield	Yes
Permissible potential difference between	
• Shield and ET 200S bus connection	75 VDC/60 VAC
• Control voltage and shield	75 VDC/60 VAC
• ET 200S bus connection and control voltage	75 VDC/60 VAC
• Channel 1 and shield, ET 200S bus connection, control voltage, channel 2	250 VAC
• Channel 2 and shield, ET 200S bus connection, control voltage, channel 1	250 VAC

Technical Specifications	
Isolation in the series tested with	
• Shield against ET 200S bus connection, control input, channel 1, channel 2	600 VDC/1 s
• Control input against ET 200S bus connection, shield, channel 1, channel 2	600 VDC/1 s
• ET 200S bus connection against control voltage, shield, channel 1, channel 2	600 VDC/1 s
• Channel 1 against shield, ET 200S bus connection, control voltage, channel 2	2545 VDC/1 s
• Channel 2 against shield, ET 200S bus connection, control voltage, channel 1	2545 VDC/1 s
Isolation in the type test tested with	
• Shield against ET 200S bus connection, control input, channel 1, channel 2	370 VAC / 520 VDC / 1 min
• Control input against ET 200S bus connection, shield, channel 1, channel 2	370 VAC / 520 VDC / 1 min
• ET 200S bus connection against control voltage, shield, channel 1, channel 2	370 VAC / 520 VDC / 1 min
• Channel 1 against shield, ET 200S bus connection, control voltage, channel 2	2300 VAC / 3250 VDC / 1 min
• Channel 2 against shield, ET 200S bus connection, control voltage, channel 1	2300 VAC / 3250 VDC / 1 min
• Surge test voltage between control voltage and channel 1, channel 2	7200 VDC/5 positive and 5 negative pulses
Current consumption	
• From backplane bus	10 mA, maximum
• From control voltage (IN P, IN M)	100 mA, maximum
Power dissipation of the module	2.1 W, typical
Status, Interrupts, Diagnostics	
Status display	Green LED
Diagnostic functions	
• Diagnostic information can be displayed	No
Data for Selecting an Actuator*	
Output current	
• Continuous thermal current	Max. 5 A
• Minimum load current	5 mA
Contact protection (internal)	No
• At the relay output	No
Wire break monitoring	No
Parallel connection of 2 outputs	Supported, observe max. total current
Control of a digital input	Possible

Technical Specifications	
Switching frequency	
• With resistive load	2 Hz, maximum
• With inductive load in accordance with IEC 60947-5-1, DC13	0.1 Hz, maximum
• With inductive load in accordance with IEC 60947-5-1, AC15	2 Hz, maximum
• Inductive load in accordance with UL 508	Pilot Duty B300, R300
Voltage induced on current interruption (internally) limited	No
Short-circuit protection of output	No, external fusible cut-out, 6 A, operating class gL/gG; with two outputs wired in parallel, each output must be fused with a 6 A fusible cut-out, operating class gL/gG. Note that for applications in accordance with EN 50156-1, the specified rated current of the overcurrent protective device must be multiplied by the safety factor 0.6 to rule out the error "non-opening of contact elements due to permanent contact welding".
Time, Frequency	
Switching time	Typically 13 ms
Release time	Typically 16 ms
Protection against Overvoltage	
Protection of outputs from surge in accordance with IEC 61000-4-5 (no protection elements required)	
• Symmetrical – Channel 1 (9/13) against (10/14) – Channel 2 (11/15) against (12/16)	+1 kV; 1.2/50 µs
• Asymmetrical – Channel 1 (9/13) or (10/14) against PE – Channel 2 (11/15) or (12/16) against PE	+2 kV; 1.2/50 µs
*: For more information on the requirements for sensors and actuators, see the *"Wiring and Fitting Modules"* chapter in this manual.	

Switching Performance and Service Life of Contacts

The table below shows the switching performance and service life of contacts. You can extend the service life beyond the value indicated in the table by installing an external protective circuit.

Table 7- 39 Switching Performance and Service Life of Contacts

Resistive Load	Voltage	Current	Duty cycle (typ.) NO contact
For resistive load	24 VDC	5.0 A	0.35 million
		3.0 A	0.5 million
		2.0 A	0.75 million
		1.0 A	1.8 million
		0.5 A	4 million
	230 VAC	5.0 A	0.1 million
		3.0 A	0.15 million
		2.0 A	0.2 million
		1.0 A	0.4 million
		0.5 A	0.8 million
For inductive load to IEC 60947-5-1 DC13/ AC15	24 VDC	1.0 A	0.1 million
		0.5 A	0.2 million
	230 VAC	1.0 A	0.2 million
		0.5 A	0.35 million

Diagnostic Data of Fail-Safe Modules

A

A.1 Einleitung

Introduction

This appendix describes the structure of diagnostic data in the system data. You need to know this structure if you want to evaluate diagnostic data of fail-safe modules in the standard user program.

Further Reading

The *System and Standard Functions* reference manual describes in detail the principles of evaluating diagnostic data of F-modules in the standard user program and describes the SFCs used for this.

A.2 Structure and Content of Diagnostic Data

SFCs for Reading out Diagnostic Data

The following SFCs are available for reading out diagnostic data of fail-safe modules in the standard user program:

Table A- 1 SFCs for Reading out Diagnostic Data

SFC Number	Identifier	Application
59	RD_REC	Reading out data records of S7 diagnostics (saved to the data area of the standard user program)
13	DPNRM_DG	Reading out slave diagnostic data (saved to the data area of the standard user program)

Position in the Diagnostic Message Frame of the Slave Diagnostics

When fail-safe modules are being used in the ET 200S and a diagnostic interrupt occurs, data records 0 and 1 are entered in the slave diagnostics of the ET 200 (= interrupt section).

The position of the interrupt section in the slave diagnostic data depends on the structure of the diagnostic message frame and on the length of the channel-specific diagnostics.

A detailed description of the structure of the diagnostic message frame and the position of the interrupt section in accordance with the PROFIBUS standard is available in the "Commissioning and Diagnostics" chapter of the *ET 200S Distributed I/O System* operating instructions.

Data Records 0 and 1 of the System Data

The diagnostic data of a module can be up to 40 bytes long and is located in data records 0 and 1 of the system data area:

- Data record 0 contains 4 bytes of diagnostic data that describe the state of the F-module.
- Data record 1 contains
  - The 4 bytes of diagnostic data of the F-module that are also in data record 0 and
  - Up to 36 bytes of channel-specific diagnostics data, depending on the F-module (see "*Channel-Specific Diagnostics from Byte 8*").

Description

The next section describes the content and structure of the individual diagnostic data bytes.

General rule: If a fault occurs, the corresponding bit is set to "1".

Bytes 0 and 1

The figure below shows the contents of bytes 0 and 1 in the diagnostic data.

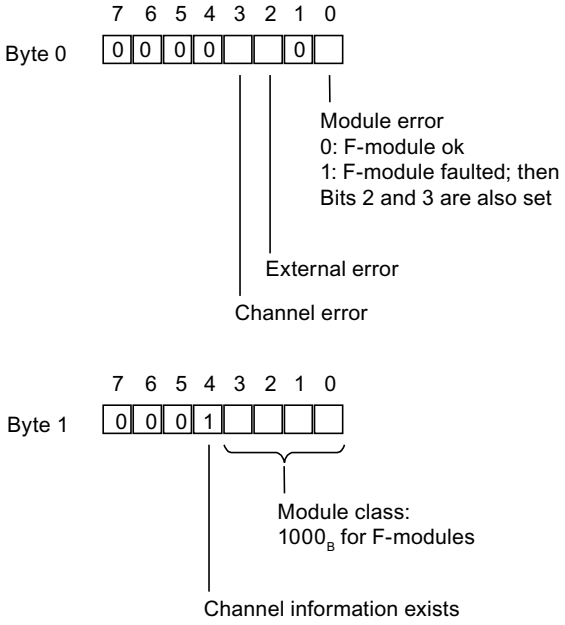


Figure A-1 Bytes 0 and 1 of Diagnostic Data

Bytes 2 and 3

The figure below shows the contents of bytes 2 and 3 in the diagnostic data.

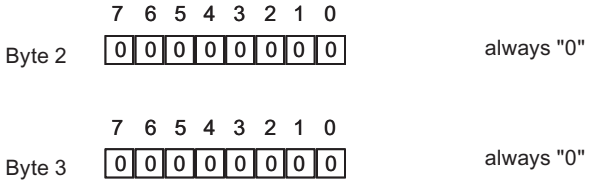


Figure A-2 Bytes 2 and 3 of Diagnostic Data

Bytes 4 to 6

The figure below shows the contents of bytes 4 to 6 in the diagnostic data.

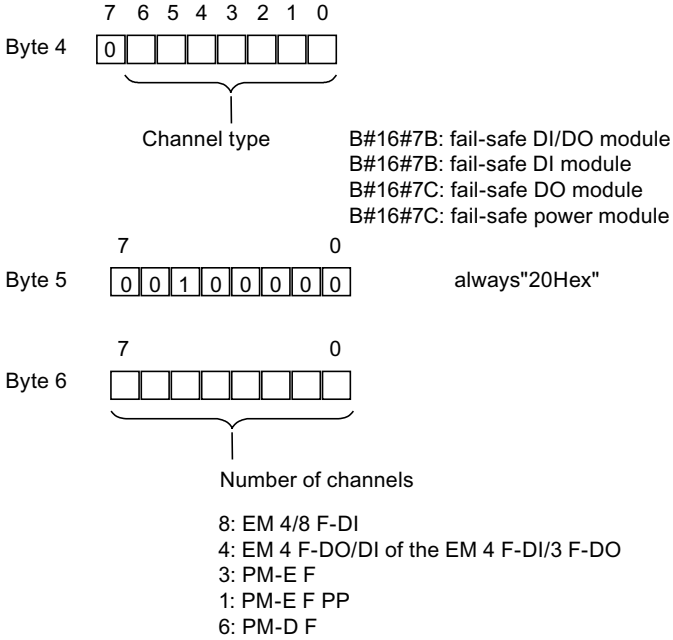


Figure A-3 Bytes 4 to 6 of Diagnostic Data

Byte 7 with EM 4/8 F-DI DC24V PROFIsafe

The figure below shows the content of Byte 7 of the diagnostic data for EM 4/8 F-DI DC24V PROFIsafe.

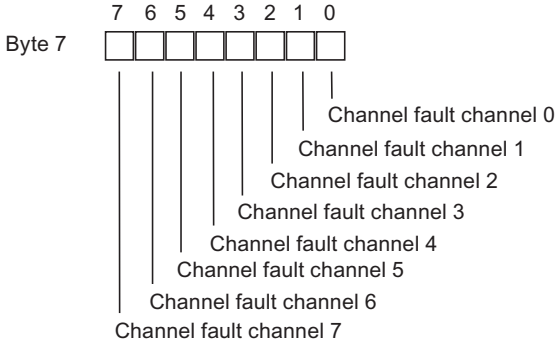


Figure A-4 Byte 7 of diagnostic data for EM 4/8 F-DI DC24V PROFIsafe

Byte 7 with EM 4 F-DI/3 F-DO DC24V PROFIsafe

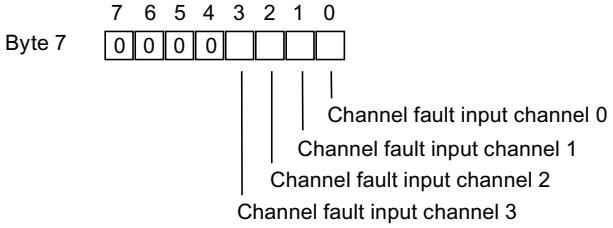


Figure A-5 Byte 7 of diagnostic data for EM 4 F-DI/3 F-DO DC24V PROFIsafe

Byte 7 with EM 4 F-DO DC24V/2A PROFIsafe

The figure below shows the content of Byte 7 of the diagnostic data for EM 4 F-DO DC24V/2A PROFIsafe.

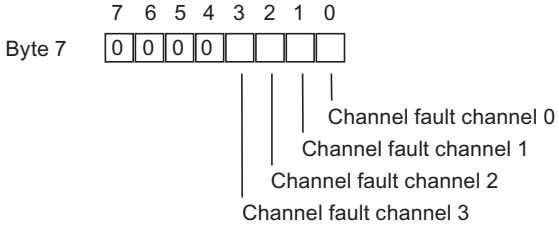


Figure A-6 Byte 7 of diagnostic data for EM 4 F-DO DC24V/2A PROFIsafe

Byte 7 with PM-E F pm DC24V PROFIsafe

The figure below shows the content of Byte 7 of the diagnostic data for the PM-E F pm DC24V PROFIsafe.

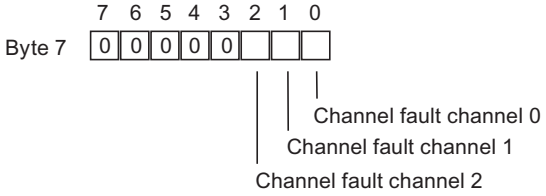


Figure A-7 Byte 7 of diagnostic data for PM-E F pm DC24V PROFIsafe

Byte 7 with PM-E F pp DC24V PROFIsafe

The figure below shows the content of Byte 7 of the diagnostic data for the PM-E F pp DC24V PROFIsafe

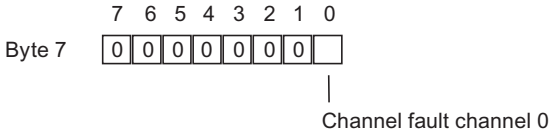


Figure A-8 Byte 7 of diagnostic data for PM-E F pp DC24V PROFIsafe

Byte 7 with PM-D F DC24V PROFIsafe

The figure below shows the content of Byte 7 of the diagnostic data for the PM-D F DC24V PROFIsafe.

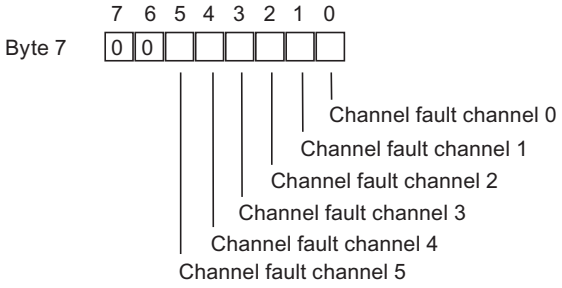


Figure A-9 Byte 7 of diagnostic data for PM-D F DC24V PROFIsafe

Channel-Specific Diagnostics from Byte 8

Channel-specific diagnostics start at byte 8 of the diagnostic data. Each channel is provided with 4 bytes of diagnostic information. The inputs apply to the EM 4 F-DI/3 F-DO.

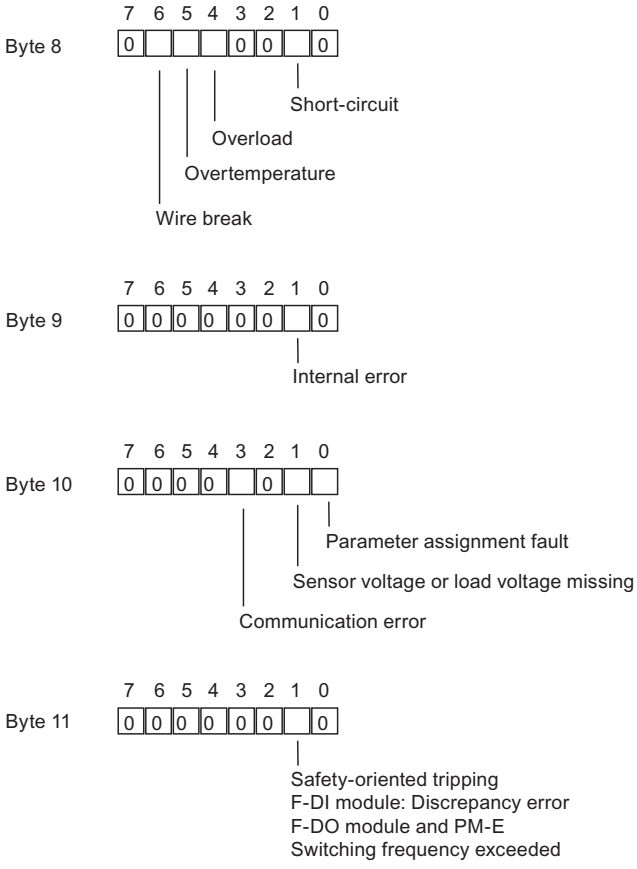


Figure A-10 Channel-Specific Diagnostics Starting at Byte 8 of the Diagnostics Data

Byte 27 on 4 F-DI/3 F-DO (Outputs)

The figure below shows the content of Byte 27 of the diagnostic data for the outputs of the 4 F-DI/3 F-DO.

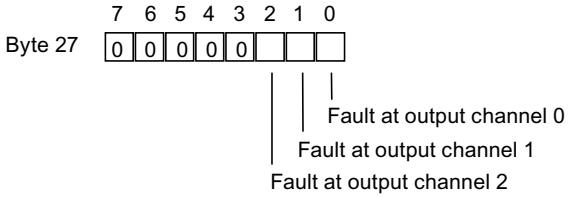
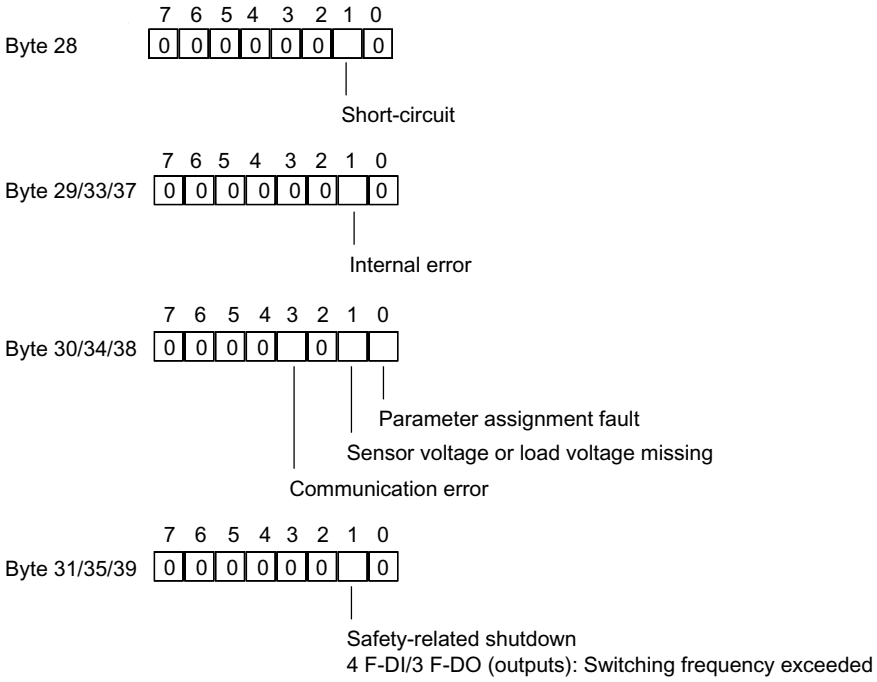


Figure A-11 Byte 27 of the diagnostic data for the outputs of the 4 F-DI/3 F-DO

Channel-Specific Diagnostics in Bytes 28 to 43

Channel-specific diagnostics start at byte 28 of the diagnostic data. Each channel is provided with four bytes of diagnostic information.



Byte 32 to 35 :
Next channel-specific diagnostic
(assignment same as Bytes 28 to 31)

Figure A-12 Channel-Specific Diagnostics Starting at Byte 28 of the Diagnostic Data

Due to the different numbers of channels of the F-modules, data record 1 has differing lengths:

EM 4/8 F-DI DC24V PROFIsafe:	40 bytes
EM 4 F-DO DC24V/2A PROFIsafe:	24 bytes
EM 4 F-DI/3 F-DO DC24V PROFIsafe:	36 bytes
PM-E F pm DC24V PROFIsafe:	20 bytes
PM-E F pp DC24V PROFIsafe:	12 bytes
PM-D F DC24V PROFIsafe:	32 bytes

Dimension drawings

B

Terminal Modules with F-Module Inserted

The section below shows dimensional drawings for each of the following:

- Terminal modules TM-x30x4x-xx with PM-E F pm, PM-E F pp, F-DI or F-DO module
- Terminal module TM-PF30S47-F1 with PM-D F-module

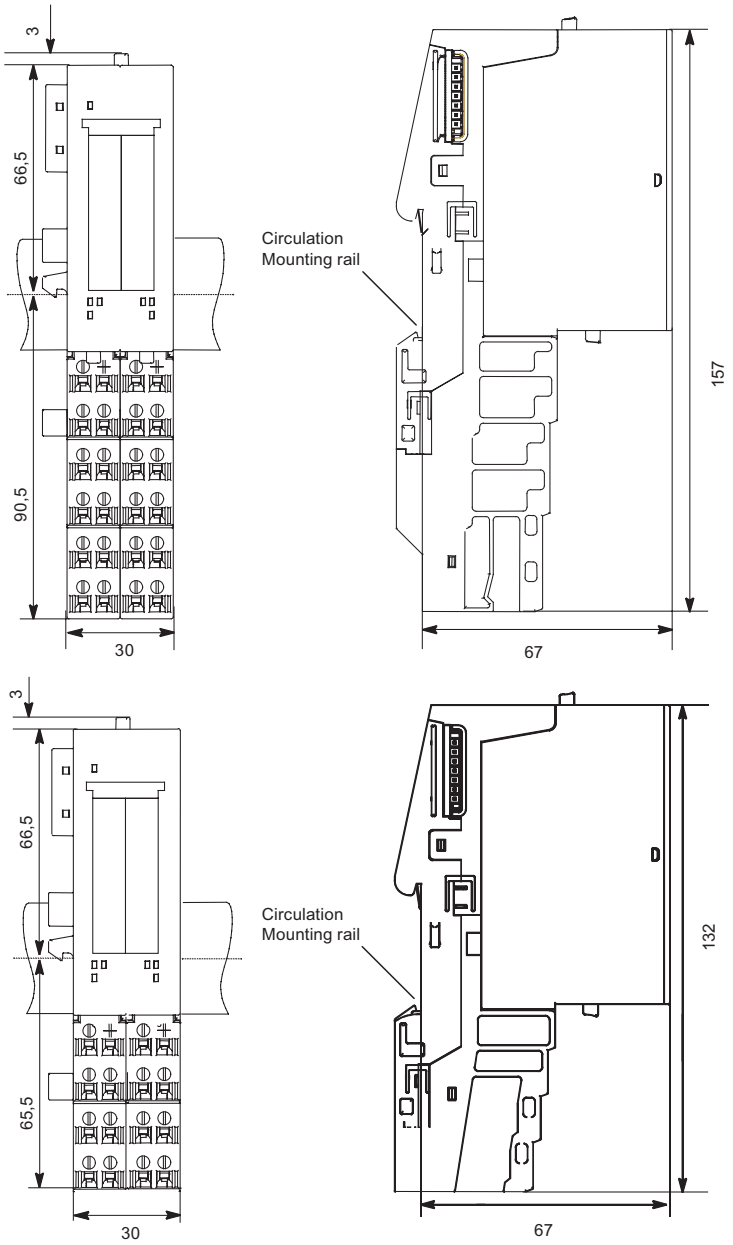


Figure B-1 Dimension Drawing of Terminal Modules with PM-E F pm, PM-E F pp, F-DI or F-DO module

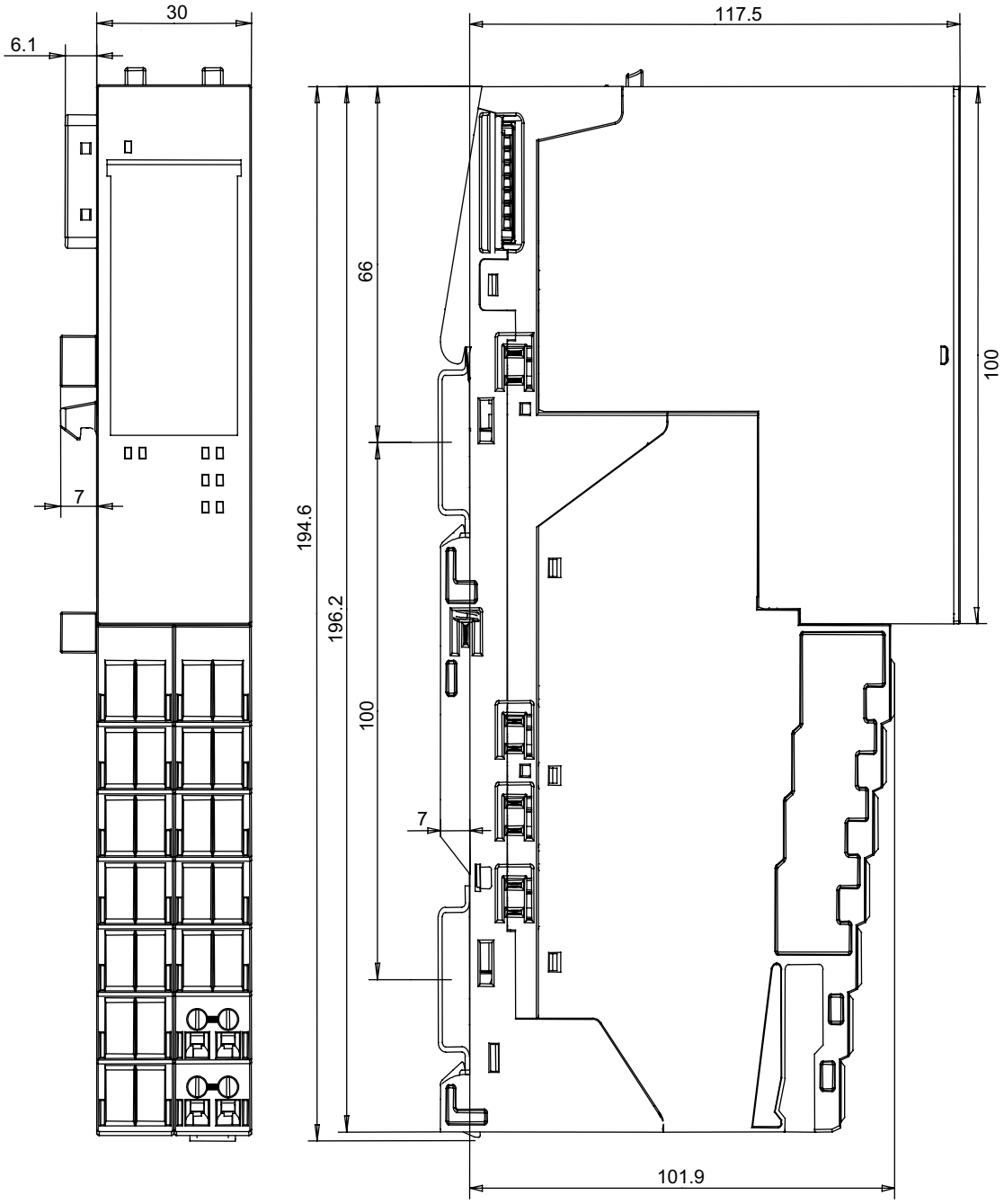


Figure B-2 Dimension drawing of terminal module with PM-D F DC24V PROFIsafe

Accessories and Order Numbers

C

Accessories and Order Numbers

The table below lists the order numbers of terminal modules, of fail-safe PMs and EMs, and of accessories which can be ordered for the fail-safe modules.

Component	Order Number
Terminal modules for F-DI and F-DO:	
TM-E30S44-01 (screw-in type), 1 item	6ES7193-4CG20-0AA0
TM-E30C44-01 (snap-on type), 1 item	6ES7193-4CG30-0AA0
TM-E30S46-A1 (screw-in type), 1 item	6ES7193-4CF40-0AA0
TM-E30C46-A1 (snap-on type), 1 item	6ES7193-4CF50-0AA0
Terminal modules for PM-E F pm DC24V PROFIsafe and PM-E F pp DC24V PROFIsafe:	
TM-P30S44-A0 (screw-in type), 1 item	6ES7193-4CK20-0AA0
TM-P30C44-A0 (snap-on type), 1 item	6ES7193-4CK30-0AA0
Terminal module for PM-D F DC24V PROFIsafe:	
TM-PF30S47-F1 (screw-in type), 1 item	3RK1903-3AA00
Fail-safe power modules:	
PM-E F pm DC24V PROFIsafe	6ES7138-4CF03-0AB0
PM-E F pp DC24V PROFIsafe	6ES7138-4CF42-0AB0
PM-D F DC24V PROFIsafe	3RK1903-3BA02
Fail-safe electronic module:	
4/8 F-DI DC24V PROFIsafe	6ES7138-4FA04-0AB0
4 F DI/3 DO DC24V PROFIsafe	6ES7138-4FC01-0AB0
4 F-DO DC24V/2A PROFIsafe	6ES7138-4FB03-0AB0
1 F-RO DC24V/AC24..230V/5A	6ES7138-4FR00-0AA0
Accessories:	
Label sheets DIN A4, yellow, quantity of 10	6ES7193-4BB00-0AA0

Response times

D

Introduction

The response times of the ET 200S F-modules are listed below. The response time of F-modules is included in the calculation of the F-system response time.

Information about the calculation of F-system response times is available in the *Safety Engineering in SIMATIC S7* System Description.

Definition of Response Time

For fail-safe digital inputs: The response time defines the interval between a signal transition at the digital input and the reliable availability of the safety message frame on the backplane bus.

For fail-safe digital outputs: The response time defines the interval between the receipt of a safety message frame from the backplane bus and the signal transition at the digital output.

Maximum response time of the PM-E F pm DC24V PROFIsafe

The maximum response time of the PM-E F pm DC24V PROFIsafe (with or without fault) is equivalent to the maximum internal processing time T_{max}.

The internal processing times of the electronic PM channel depend on the readback time parameter setting (see table below).

Table D- 1 PM-E F pm DC24V PROFIsafe: Internal processing times of the electronic PM channel

PM-E F pm DC24V PROFIsafe (electronic PM channel)			
Programmed Readback Time	Limit Frequency	Minimum Internal Processing Time T_{min}	Maximum Internal Processing Time T_{max}
1 ms	32.3 Hz	4 ms	16 ms
5 ms	28.6 Hz	4 ms	20 ms
10 ms	25.0 Hz	4 ms	25 ms
50 ms	12.5 Hz	4 ms	55 ms
100 ms	7.7 Hz	4 ms	90 ms
200 ms	4.3 Hz	4 ms	150 ms
400 ms	2.3 Hz	4 ms	300 ms

Table D- 2 PM-E F pm DC24V PROFIsafe: Internal processing times of the P1/2 channel

Measuring Channel	Minimum Internal Processing Time T_{min}	Maximum Internal Processing Time T_{max}
PM-E F pm DC24V PROFIsafe (P1/2 channel; relay; switch on)	4 ms	10 ms
PM-E F pm DC24V PROFIsafe (P1/2 channel; relay; switch off)	6 ms	14 ms

Maximum response time of the PM-E F pp DC24V PROFIsafe

The maximum response time of the PM-E F pp DC24V PROFIsafe (with or without fault) is equivalent to the maximum internal processing time T_{max}.

Table D- 3 PM-E F pp DC24V PROFIsafe: Internal processing times

Measurement channel	minimum internal processing time T_{min}	maximum internal processing time T_{max}
PM-E F pp DC24V PROFIsafe (P1/2 channel; relay; switch on)	4 ms	10 ms
PM-E F pp DC24V PROFIsafe (P1/2 channel; relay; switch off)	6 ms	12 ms

Maximum response time of the PM-D F DC24V PROFIsafe

The maximum response time of the PM-D F DC24V PROFIsafe (with or without fault) is equivalent to the maximum internal processing time T_{max}.

Table D- 4 PM-D F DC24V PROFIsafe: Internal processing times

Measuring Channel	Minimum Internal Processing Time T_{min}	Maximum Internal Processing Time T_{max}
PM-D F DC24V PROFIsafe (electronic PP channel)	3 ms	9 ms

Maximum response time of the EM 4/8 F-DI DC24V PROFIsafe

Formula for calculating the maximum response time if there is no fault:

Maximum response time
without fault = T_{max} + input delay + short-circuit test time*

*: Short-circuit test time = 2 x input delay

Program the input delay and short-circuit test in *STEP 7*.

Table D- 5 EM 4/8 F-DI DC24V PROFIsafe: Internal Processing Times

Sensor evaluation	minimum internal processing time T_{min}	maximum internal processing time T_{max}
1oo1 and 1oo2	5 ms	11 ms

Maximum response time if a fault occurs:

The table below contains the maximum response times of the F-DI module when a fault occurs, depending on the parameter settings in *STEP 7* and on the sensor evaluation.

Table D- 6 EM 4/8 F-DI DC24V PROFIsafe: Maximum Response Time if a Fault Occurs

	1oo1 evaluation			1oo2 evaluation**		
Input Delay	0.5 ms	3 ms	15 ms	0.5 ms	3 ms	15 ms
Short-circuit test deactivated	18 ms	20 ms	32 ms	12 ms	14 ms	26 ms
Short-circuit test activated	29 ms	40 ms	91 ms	13 ms	20 ms	56 ms

: The response times with **1oo2 evaluation also depend on the configured discrepancy behavior:

Provide 0 value: The times defined in the table above apply.

Provide last valid value: The times in the table above are extended by the programmed discrepancy time.

Note

Please note that the Excel files for calculating the maximum response times (*s7fcotia.xls* and *s7ftimea.xls*) included with the *S7 Distributed Safety* and *S7 F/FH Systems* option packages already support calculation of the extension of the "Maximum response time in the event of a fault" by the programmed discrepancy time.

Maximum response time of the EM 4 F-DI/3 F-DO DC24V PROFIsafe

Formula for calculating the maximum response time if there is no fault:

maximum response time
without a fault = T_{max} + input delay + short-circuit test time*

*: Short-circuit test time = 2 x input delay

Parameters for the input delay and the short-circuit test are assigned in *STEP 7*.

Table D- 7 EM 4 F-DI/3 F-DO DC24V PROFIsafe: Internal Processing Times

Evaluation of the Sensors	minimum internal processing time T_{min}	maximum internal processing time T_{max}
1oo2	4 ms	9 ms

Maximum response time if a fault occurs:

The table below contains the maximum response times of the F-DI/F-DO module when a fault occurs, depending on the parameter settings in *STEP 7* and on the sensor evaluation.

Table D- 8 EM 4 F-DI/3 F-DO DC24V PROFIsafe: Maximum Response Time if a Fault Occurs

1oo2 evaluation*	
Input Delay	**3 ms**
Short-circuit test deactivated	14 ms
Short-circuit test activated	22 ms
*: The response times with **1oo2 evaluation** also depend on the configured discrepancy behavior: **Provide 0 value**: The times defined in the table above apply. **Provide last valid value**: The times in the table above are extended by the programmed discrepancy time.	

Note

Please note that the Excel files for calculating the maximum response times (*s7fcotia.xls* and *s7ftimea.xls*) included with the *S7 Distributed Safety* and *S7 F/FH Systems* option packages already support calculation of the extension of the "Maximum response time in the event of a fault" by the programmed discrepancy time.

Maximum response time of outputs:

The maximum response time of the EM 4 F-DI/3 F-DO DC24V PROFIsafe (with or without fault) is equivalent to the maximum internal processing time T_{max}.

The internal processing times of the electronic PM channel depend on the readback time parameter setting (see table below).

Table D- 9 EM 4 F-DI/3 F-DO DC24V PROFIsafe: Internal Processing Times

EM 4 F-DI/3 F-DO DC24V PROFIsafe (electronic PM channel)			
Programmed Readback Time	Limit Frequency	Minimum Internal Processing Time T_{min}	Maximum Internal Processing Time T_{max}
1 ms	37.0 Hz	4 ms	13 ms
5 ms	32.2 Hz	4 ms	14 ms
10 ms	27.7 Hz	4 ms	20 ms
50 ms	13.2 Hz	4 ms	32 ms
100 ms	7.9 Hz	4 ms	50 ms
200 ms	4.4 Hz	4 ms	75 ms
400 ms	2.3 Hz	4 ms	140 ms

Maximum response time of the EM 4 F-DO DC24V/2A PROFIsafe

The maximum response time of the EM 4 F-DO DC24V/2A PROFIsafe (with or without fault) is equivalent to the maximum internal processing time T_{max}.

The internal processing times of the electronic PM channel depend on the readback time parameter setting (see table below).

Table D- 10 EM 4 F-DO DC24V/2A PROFIsafe: Internal Processing Times

EM 4 F-DO DC24V/2A PROFIsafe (electronic PM channel)			
Programmed Readback Time	Limit Frequency	Minimum Internal Processing Time T_{min}	Maximum Internal Processing Time T_{max}
1 ms	32.3 Hz	4 ms	16 ms
5 ms	28.6 Hz	4 ms	20 ms
10 ms	25.0 Hz	4 ms	25 ms
50 ms	12.5 Hz	4 ms	55 ms
100 ms	7.7 Hz	4 ms	100 ms
200 ms	4.3 Hz	4 ms	150 ms
400 ms	2.3 Hz	4 ms	300 ms

Maximum response time of the EM 1 F-RO DC24V/AC24..230V/5A

The maximum response time of the EM 1 F-RO DC24V/AC24..230V/5A (with or without fault) is equivalent to the total of:

- the maximum response time of the fail-safe output used to activate the F-RO module
- plus the relay switching or release time of the F-RO module

See also

Properties of the 4/8 F-DI 24 VDC PROFIsafe Digital Electronic Module (Page 105)

Connecting Loads

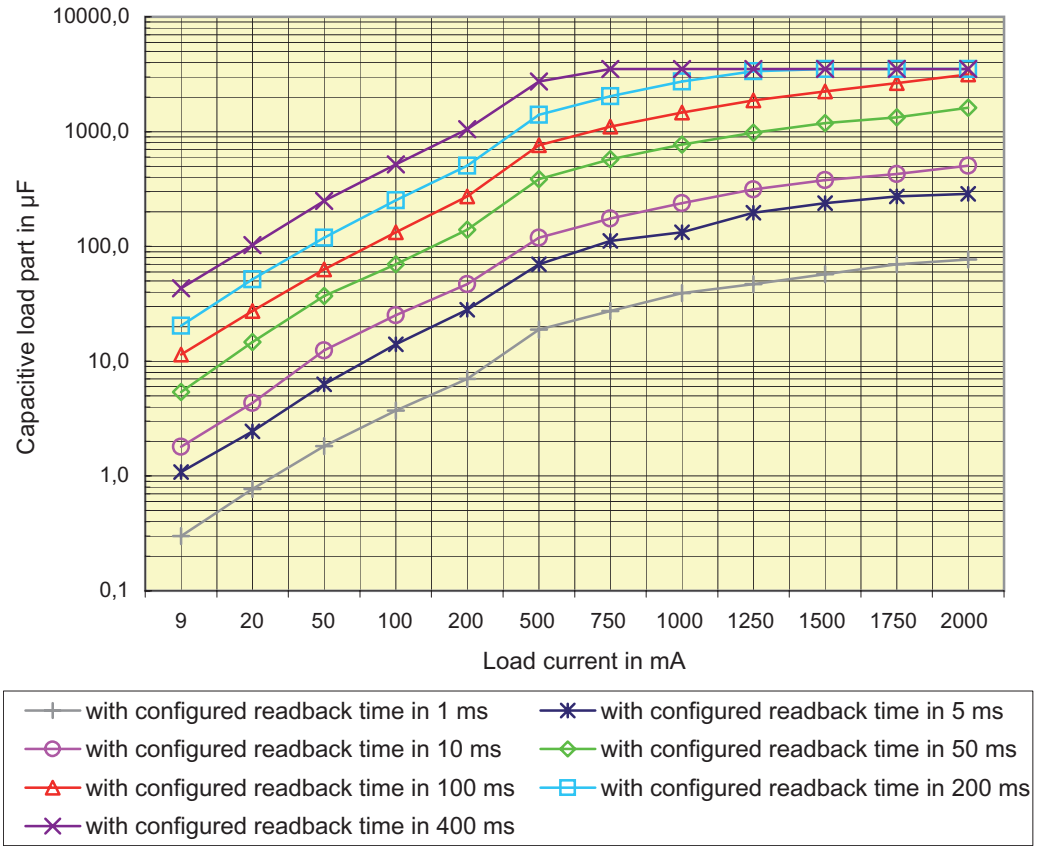
E

E.1 Connecting capacitive loads

Connecting capacitive loads on PM-E F pm DC24V PROFIsafe, EM 4 F-DO DC24V/2A PROFIsafe

If the electronic outputs of the PM-E F pm DC24V PROFIsafe, of EM 4 F-DO DC24V/2A are connected to low-power loads that have capacitance, this can lead to generation of a "short-circuit" error message. Reason: The capacitance cannot be sufficiently discharged during the programmed self-test readback time.

The figure below shows the typical curves of the parameterized readback times indicating the relationship between load resistance and connectable load capacitance.



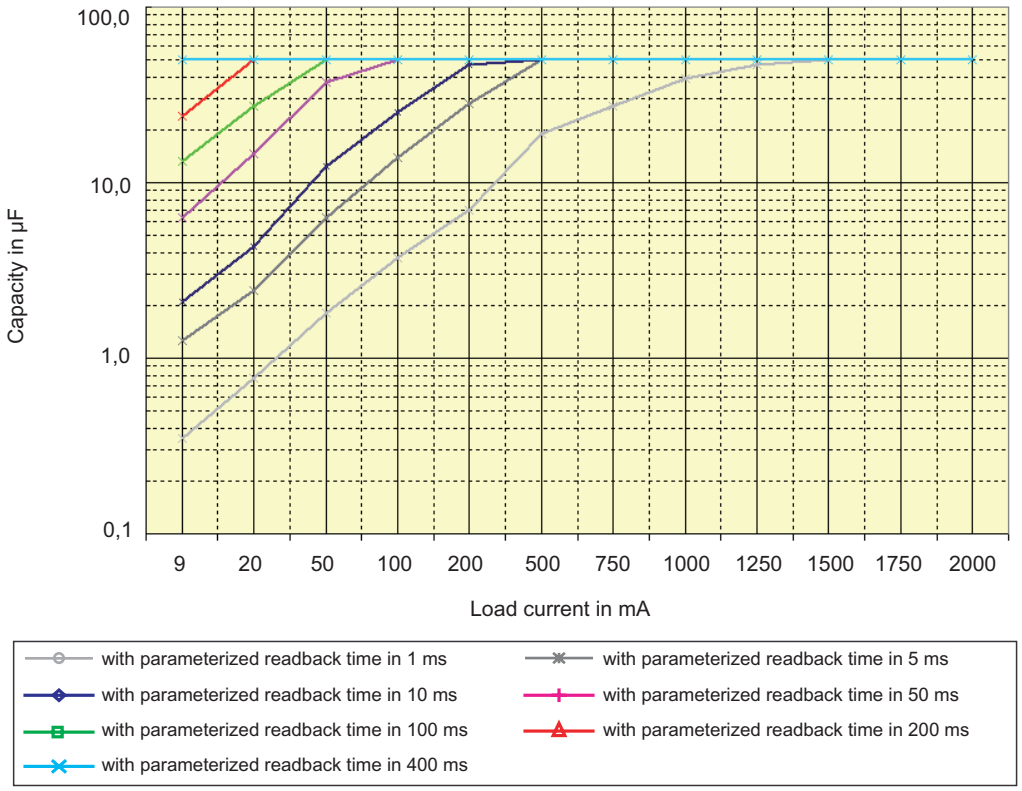
Remedy:

1. Determine the load current and capacitance of the load.
2. Locate the operating point in the diagram above.
3. If the operating point is above the curve, you must increase the load current until the new operating point is below the curve by connecting a resistor in parallel.

Connecting Capacitive Loads at the EM 4 F-DI/3 F-DO DC24V PROFIsafe

The figure below shows the typical curves of the parameterized readback times indicating the relationship between load resistance and connectable load capacitance.

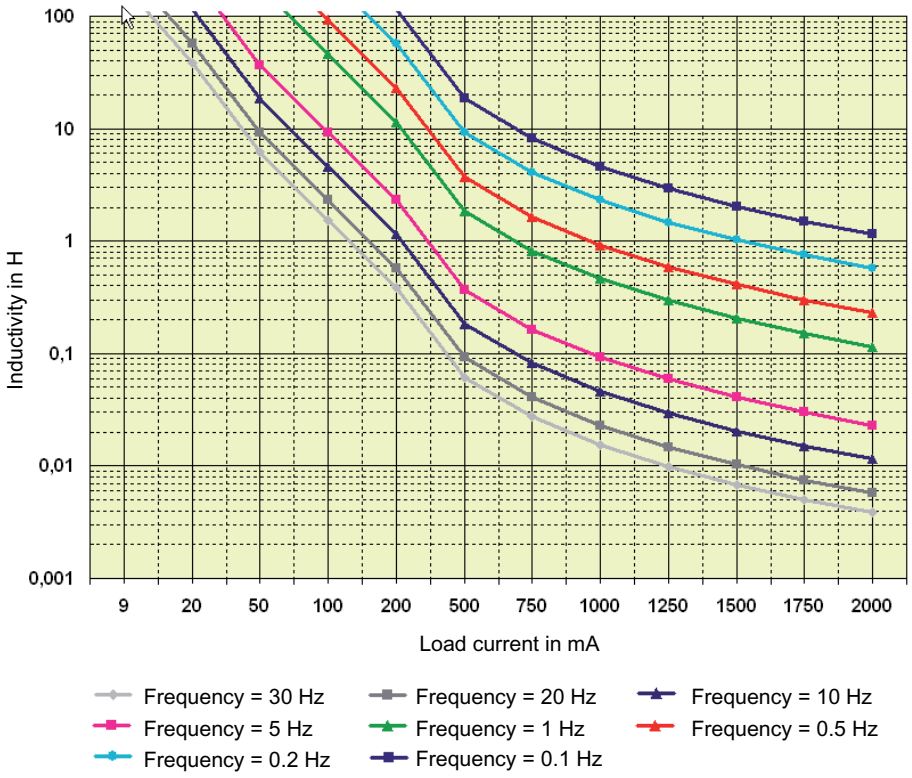
Behavior is as described above.



E.2 Switching inductive loads

Connecting inductive loads on PM-E F pm DC24V PROFIsafe, EM 4 F-DO DC24V/2A PROFIsafe and EM 4 F-DI/3 F-DO DC24V PROFIsafe

The diagram below shows the maximum permitted inductive loads as a function of the load current and switching frequency.



Glossary

1oo1 evaluation1oo1 evaluation

-> 1oo1 evaluation

Type of -> sensor evaluation – with the 1oo1 evaluation -> sensor is non-redundant and connected to the F-module via one channel.

1oo1 evaluation1oo1 evaluation

-> 1oo1 evaluation

Type of -> sensor evaluation – with the 1oo1 evaluation -> sensor is non-redundant and connected to the F-module via one channel.

1oo2 evaluation1oo2 evaluation

-> 1oo2 evaluation

Type of -> sensor evaluation - 1oo2 evaluation covers two input channels which are interconnected either with a single dual-channel sensor, or with two single-channel sensors. The input signals are compared internally for equivalence or nonequivalence.

1oo2 evaluation1oo2 evaluation

-> 1oo2 evaluation

Type of -> sensor evaluation - 1oo2 evaluation covers two input channels which are interconnected either with a single dual-channel sensor, or with two single-channel sensors. The input signals are compared internally for equivalence or nonequivalence.

Acknowledgment time

The -> F-I/O acknowledges the sign of life specified by the -> F-CPU within the acknowledgment time. The acknowledgment time is included in the calculation of the overall > monitoring time and -> response time for the F-system.

Actuator

Actuators can be power relays or contactors for switching on loads, or they can be loads themselves (e.g. directly controlled solenoid valves).

AUX1 bus

Power modules allow the additional connection of a voltage (24 VDC) which you can wire via the AUX(iliary) bus. AUX(iliary) buses can be used individually as a protective conductor bus or to supply additionally-required voltage.

Availability

Availability is the probability that a system is functional at a specific point in time. Availability can be enhanced by redundancy, for example by using multiple -> sensors at the same measuring point.

Backplane bus

The backplane bus is a serial data bus via which the IM 151 interface module communicates with the electronic modules/motor starters, supplying them with the required voltage. The modules are interconnected by way of terminal modules.

Category

Category in accordance with EN 954-01.

-> Fail-safe modules can be used in safety mode up to Category 4.

Channel error

Channel-specific fault, such as a wire break or short circuit.

In channel-specific passivation, the affected channel is either automatically reintegrated or the F-module must be removed and reinserted after the fault has been eliminated.

Channel group

The channels of a module are grouped together in a channel group. Certain parameters in *STEP 7* can only be assigned to channel groups and not to individual channels.

Channel number

Channel numbers are used to uniquely identify the inputs and outputs of a module and to assign channel-specific diagnostic messages.

Channel-specific passivation

With this type of passivation, only the affected channel is passivated when a -> channel fault occurs. All channels of the -> fail-safe module are passivated when a -> module fault is detected.

Configuring

A configuration denotes the systematic arrangement of the individual ET 200S modules (set-up).

CRC

Cyclic Redundancy Check -> CRC signature

CRC signature

The validity of the process values in the safety message frame, the accuracy of the assigned address references, and the safety-related parameters are validated by means of the CRC signature in the safety message frame.

Dark period

Dark periods occur during shutdown tests and complete bit pattern tests. The fail-safe output module switches test-related zero signals to the active output. This output is then briefly disabled (= dark period). An -> actuator with sufficient lag does not respond to these signals and remains switched on.

Discrepancy analysis

The discrepancy analysis for equality/non-equality is used at fail-safe inputs to detect errors based on the timing of two signals with the same functionality. Discrepancy analysis is initiated when different levels (when testing for nonequivalence: same voltage levels) are detected at two associated input signals. The signals are checked to determine whether the difference (when checking for nonequivalence: the consistency) has disappeared within a programmable period known as the -> discrepancy time. If not, this means that a discrepancy error exists.

The discrepancy analysis compares the two input signals of the 1oo2 sensor evaluation in the fail-safe input module.

Discrepancy time

Configured time for the -> discrepancy analysis. If the discrepancy time is set too high, the times for fault detection and -> fault reaction are extended unnecessarily. If the discrepancy time is set too low, availability is decreased unnecessarily since a discrepancy error is detected when, in reality, no error exists.

DP master

A master that behaves in accordance with IEC 61784-1:2002 Ed1 CP 3/1 is known as a DP master.

DP slave

A DP slave is a slave operated on PROFIBUS with the PROFIBUS DP protocol that behaves in accordance with IEC 61784-1:2002 Ed1 CP 3/1.

F monitoring time

-> PROFIsafe monitoring time

Fail-safe modules

These are ET 200S modules that can be used for safety-related operation (-> safety mode) in the ET 200S distributed I/O system. These modules are equipped with integrated -> safety functions.

Fail-safe systems

Fail-safe systems (F-systems) remain in a safe state or immediately assume another safe state as soon as particular failures occur.

Fault response time

The maximum fault response time of an F-system defines the interval between the occurrence of any fault and a safe reaction at all affected fail-safe outputs.

For -> F-systems in general: The maximum fault response time defines the interval between the occurrence of any fault at any -> F-I/O and the safe reaction at the corresponding fail-safe output.

For digital inputs: The maximum fault response time defines the interval between the occurrence of the fault and the safe reaction at the backplane bus.

For digital outputs: The maximum fault response time defines the interval between the occurrence of the fault and the safe reaction at the digital output.

Fault tolerance time

The fault tolerance time of a process is the time a process can be left unattended without risk to life and limb of the operating personnel, or damage to the environment.

Within the fault tolerance time, the F-system can initiate any process control actions, i.e. it can control its process incorrectly or even not at all. The fault tolerance time depends on the type of process and must be determined on a case-by-case basis.

F-CPU

An F-CPU is a central processing unit with fail-safe capability which is approved for use in S7 Distributed Safety/S7 F/FH systems.

For S7 F/FH Systems, the F-copy license allows the central processing unit to be used as an F-CPU. In other words, it can execute a -> safety program.

An F-copy license is not required for S7 Distributed Safety. The F-CPU can also execute a -> standard user program.

F-I/O

Group designation for fail-safe inputs and outputs available in *SIMATIC S7* for the integration in the S7 Distributed Safety and S7 F/FH Systems fail-safe systems. Available F-I/O modules:

- Fail-safe I/O module for ET 200eco
- S7-300 fail-safe signal modules (F-SMs)
- Fail-safe modules for ET 200S
- Fail-safe DP standard slaves (for S7 Distributed Safety only)
- fail-safe PA field devices
- fail-safe IO devices

F-Systems

-> Fail-safe systems

Interconnecting

Refers to the opening of a new voltage group by a power module.

This allows individual grouping of sensor and load supplies.

IO controller

-> PROFINET IO controller

IO device

-> PROFINET IO device

Module fault

Module faults can be external faults (e.g. missing load voltage) or internal faults (e.g. processor failure). Internal faults always require module replacement.

Monitoring time

-> PROFIsafe monitoring time

Motor starter (MS)

Motor starter is a generic term for direct and reversing starters. Motor starters are used to determine motor startup and the direction of rotation.

M-switch

Each fail-safe digital output of the ET 200S F-modules consists of a P-switch DOx P and an M-switch DOx M. The load is connected between the P and M-switches. To ensure voltage is applied to the load, both switches are always activated.

Nonequivalent sensor

An exclusive OR -> sensor is a changeover switch that is wired in -> fail-safe systems (dual-channel connection) to two inputs of a -> fail-safe I/O (for -> 1oo2 evaluation of sensor signals).

Parameter assignment

Assigning parameters with PROFIBUS DP: Transfer of slave parameters from the DP master to the DP slave

Assigning parameters to modules/submodules: Sets the behavior of modules/submodules with the *STEP 7* configuration software

Passivation

If an -> F-I/O detects a fault, it switches either the affected channel or all channels to a -> safe state; i.e. the channels of this F-I/O are passivated. The F-I/O reports the detected fault to the -> F-CPU.

When passivating channels at F-I/O with inputs, the -> F-system returns fail-safe values instead of the process values pending at the fail-safe inputs to the -> safety program.

When passivating channels at F-I/O with outputs, the F-system returns fail-safe values (0) to the fail-safe outputs instead of the output values provided by the safety program.

PD

PProgramming **d**device (PD): Personal computer in special compact industrial design. A PD is fully equipped for programming SIMATIC automation systems.

Performance Level

Performance Level (PL) to ISO 13849

Potential group

A group of electronic modules supplied by the same power module.

Prewiring

Denotes the wiring of terminal modules prior to insertion of the electronic modules.

Process image

The process image is part of the system memory of the CPU. At the start of cyclic program execution, the signal states of the inputs are transferred to the process image of the inputs. At the end of the cyclic program, the process output image is transferred to the outputs as the signal state.

PROFIBUS

PROcess **FI**eld **BUS**, process and fieldbus standard specified in IEC 61784-1:2002 Ed1 CP 3/1. This standard specifies the functional, electrical and mechanical properties of a bit-serial fieldbus system.

PROFIBUS is available with the DP (= distributed I/O), FMS (= fieldbus message specification), PA (= process automation), or TF (= technological functions) protocols.

PROFINET IO

PROFINET IO is the PROFINET communication concept for implementing modular, distributed applications.

PROFINET IO enables creation of automation solutions using the familiar, proven methods of PROFIBUS.

PROFINET IO implementation is based on both the PROFINET standard for automation devices and the *STEP 7* engineering tool.

This means that you have the same application view in *STEP 7*, regardless of whether you are configuring PROFINET or PROFIBUS devices. Creation of your user program is similar for PROFINET IO and PROFIBUS DP, provided you use the expanded blocks and system status lists for PROFINET IO.

PROFINET IO controller

Device via which connected IO devices are addressed. That is, the IO controller exchanges input and output signals with assigned field devices. The IO controller is often the controller in which the automation program runs.

PROFINET IO device

A PROFINET IO device is a decentralized field device that is assigned to one of the IO controllers (e.g. remote IO, valve terminals, frequency converters, switches)

PROFINET IO supervisor

Programming device (PD), PC or HMI device used for commissioning and diagnostics.

PROFINET IO controller with assigned PROFINET IO devices.

PROFIsafe

PROFIsafe is the safety-related PROFIBUS DP/PA bus profile for communication between the -> safety program and the -> F-I/O in an -> F-system.

PROFIsafe address

Each -> fail-safe module is assigned a separate PROFIsafe address. The PROFIsafe address must be configured in *STEP 7 HW Config* and set via a switch on the fail-safe I/O.

PROFIsafe monitoring time

Monitoring time for safety-related communication between the F-CPU and F-I/O.

Proof-test interval

Period after which a component must be forced to fail-safe state, that is, it is either replaced with an unused component, or is proven faultless.

P-switch

-> M-switch

Redundancy, availability-enhancing

Multiple instances of components with the objective of maintaining component functionality in the event of hardware faults.

Redundancy, safety-enhancing

Multiple installations of components with the goal of reducing hardware faults; for example, -> 1oo2 evaluation in -> fail-safe modules.

Reintegration

The -> F-I/O must be reintegrated (depassivated) after a fault has been cleared. Reintegration (switchover from fail-safe values to process values) occurs either automatically or only after a user acknowledgment in the safety program.

For an F-I/O module with inputs, the process values pending at the fail-safe inputs are again made available to the -> safety program following reintegration. For an F-I/O module with outputs, the output values provided by the -> safety program are again made available to the fail-safe outputs following reintegration.

Response time

The response time starts with the detection of an input signal and ends with the modification of a logically linked output signal.

The actual response time is between the shortest and the longest response time. The longest response time must always be anticipated when configuring a plant.

For fail-safe digital inputs: The response time defines the interval between a signal transition at the digital input and the reliable availability of the -> safety message frame on the backplane bus.

For fail-safe digital outputs: The response time defines the interval between the receipt of a safety message frame from the backplane bus and the signal transition at the digital output.

Reversing starter

A -> motor starter which determines the rotational direction of a motor. Consists of a circuit-breaker and two contactors.

Safe state

The basic principle of the safety concept in F-systems is the existence of a safe state for all process variables. For the digital F-I/O, for example, the safe state is the value "0".

Safety class

Safety Integrity Level (SIL) in accordance with IEC 61508. The higher the Safety Integrity Level, the more rigid the measures for prevention of systematic faults and for management of systematic faults and hardware failures.

The fail-safe modules support operation in safety mode up to safety class SIL3.

Safety function

The safety function is a mechanism built into the -> F-CPU and -> F-I/O that allows them to be used in -> S7 Distributed Safety or S7 F/FH fail-safe systems.

In accordance with IEC 61508: A safety function is implemented by a safety system in order to maintain or force a system safe state in the event of a specific fault.

Safety message frame

In safety mode, data are transferred between the -> F-CPU and the -> F-I/O in a safety message frame.

Safety mode

Operating mode of the -> F-I/O which allows -> safety-related communication by means of -> safety message frames.

ET 200S -> fail-safe modules can only be operated in safety mode.

Safety program

Safety-related user program.

Safety-related communication

Type of communication for the exchange of fail-safe data.

Sensor evaluation

There are two types of sensor evaluation:

-> 1oo1 evaluation – sensor signal is read once

-> 1oo2 evaluation – sensor signal is read in twice from the same F-module and compared internally

Sensors

Sensors are used for accurate detection of digital and analog signals as well as routes, positions, velocities, rotational speeds, masses, etc.

SIL

Safety Integrity Level -> safety class

Standard mode

Operating mode of the F-I/O which supports standard communication, but not -> safety-related communication by means of -> safety message frames.

Fail-safe signal modules of the S7-300 can be operated in standard mode or in -> safety mode. Fail-safe ET 200S modules are designed for operation in safety mode only.

Static parameters

Static parameters can only be set when the CPU is in STOP mode, and cannot be changed while the user program is running by means of SFC (system function).

Terminal module

The ET 200S distributed I/O system is terminated with the terminal module. An ET 200S cannot be operated without a terminal module.

Voltage bus (P1/P2)

Two internal buses (P1 and P2) supply the electronic modules with voltage. The voltage buses are fed by the power module and are connected via terminal modules.

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