SIEMENS

SIMATIC

Distributed I/O
ET 200iSP Distributed I/O - Failsafe Module

Operating Instructions

08/2016
A5E38986048-AA

Legal information

Warning notice system

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

⚠ DANGER

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

⚠ WARNING

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

⚠ CAUTION

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

NOTICE

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

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

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING

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

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Disclaimer of Liability

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

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Preface

Purpose of 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 200iSP distributed I/O device.

Basic knowledge required

Working with this manual requires general knowledge of automation engineering. You also require knowledge of the *STEP 7* basic software and the ET 200iSP distributed I/O device.

Scope of this manual

Module	Order number	as of product version
Digital electronic module 8 F-DI Ex NA-MUR	6ES7138-7FN00-0AB0	01
Digital electronic module 4 F-DO Ex 17,4V/ 40mA; PP-switching	6ES7138-7FD00-0AB0	01
Analog electronic module 4 F-AI Ex HART	6ES7138-7FA00-0AB0	01

What's new compared to the previous version

These operating instructions are the first edition.

Approvals

Refer to chapter "Standards and Approvals (Page 51)".

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

- Safety class SIL3 (Safety Integrity Level) according to IEC 61508:2010
- Performance Level (PL) e and Category 4 according to ISO 13849-1:2015 or EN ISO 13849-1:2015

CE approvals

Refer to chapter "Standards and Approvals (Page 51)".

C-Tick-Mark for Australia

Refer to chapter "Standards and Approvals (Page 51)".

Standards

Refer to chapter "Standards and Approvals (Page 51)".

Position in the IT environment

Depending on the use case, you will also require the additional documentation listed below for working with fail-safe modules.

This manual contains corresponding cross-references to additional documentation.

Documentation	Brief description of relevant contents
Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789)	Describes the hardware of the ET 200iSP (such as installation, mounting and wiring of the ET 200iSP distributed I/O device)
Operating Instructions SIMATIC S7-300 CPU-31xC and CPU 31x: Hardware and Installation (http://support.automation.siemens.com/WW/view/en/13008499)	Describes the configuration, installation, wiring, addressing, and commissioning of S7-300 systems
Manual Automation Systems Principles of Explosion Protection (http://support.automation.siemens.com/WW/view/en/12521844)	Describes the basic principles of explosion protection
System description Safety Engineering in SIMATIC S7 (http://support.automation.siemens.com/WW/view/en/12490443)	• Provides an overview of the use, configuration and functionality of S7 Distributed Safety and S7 F/FH fail-safe systems. • Contains a summary of detailed technical information relating to fail-safe technology in S7-300 and S7-400 systems • Includes information on the calculation of monitoring and response times of S7 Distributed Safety and S7 F/FH fail-safe systems
for integration in the S7 F/FH fail-safe system	• The manual S7 F/FH Systems - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/2201072) describes the tasks that must be performed to set up and commission a fail-safe system S7 F/FH F.
	• The Automation System S7-400, M7-400 Hardware and Installation (http://support.automation.siemens.com/WW/view/en/19537233) installation manual describes the installation and wiring of S7-400 systems. • The SIMATIC S7-400H Fault-Tolerant Systems (http://support.automation.siemens.com/WW/view/en/1186523) system manual describes the CPU 41x-H central processing units and the tasks required to set up and commission an S7-400H fault-tolerant system. • The CFC for SIMATIC S7 (http://support.automation.siemens.com/WW/view/en/2201072) manual / online help provides a description of programming with CFC.

Documentation	Brief description of relevant contents
For integration in the F-system S7 Distributed Safety	The manual / online help S7 Distributed Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/22099875) describes: • the configuration of fail-safe CPU and I/O • how to program a fail-safe CPU in F-FBD or F-LAD
	Documentation required, depending on the F-CPU used: • The SIMATIC S7-300 CPU-31xC and CPU 31x: Hardware and Installation (http://support.automation.siemens.com/WW/view/en/13008499) operating Instructions describe the installation and wiring of S7-300 systems. • The S7-300 CPU 31xC and CPU 31x: Technical Data (http://support.automation.siemens.com/WW/view/en/36305149) manual describes the CPUs 315-2 DP and PN/DP, the CPU 317-2 DP and PN/DP and the CPU 319-3 PN/DP. • The Automation System S7-400 Hardware and Installation (http://support.automation.siemens.com/WW/view/en/1117849) installation manual describes the installation and wiring of S7-400 systems. • The S7-400 Automation System CPU Specifications (http://support.automation.siemens.com/WW/view/en/14016796) reference manual describes the CPU 416-2 and die CPU 416-3 PN/DP. • The ET 200S IM151 /CPU Interface Module (http://support.automation.siemens.com/WW/view/en/29863629) manual describes the IM 151-7 CPU. • Every applicable F-CPU has its own Product Information. The Product Information describes only the deviations from the corresponding standard CPUs.
STEP 7 manuals	• The Configuring Hardware and Communication Connections with STEP 7 (http://support.automation.siemens.com/WW/view/en/18652631) manual describes how to use the corresponding standard tools of *STEP 7*. • The System and Standard Functions for S7-300/400 (http://support.automation.siemens.com/WW/view/en/1214574) reference manual describes access / diagnostics functions of the distributed I/O.
Online help for *STEP 7*	• Describes the operation of *STEP 7* standard tools • Contains information about how to configure and assign parameters to modules and intelligent slaves • Contains a description of the programming languages FBD and LAD
PCS 7 manuals	• Describe the handling of the *PCS 7* control system (required if fail-safe I/O are implemented in a master control system)

The entire SIMATIC S7 documentation is available on CD-ROM and the Internet (http://www.siemens.com/simatic-tech-doku-portal).

Guide

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

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

- Installation and use
- Configuring and parameter assignment
- Addressing, installation and wiring
- Evaluating diagnostics data
- Technical specifications
- Order numbers

Conventions

The terms "safety technology" and "fail-safe technology" are used synonymously in this manual. The same applies to the use of the terms "fail-safe" and "F-". "F-module is a synonym for "fail-safe module".

"*S7 Distributed Safety*" and "*S7 F Systems*" in italic letters denote optional packages for the two fail-safe systems "S7 Distributed Safety" and "S7 F/FH Systems".

Recycling and disposal

Thanks to the fact that it is low in contaminants, this ET 200iSP distributed I/O device is recyclable. Contact a company which is certified for the disposal of electronic scrap for environment-friendly disposal and recycling of your old device.

Additional support

Your local Siemens representative will be pleased to provide answers to any open issue relating to the use of products described in this manual:

You will find information on who to contact on the Web (http://www.siemens.com/automation/partner).

A guide to the technical documentation for the various SIMATIC products and systems is available on the Web (http://www.siemens.com/simatic-tech-doku-portal).

You will find the online catalog and online ordering system on the Web (http://mall.automation.siemens.com).

Training centers

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

You will find more information on the Web (http://www.sitrain.com).

H/F Competence Center

The H/F Competence Center in Nuremberg offers special workshops on *SIMATIC S7* fail-safe and fault-tolerant automation systems. The H/F Competence Center also provides support in terms of on-site engineering, commissioning, and troubleshooting.

For questions about workshops, etc., contact: hf-cc.aud@siemens.com

Technical Support

To contact Technical Support for all Industry Automation products, use the Support Request Web form (http://www.siemens.com/automation/support-request).

You can find additional information about our Technical Support on the Web (http://www.siemens.com/automation/service).

Service & Support on the Internet

In addition to our documentation, we also offer a comprehensive technical knowledge base in the Internet (http://www.siemens.com/automation/service&support).

There you will find:

- the Newsletter which provides the latest information about your products
- The right documents; using our Service & Support search functions
- A forum where users and experts from all over the world exchange ideas
- Your local contact partner for Industry Automation products in our Contact Partners database
- Information about on-site service, repairs, spare parts, and much more is available under "Repairs, spare parts, and consulting".

Important information concerning the safe operation of your plant

Note

Plants with safety-related characteristics are subject to special requirements for operational safety for which the operator is responsible. The supplier also undertakes to conform to special measures for product monitoring. Siemens publishes a special newsletter to keep plant operators informed about product developments and properties which may form important issues in terms of operational safety. You should subscribe to the corresponding newsletter in order to obtain the latest information and to allow you to modify your plant accordingly. Please go to the Internet (http://www.siemens.com/automation/service&support) and register for the following newsletters:

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

Activate the "News" check box to subscribe to the corresponding newsletter.

Table of contents

Product Overview

1

1.1 Introduction

Overview

This chapter provides information about the following topics:

- ET 200iSP distributed I/O device with fail-safe modules and its place in SIMATIC S7 fail-safe automation systems
- Components comprising the ET 200iSP distributed I/O device with fail-safe modules
- The steps you must perform, ranging from selection of the F-modules to commissioning of ET 200iSP on PROFIBUS RS 485-IS.

1.2 ET 200iSP 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 200iSP distributed I/O device

The ET 200iSP distributed I/O device is a DP slave device on the PROFIBUS RS 485-IS, which can include fail-safe modules as well as standard ET 200iSP modules.

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

Fail-safe modules

The major difference between fail-safe modules and standard ET 200iSP 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 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 safety-related shutdown procedures with short-circuit and cross-circuit protection up to the actuator.

Note

The Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789) is required for application planning, installation, wiring, commissioning and diagnostics, maintenance, and general technical specifications of the fail-safe modules.

1.3 Using fail-safe ET 200iSP modules

Possible uses of ET 200iSP with fail-safe modules

The use of ET 200iSP with fail-safe modules allows conventional configurations in safety engineering to be replaced with PROFIBUS-DP 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 200iSP modules can be used:

- In the S7 Distributed Safety F-system with the *S7 Distributed Safety* optional package V5.4 or higher
- In the S7 F/FH Systems F-system with the *S7 F Systems* optional package version V6.0 or higher and the *S7 F Systems* F-library Lib V1_3
- To connect ET 200iSP fail-safe modules to PROFIBUS DP with Distributed Safety or S7 F/FH Systems, you need:
  - ET 200iSP fail-safe modules
  - Interface module IM152-1 (6ES7152-1AA00-0AB0) firmware version V2.0.8
  - RS485-IS coupler
  - F-CPU
  - *STEP 7* V5.3 SP3 or higher
  - *S7 Distributed Safety*V5.4 or higher with *S7 F Configuration Pack* V5.5 Service pack 8 or higher
    The *F Configuration Pack* can be obtained on the Internet (http://support.automation.siemens.com/WW/view/en/15208817).
  - *S7 F Systems* V6.0 or higher and *S7 F Systems* F-library Lib V1_3
- When used with the HART function:
  - SIMATIC PDM
  - EDD (Electronic Device Description) for ET 200iSP Version 1.1.14 or higher

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

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

- ET 200iSP distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789)
- Safety Engineering in SIMATIC S7 (http://support.automation.siemens.com/WW/view/en/12490443)
- S7 Distributed Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/22099875) or S7 F/FH Systems - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/2201072)

Further information on the PROFIBUS RS 485-IS can be found on the Internet (http://www.profibus.com).

F-System with ET 200iSP

The following figure presents an example of a configuration for an S7 Distributed Safety F-system with ET 200iSP on PROFIBUS DP. Additional Information about application planning, see ET 200iSP distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789) operating instructions.

The fail-safe DP master exchanges safety-related and non-safety-related data with the fail-safe and standard ET 200iSP modules.

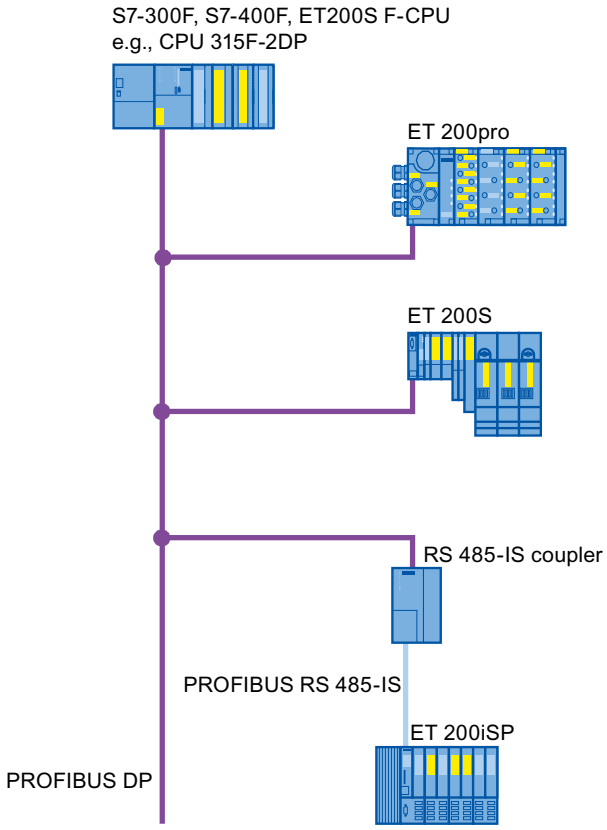


Figure 1-1 S7 Distributed Safety fail-safe automation system (example configuration)

Availability of fail-safe electronic modules

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

- Digital electronic module 8 F-DI Ex NAMUR
- Digital electronic module 4 F-DO Ex 17,4V/40mA; PP-switching
- Analog electronic module 4 F-AI Ex HART

You use the standard ET 200iSP terminal modules for the fail-safe electronic modules. The interface module is the IM 152 (firmware Version 2.0 or higher), same as for the standard ET 200iSP.

Use in safety mode only

Fail-safe modules can only be used in safety mode. They cannot be used in standard mode. Here, safety mode and standard mode refer to the respective F-I/O operating modes in which safety-related communication using safety message frames is possible and not possible. The intrinsic safety property of the modules is not affected by this.

The combination of fail-safe modules and standard modules within an ET 200iSP is possible.

Use in safety mode with parameter setting "Keep last valid value" at digital output modules

The 4 F-DO Ex 17,4V/40mA electronic module can only be used in accordance with standards EN54-2/-4 or NFPA72 with the parameter setting "Keep last valid value".

Also refer to chapter "Response of the fail-safe output module with parameter setting "Keep last valid value" (Page 41)".

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:

Safety class in safety mode[1)]		
In accordance with IEC 61508	In accordance with EN ISO 13849 -1:	
SIL2	Category 3	Performance Level (PL) d
SIL3	Category 3	Performance Level (PL) e
SIL3	Category 4	Performance Level (PL) e

1) Valid only if "Keep last valid value" was not assigned for digital output modules.

1.4 Guide for commissioning ET 200iSP with fail-safe modules

Introduction

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

Requirements

WARNING

Hazardous area Zone 1 and Zone 2: You may open the enclosure of the ET 200iSP briefly for the permitted maintenance work.

Hazardous area Zone 21 and Zone 22: You must not open the enclosure of the ET 200iSP in areas with combustible dust.

Observe Chapter "Maintenance" in the Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789) for the fail-safe modules.

Safety information

Note

The national regulations have to be observed during commissioning.

The directives in accordance with EN 60079-17 have to be observed at function checks. This standard contains the regulations of the international standard IEC 60079-17.

Carrying out tests

Note

You have to ensure the safety of your system. Before carrying out the final commissioning of a system you should carry out a complete function test and the required safety tests.

Include foreseeable possible errors when planning the tests. This is done to avoid endangering persons or systems during operation.

Requirements

Observe Chapter "Commissioning and diagnostics" in the Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789).

Sequence of steps from selecting the F-modules to commissioning the ET 200iSP

Table 1-1 Sequence of steps from selecting the F-modules to commissioning the ET 200iSP

Step	Procedure	See ...
1.	Select F-modules for ET 200iSP configuration	Chapter "Configuration and parameter assignment (Page 21)"
2.	Configure and assign parameters to the F-modules	Chapter "Configuration and parameter assignment (Page 21)" and Chapter "Digital electronic modules (Page 57)" or "Analog electronic modules (Page 103)"
3.	Set PROFIsafe addresses on F-modules	Chapter "Addressing and installation (Page 27) "
4.	Mount the ET 200iSP	Chapter "Addressing and installation (Page 27)"
5.	Wire the ET 200iSP	Chapter "Wiring and fitting modules (Page 33)"

Step	Procedure	See ...
6.	Commission ET 200iSP on PROFIBUS-DP	Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789)
7.	Run diagnostics on ET 200iSP if commissioning failed	Chapter "Fault reactions and diagnostics (Page 39)", Chapter "Digital electronic modules (Page 57)" or "Analog electronic modules (Page 103)" and Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789)

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.

Configuration and parameter assignment

2

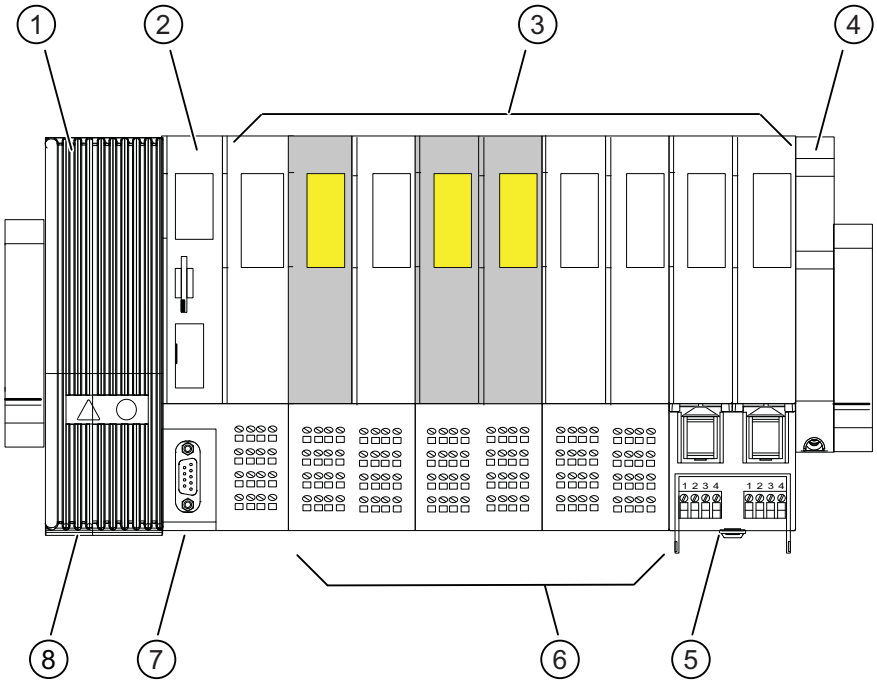
2.1 Configuration of ET 200iSP with fail-safe modules

Introduction

Every ET 200iSP consists of a power supply, an interface module, and a maximum of 32 electronic modules (e.g., digital electronic modules). The ET 200iSP distributed I/O devices support configurations with standard and fail-safe modules. Take the maximum current consumption into consideration. This chapter presents an example configuration.

Configuration example of ET 200iSP with fail-safe modules

The following figure shows a configuration example using standard and fail-safe modules in an ET 200iSP.



① Power supply PS
② Interface module IM 152
③ Fail-safe and standard modules
④ Termination module
⑤ Terminal module TM-RM/RM
⑥ Terminal module TM-EM/EM
⑦ Terminal module TM-IM/EM
⑧ Terminal module TM-PS-A/TM-PS-A UC

Figure 2-1 ET 200iSP configuration example with fail-safe modules

Further information about the configuration of an ET 200iSP

You can find more information on the configuration of an ET 200iSP in the Operating Instructions "ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789)".

2.2 Assigning of the modules of an ET 200iSP with respect to each other

Assigning fail-safe electronic modules to terminal modules

The table below provides

- an aid for selecting individual terminal modules and
- a slot assignment on the terminal modules.

Table 2-1 Terminal modules for F-electronic modules

Terminal module	TM-IM/EM 60S (screw-type terminals) TM-IM/EM 60C (spring-loaded terminals)		TM-EM/EM 60S (screw-type terminals) TM-EM/EM 60C (spring-loaded terminals)	
Order No. 6ES7193-	7AA00-0AA0 7AA10-0AA0		7CA00-0AA0 7CA10-0AA0	
Slot assignment	IM152-1	F-modules	F-modules	F-modules

Further terminal modules for standard operation are contained in the Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789).

2.3 Maximum number of connectable electronic modules/maximum configuration

Maximum configuration

Each ET 200iSP station consists of a maximum of 32 electronic modules. These include digital and analog standard and fail-safe electronic modules.

Width of the ET 200iSP

The maximum configuration width of the ET 200iSP amounts to (power supply + interface module + 32 electronic modules + termination module):

- 1.095 m (with a power supply and an IM 152)
- 1.185 m (with two power supply units and two IM 152 units)

Address space

The interface module supports a maximum of 244 input bytes and 244 output bytes. There are DP masters that do not handle the complete address space.

Limit of the connectable electronic module

The actual number of electronic modules can be limited by

- The operational current output of the Power Supply PS
- The used input and output address ranges of the fail-safe modules (for example 12 bytes input range for 4 F-AI Ex HART)

Operational current consumption of the F-electronic modules

You have to take the maximum operational current output of the Power Supply PS into account for the ET 200iSP. The relevant limit must not be exceeded. Check the **operational current consumption** of your ET 200iSP configuration with the **spreadsheet**! (See Chapter "Maximum number of connectable electronic modules" in the Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789).)

Note

ET 200iSP always conforms with safety-relevant current consumption limits (limit value < 15 A, see EC Prototype Test Certification KEMA 04ATEX2242). With all configuration variants, the number of modules is restricted in this regard only by the operational current output or the maximum number of modules (32).

Table 2-2 Operational current consumption of the F-electronic modules

Fail-safe electronic module	Operational current see...	Calculation see...
8 F-DI Ex NAMUR	Chapter "Technical specifications of electronic module 8 F-DI Ex NAMUR (Page 81)"	Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789)
4 F-DO Ex 17,4V/40mA	Chapter "Technical specifications of electronic module 4 F-DO Ex 17.4V/40mA (Page 98)"	
4 F-AI Ex HART	Chapter "Technical specifications of electronic module 4 F-AI Ex HART (Page 137)"	

Length of the used input and output address ranges

The maximum number of electronic modules of an ET 200iSP also depends on the length of the used input and output address ranges of the electronic modules. The maximum address area amounts to 244 bytes for inputs, and 244 bytes for outputs. When checking your ET 200iSP configuration you have to take the following extended input and output address ranges of the fail-safe electronic modules compared to the standard electronic modules into account!

Table 2-3 Extended input and output address ranges of the fail-safe electronic modules

Fail-safe electronic module	Input bytes	Output bytes
8 F-DI Ex NAMUR	6 bytes	4 bytes
4 F-DO Ex 17,4V/40mA	5 bytes	5 bytes
4 F-AI Ex HART	12 bytes	4 bytes

2.4 Configuration and parameter assignment

Prerequisite

The requirements from Chapter "Using fail-safe ET 200iSP modules (Page 14)" apply to configuring and assigning parameters of ET 200iSP fail-safe modules.

Configuring

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

Parameter assignment for module properties

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

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.

2.5 Firmware update

When should a firmware update be carried out?

After compatible enhancement of functions, you should update the fail-safe electronic modules to the latest firmware version:

Where do I obtain the latest firmware?

The latest firmware is available on the Internet (http://support.automation.siemens.com/WW/view/en/25536344/133100). There you will also find a description of the update procedure:

Requirements

WARNING

Check of the firmware version for F-validity

When using a new firmware version, you must check whether the utilized firmware version is approved for use in the respective module.

The appendixes for the certificates for S7 Distributed Safety and S7 F/FH Systems specify which firmware version is approved.

- *STEP 7* V5.4 SP3 or higher
- The firmware update can only be performed when the F-CPU is in STOP mode.

You can find additional information in the *STEP 7* online help.

Updating firmware

During a firmware update the SF LED of the module flashes at 0.5 Hz as long as no other module fault is pending.

Note

Display the firmware version of the module to verify that the firmware update was performed on the right module.

Note

If the firmware update was aborted, the previous firmware is activated on the module.

Wait until the module is ready to operate again. If the no longer becomes ready to operate, proceed as follows:

- Switch the power supply of the F-CPU OFF/ON.
- Remove and insert the module.

Then you can perform the firmware update again.

Contact SIMATIC Customer Support if necessary.

Labeling firmware

After the firmware update, you must label the firmware version on the module.

The firmware version must be visible below the label.

2.6 Removing and inserting fail-safe electronic modules during operation (hot swapping)

Properties

The ET 200iSP distributed I/O device supports the removing and insertion of an electronic module (1 gap) during operation (RUN mode). See also the Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789). The information given there also applies for the fail-safe electronic modules.

Addressing 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
8 F-DI Ex NAMUR	x + 0 to x + 5	x + 0 to x + 3
4 F-DO Ex 17,4V/40mA	x + 0 to x + 4	x + 0 to x + 4
4 F-AI Ex HART	x + 0 to x + 11	x + 0 to x + 3
x = Module start address		

Addresses occupied by user data

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

Table 3-2 Addresses occupied by user data

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
8 F-DI Ex NAMUR (inputs):								
x + 0	Channel 7	Channel 6	Channel 5	Channel 4	Channel 3	Channel 2	Channel 1	Channel 0
4 F-DO Ex 17,4V/40mA (outputs):								
x + 0	—	—	—	—	Channel 3	Channel 2	Channel 1	Channel 0
4 F-AI Ex HART (inputs):								
x + 0, x + 1	Channel 0							
x + 2, x + 3	Channel 1							
x + 4, x + 5	Channel 2							
x + 6, x + 7	Channel 3							
x = Module start address								

WARNING

You may only access the addresses occupied by user 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 lower-order channel of the channels that are grouped as a result of the 1oo2 sensor evaluation can be accessed in the safety program.

Additional information

For detailed information about the F-I/O access, refer to the Manual S7 Distributed Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/22099875) or S7 F/FH Systems - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/2201072)

3.2 Assigning the PROFIsafe address

PROFIsafe address

Every fail-safe module has its 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 the object properties of the fail-safe modules in the "DIP switch setting" parameter. You must take this PROFIsafe address from the parameter assignment dialog box and set it on the respective fail-safe module using the address switch.

You can edit the configured F_destination_address. 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 200iSP 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 *STEP 7*.
- **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[1] and station[2] (system-wide). You can assign up to 1,022 different PROFIsafe destination addresses.
  Exception: The F-I/O 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 F-I/O, i.e., the PROFIsafe destination address and thus also the address switch setting on the F-I/O I only[3] has to be unique within the Ethernet subnet, including all subordinate PROFIBUS subnets and station-wide[2] (system-wide). You can assign up to 1,022 different PROFIsafe destination addresses.
  Exception: The F-I/O 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.

[1] A network consists of one or more subnets. "Network-wide" = across subnet boundaries.

[2] "Station-wide" means for one station in *STEP 7* (for example, an S7-300 station or I-slave)

[3] Beyond Ethernet subnet boundaries if cyclic PROFINET IO communication (RT communication) is excluded.

3.3 Installing

Safety information

DANGER

Danger to life through incorrect installation

During mounting, observe the guidelines according to EN 60079-14. The conditions for the electrical parameters in the standard apply to simple electrical circuits. Refer to chapter "Configuration Options in Zones" in the operating instructionsET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789).

⚠ WARNING

Danger from sparks that are capable of ignition or unacceptable surface temperatures. Never install when an explosive atmosphere is present!

The following actions/work steps are prohibited during operation of the ET 200iSP while voltage is applied to the terminal module TM-PS-A/ TM-PS-A UC:

- Disconnection of the supply voltage at the terminal module TM-PS-A/ TM-PS-A UC.
- Loosening of the securing screw at the termination module.
- Dismantling of the termination module as well as all changes affecting the configuration of the terminal modules.

Requirements

For the selection of the enclosure and the installation of the fail-safe electronic module, observe the "Installation" section in the ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789) operating instructions.

Installing the fail-safe modules

Fail-safe electronic modules are part of the ET 200iSP range of modules. They are mounted using the same procedure as for all standard modules in an ET 200iSP.

Detailed information about aspects of the installation is available in the ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789) operating instructions.

Please also note the section "Assigning the PROFIsafe address (Page 28)" regarding the F-address switch on the fail-safe electronic modules.

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.

Overview

This chapter covers the special features involved in wiring and fitting fail-safe modules. Relevant information that applies equally to ET 200iSP with fail-safe modules and ET 200iSP with standard modules can be found in the Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789).

4.2 Power supply for the fail-safe modules

Power Supply PS

You use the same Power Supply PS to operate the ET 200iSP with fail-safe modules as for standard operation. These are:

- Power Supply PS DC24V product version 3 or higher
- Power Supply PS AC120/230V

Reference

Detailed information about the Power Supply PS for ET 200iSP is available in Chapter "Power Supply" in Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789).

Power supply requirements for compliance with NAMUR Recommendation

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 (http://mall.automation.siemens.com).

Of course, these requirements also apply to other power supply units/power packs not produced in the ET 200iSP mounting technology.

4.3 Wiring Fail-Safe Modules

DANGER

Danger to life through incorrect installation

When laying cables and performing wiring, observe the installation and erection instructions in accordance with EN 60079-14 as well as country-specific rules.

DANGER

Danger to life through incorrect installation

The interconnection of an intrinsically safe sensor, actuator, or HART field device with the input/output of an electronic module must result in an intrinsically safe circuit! The following therefore applies:

The resulting safety-related values must be checked when selecting the sensor, actuator, or HART field device to be interconnected with the electronic module!

The inductance and capacitance of the cable must be taken into account! Refer to chapter "Configuration Options in Zones" in the operating instructionsET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789).

WARNING

Risk to intrinsic safety

If an electronic module is interchanged by mistake or the terminals are connected incorrectly to the sensor, actuator, or HART field device, the intrinsic safety is endangered:

Connect only Ex i circuits to the intrinsically safe inputs and outputs of the electronic modules!

Check the wiring between the electronic modules and sensors, actuators, and HART field devices!

Requirements

For the fail-safe electronic module, note the "Wiring" section and the information about the equipotential bonding EB (according to EN 60079-14) in the operating instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789).

Wiring as for ET 200iSP

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

Refer to the ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789) operating instructions for detailed information on wiring and fitting the modules and IM 152.

⚠ WARNING

Danger of short-circuiting

When assigning signals of the 8 F-DI Ex NAMUR module, ensure that only signals whose short-circuit does not involve grave safety risks are routed within a cable or sheathed cable.

Supported mounting rails

Information on the mounting rails that are used and on their use can be found in the ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789) operating instructions.

Note

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

Terminal assignment of the TMs

The terminal assignment of the terminal modules depends on which electronic module is inserted.

4.4 Inserting and Removing Fail-Safe Modules

Inserting and removing electronic modules

In ET 200iSP, the same procedure is used to insert and remove both fail-safe modules and standard modules on terminal modules.

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 200iSP.

Note

Note that replacing a fail-safe modules in ET 200iSP during operation generates a communication error on the F-CPU.

You must acknowledge the communication error in your safety program (for information about F-system behavior after communication errors, fail-safe value output, and user acknowledgment, refer to the Manual S7 Distributed Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/22099875) or). S7 F/FH Systems - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/2201072)).

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

Remember to set the PROFIsafe address

When replacing F-modules, ensure that the address switch (DIP switch) setting on the module side is identical with that of the replaced F-module.

See also

Response of the fail-safe output module with parameter setting "Keep last valid value" (Page 41)

4.5 Requirements for Sensors and Actuators

General requirements for sensors and actuators

Note the following important warning regarding safety-related use of sensors and actuators:

WARNING

Note 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 20 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 the respective safety class, suitably qualified sensors and actuators are necessary.

Additional sensor requirements

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

Additional requirements for sensors and NAMUR sensors

WARNING

A "0" value is output to the F-CPU when faults are detected at the fail-safe input modules. You must therefore ensure that the "0" state of the sensors triggers a safe response in the safety program.

Example: The safety program of an EMERGENCY-OFF sensor must cause the actuator involved to shut down when the "0" state occurs (EMERGENCY-OFF button pressed).

Duration requirements for sensor signals

WARNING

Observe the following requirements for sensor signals:

- In order to guarantee accurate detection of sensor signals by the 8 F-DI Ex NAMUR 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 8 F-DI Ex NAMUR module

The following table lists the minimum duration of the sensor signals for the 8 F-DI Ex NAMUR module. It depends on the input state, the assigned input delay, the parameters of the sensor

supply tests, and the assigned behavior at discrepancy for 1oo2 evaluation. The maximum permissible switching frequency of the sensor signals results from the minimum durations.

Table 4-1 Minimum duration of the sensor signals for the EM 8 F-DI Ex NAMUR

Sensor supply test parameters	Deactivated			Activated
Assigned input delay	1 ms	3 ms	15 ms	Not relevant
Minimum duration of the "0" signal[1)]	1.4 ms	3.5 ms	16 ms	Time for sensor test + ramp-up time of the sensor after sensor test
Minimum duration of the "1" signal	15 ms	17 ms	29 ms	Time for sensor test + ramp-up time of the sensor after sensor test + 14 ms
Maximum permissible switching frequency of the sensor signals	33 Hz	29 Hz	17 Hz	1 / [2 x (Time for sensor test + ramp-up time of the sensor after sensor test + 14 ms)]

1) With assigned behavior at discrepancy "Provide last valid value", the minimum duration of the "0" signal increases to the value for the "1" signal.
Example: Behavior at discrepancy "Provide last valid value", sensor supply test deactivated, input delay 3 ms: Minimum duration of the "0" signal = 17 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 System Description Safety Engineering in SIMATIC S7 (http://support.automation.siemens.com/WW/view/en/12490443).

Additional requirements for actuators

The fail-safe output modules test the outputs at regular intervals. The F-module briefly switches off the activated outputs and, if necessary, switches on the deactivated outputs. You can assign the maximum duration of the test pulses (dark and light period).

High-speed actuators may briefly drop out or be activated during this test. If your process does not tolerate this, set the pulse duration of the light or dark test correspondingly or use actuators that have sufficient lag.

⚠ WARNING

If the actuators switch voltages greater than 24 VDC (for example, 230 VDC), safe electrical isolation must be ensured between the outputs of a fail-safe output module and the components carrying a higher voltage (in accordance with EN 60664-1).

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

Technical specifications of sensors and actuators

Refer to the F-module chapters for technical specifications to assist you in selecting sensors and actuators.

Fault reactions and diagnostics 5

5.1 Fault reactions

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.

For analog fail-safe modules see Chapter "Analog value representation (Page 112)".

Fault reactions 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 faults or channel faults are detected (e.g., wire break, short-circuit, or discrepancy error)

Detected faults are entered in the diagnostic buffer of the fail-safe module and the diagnostic buffer the F-CPU and communicated 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 involving channels that have been set to "deactivated" do not trigger any diagnostic reaction or error handling, even when this channel is affected indirectly by a channel pair 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

When **fail-safe input modules** are passivated, the F-system provides fail-safe values for the user program instead of the process values set at the fail-safe inputs:

- In *S7 Distributed Safety* F-systems: Fail-safe value "0" is always output for fail-safe digital input and analog input modules.
- In *S7 F/FH Systems* F-systems: Fail-safe value "0" is always output for fail-safe digital input modules. You can assign the fail-safe value in the safety program (in the F-channel driver) for fail-safe analog input modules.

When **fail-safe output modules** are passivated, 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.

Fail-safe values are used only for the affected channel or for all channels of the relevant fail-safe module, depending on the configuration and the type of fault (F-I/O fault, channel fault, or communication error).

For the behavior of the 4 F-DO Ex 17,4V/40mA as a function of the "Behavior at CPU stop" parameter, see Chapter "Response of the fail-safe output module with parameter setting "Keep last valid value" (Page 41)".

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. For information about this, refer to the module chapters in the tables "Causes of Faults and Corrective Measures".

After reintegration, the following occurs:

- For a fail-safe input module, the process values pending at the fail-safe inputs are made available to the safety program again
- For a fail-safe output module, the output values made available in the safety program are again transferred to the fail-safe outputs

Additional information on passivation and reintegration

For additional information about passivation and reintegration of F-I/O, refer to Manual S7 Distributed Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/22099875) or S7 F/FH Systems - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/2201072).

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 digital electronic module 8 F-DI Ex NAMUR (Page 57)

Properties of digital electronic module 4 F-DO Ex 17.4V/40mA (Page 84)

Properties of analog electronic module 4 F-AI Ex HART (Page 103)

5.2 Response of the fail-safe output module with parameter setting "Keep last valid value"

This chapter applies to the EM 4 F-DO Ex 17,4V/40mA and its "Behavior at CPU STOP" parameter.

Response of the 4 F-DO Ex 17,4V/40mA as a function of the "Behavior at CPU STOP" parameter

Depending on the "Behavior at CPU STOP" parameter, the 4 F-DO Ex 17,4V/40mA responds in conformity to the following standards:

"Behavior at CPU STOP" parameter assignment	
Switch to fail-safe value "0"	**Keep last valid value**
In conformity with all the standards specified in the certificates. The certificates are available on the Internet at: • Certificate for S7 Distributed Safety (http://support.automation.siemens.com/WW/view/en/11669702/134200) • Certificate for S7 F/FH Systems (http://support.automation.siemens.com/WW/view/en/13711209/134200)	Only in conformity with: • NFPA72 • EN54-2 /-4

Applications

Typical applications for safety mode with parameter setting "Keep last valid value" are:

- Ventilation systems
- Smoke flaps

Fault reactions

Note

Consult the respective standards for installation.

Note

Only EN54-2 /-4 or NFPA72 will be met with parameter setting "Keep last valid value".

The last valid value will be retained in case of the following communication errors/interruptions:

- STOP of F-CPU (interruption of PROFIsafe communication)
- Interruption of PROFIsafe communication
  - in case of CRC errors
  - Interruption of PROFIBUS/PROFINET connection
  - Timeout of data frame monitoring
- Error in safety program of the F-CPU
- Error in PROFIsafe protocol

The current process value will be issued again once PROFIsafe communication resumes.

The safe state "0" will be assumed at the output of the digital output module in case of the following errors:

- Channel faults, always channel-level (independent of "Behavior after channel faults" parameter)
- Module faults

With a pending channel fault in connection with *S7 Distributed Safety*, the last valid value of all error-free channels will be retained after a STOP-RUN transition of the F-CPU until reintegration. You must correct the channel fault before reintegration is possible, if the "Behavior after channel faults" parameter is set to "Passivate the entire module".

5.3 Fault Diagnostics

Definition

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.

Diagnostic messages/displays are not safety critical

The diagnostic messages and displays are not safety critical and are therefore not implemented as safety-related functions. Consequently, the diagnostic messages and displays are not tested internally.

Diagnostic options for fail-safe modules in ET 200iSP

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

- LED display on the module front panel
- Diagnostic buffer entries of the fail-safe modules (slave diagnostics in accordance with IEC 61784-1:2003)
- Slave diagnostics in accordance with IEC 61784-1:2003

Non-assignable diagnostic functions

Fail-safe electronic modules provide non-assignable diagnostic functions. This means that the diagnostic functions are always activated, and are automatically made available by the fail-safe module in *STEP 7* and passed on to the F-CPU in the event of a fault.

Assignable diagnostic functions

You can assign (activate) certain diagnostic functions:

- For the 8 F-DI Ex NAMUR module: wire break detection and the chatter monitoring
- For the 4 F-DO Ex 17,4V/40mA module: short-circuit level, overload detection, and wire break detection
- For the 4 F-AI Ex HART module: wire-break detection, HART diagnostics, and HART warning

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

Diagnostics by LED Display

Every fail-safe electronic module 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. It goes dark when all faults have been eliminated and acknowledged.

The fail-safe electronic modules additionally have LEDs for

- Safety mode display (SAFE LED; green)
- Status display per channel (red LED); at inputs with HART functionality additionally green LED per channel

The channel LED and SF LED turn red as soon as a diagnostic function is triggered by the fail-safe module. The LEDs go dark when all faults have been eliminated.

The green channel LED lights up when HART operation is possible.

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

5.3.1 Slave diagnostics

Slave diagnostics

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

The general structure of the slave diagnostics is specified in the corresponding chapter of the Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789). The statements made there in the chapters "Station status 1 to 3", "Master PROFIBUS address", "Manufacturer identification", "Identifier-related diagnostics", and "Module status" also apply.

A description of channel-specific diagnostics for fail-safe modules is presented below.

Channel-specific diagnostics

In the ET 200iSP, there are three bytes available for channel-specific diagnostics, starting at Byte 25. The maximum number of channel-related diagnostics is limited to the maximum total length of the slave diagnostics of 96 bytes with the IM 152. The length of slave diagnostic data is determined by the number of current channel-specific diagnostics. If there are more channel-specific diagnostics than can be displayed in the slave diagnostics, Bit 7 (diagnostics overflow) is set in the Station status 3.

Channel-specific diagnostics for fail-safe modules are structured as follows.

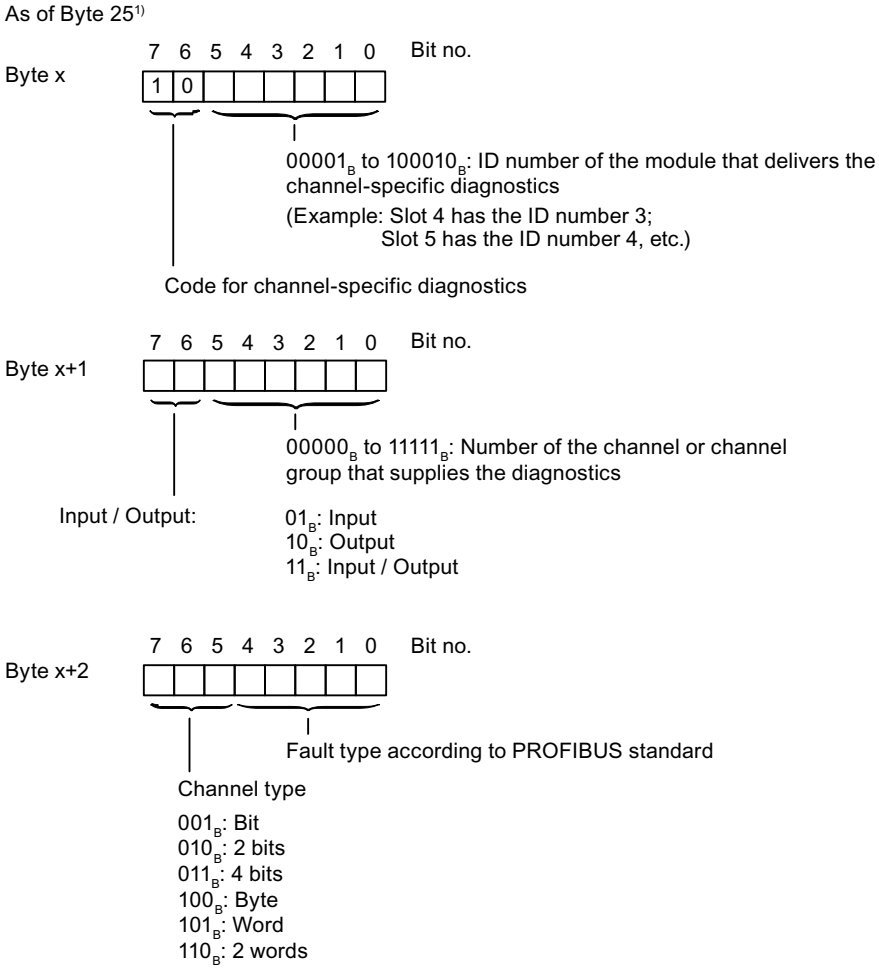


Figure 5-1 Structure of the channel-related diagnostics

Note

The module slot coding is contained in Byte 25, 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. Use the parameter RET_VAL of SFC 13 for this purpose.

Possible fault types of fail-safe modules

The table below lists the messages of the IM 152-1.

Table 5-1 Possible fault types of fail-safe modules

Fault type		Error text
1_D	1_H	Short-circuit
2_D	2_H	Undervoltage/HART: Analog output current specified
4_D	4_H	Overload/HART: Analog output current saturated
5_D	5_H	Overtemperature
6_D	6_H	Line break
7_D	7_H	Upper limit exceeded
8_D	8_H	Lower limit fallen below
9_D	9_H	Fault
16_D	10_H	Parameter assignment error
17_D	11_H	Sensor voltage or load voltage missing
19_D	13_H	HART communication error (HART diagnostics)
22_D	16_H	HART additional status available (HART warning)
25_D	19_H	Safety-related shutdown
26_D	$1A_H$	External fault
27_D	$1B_H$	HART configuration changed (HART warning)
28_D	$1C_H$	PROFIsafe communication error
29_D	$1D_H$	HART primary variable outside the limits (HART diagnostics)
30_D	$1E_H$	HART secondary variable outside the limits (HART diagnostics)

Response of fail-safe 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
- The SF LED of the corresponding fail-safe module extinguishes

Specific information about diagnostic functions

All module-specific diagnostic functions, possible causes of faults, and their corrective measures can be found in the chapters about the respective modules.

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

Reading out diagnostic functions

You can display the cause of a fault in the 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 Reference Manual System and Standard Functions for S7-300/400 (http://support.automation.siemens.com/WW/view/en/1214574)).

See also

Diagnostic functions of electronic module 8 F-DI Ex NAMUR (Page 76)

Diagnostic functions of electronic module 4 F-DO Ex 17.4V/40mA (Page 95)

Diagnostic functions of electronic module 4 F-AI Ex HART (Page 131)

5.3.2 Alarms of the fail-safe modules

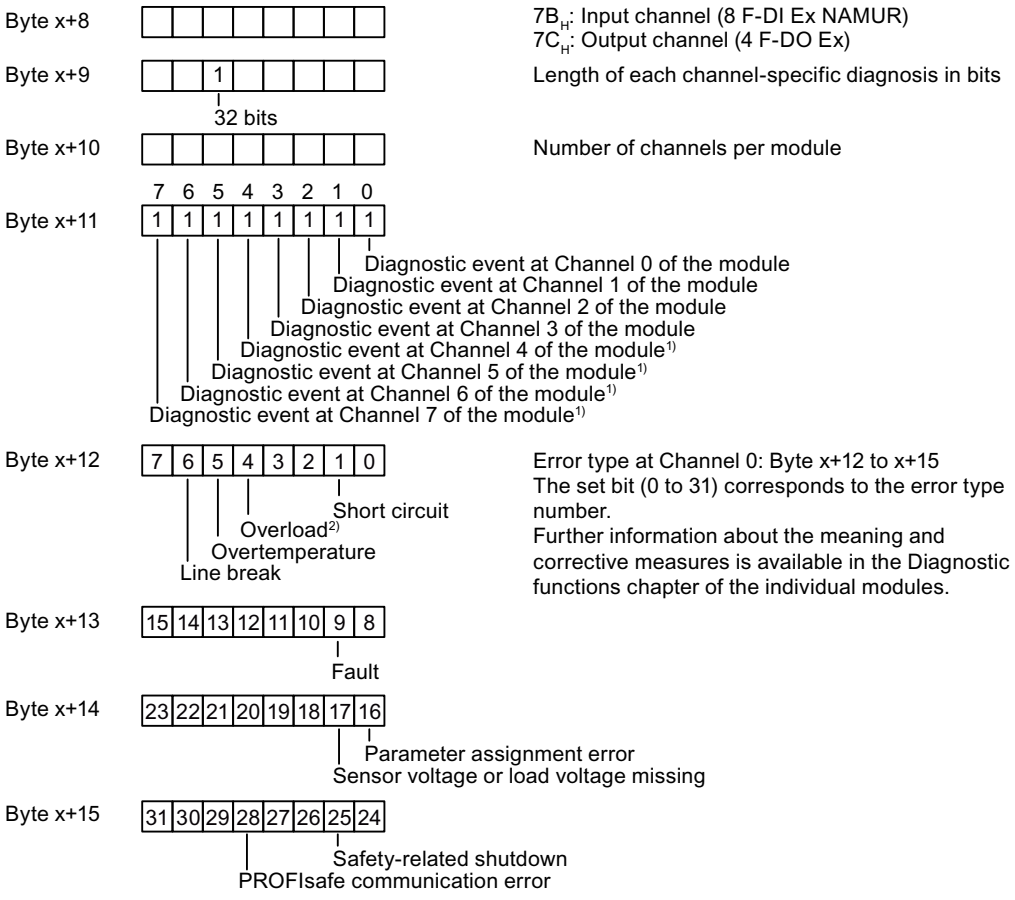
Alarms

The general structure of the alarm section of the slave diagnostics is specified in the corresponding chapter of the Operating Instructions ET 200iSP distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789).

The following section additionally describes the structure of the diagnostic interrupt of the fail-safe modules as of Byte x+8 and the SKF identifiers (*STEP 7*) of the fail-safe modules.

Diagnostic interrupt of the fail-safe modules 8 F-DI Ex NAMUR and 4 F-DO Ex 17,4V/40mA as of Byte x +8

The diagnostic interrupt is structured as follows for these fail-safe modules:



Byte x+16 to x+19	Error type at Channel 1: See Byte x+12 to x+15
Byte x+20 to x+23	Error type at Channel 2: See Byte x+12 to x+15
Byte x+24 to x+27	Error type at Channel 3: See Byte x+12 to x+15
Byte x+28 to x+31	Error type at Channel 4: See Byte x+12 to x+15[1)]
Byte x+32 to x+35	Error type at Channel 5: See Byte x+12 to x+15[1)]
Byte x+36 to x+39	Error type at Channel 6: See Byte x+12 to x+15[1)]
Byte x+40 to x+43	Error type at Channel 7: See Byte x+12 to x+15[1)]

1) Only valid for 8 F-DI Ex NAMUR
2) Only valid for 4 F-DO Ex

Figure 5-2 Structure, as of Byte x+8, for diagnostics interrupts 8 F-DI Ex NAMUR and 4 F-DO Ex 17,4V/40mA

Diagnostic interrupt of the fail-safe module 4 F-AI Ex HART as of Byte x+8

The diagnostic interrupt is structured as follows for this fail-safe module.

- As of Byte x+8:

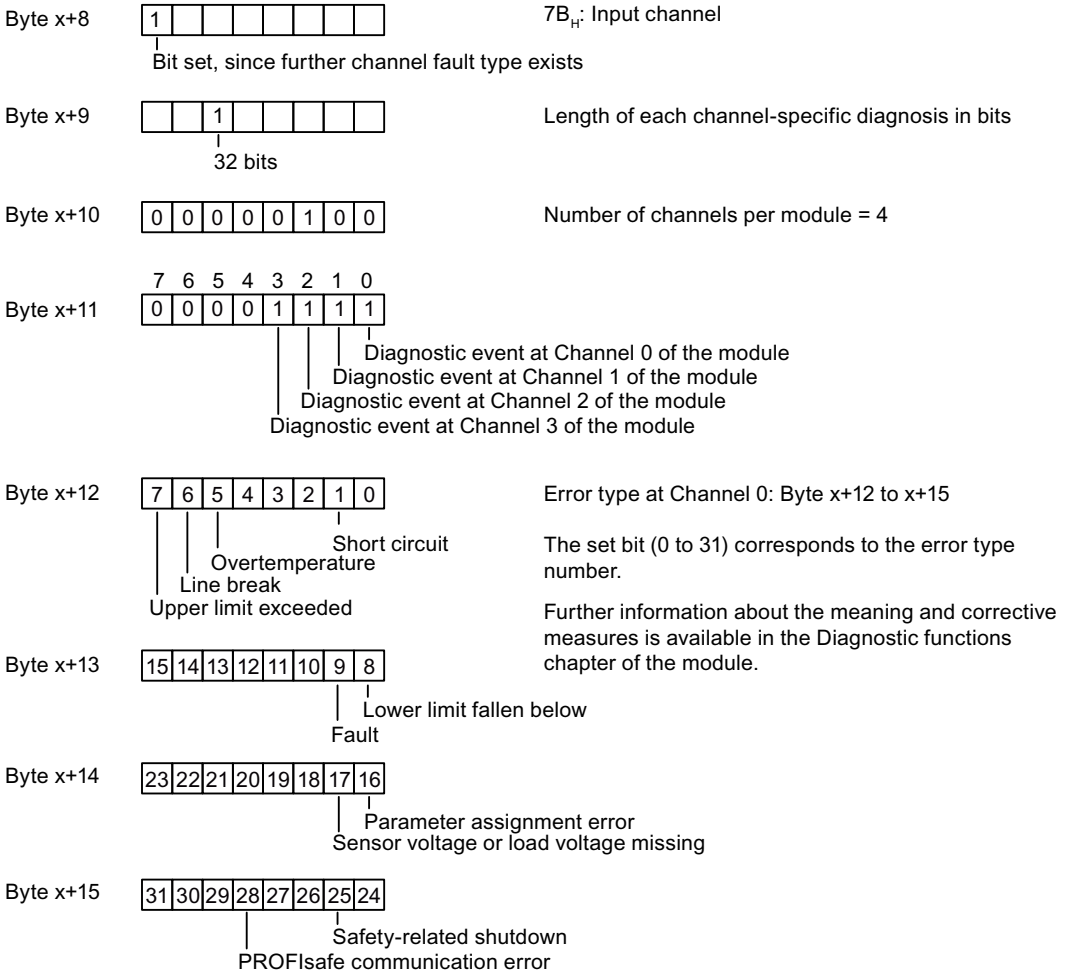


Figure 5-3 Structure as of Byte x+8 for diagnostic interrupt 4 F-AI Ex HART

- As of Byte x+28:

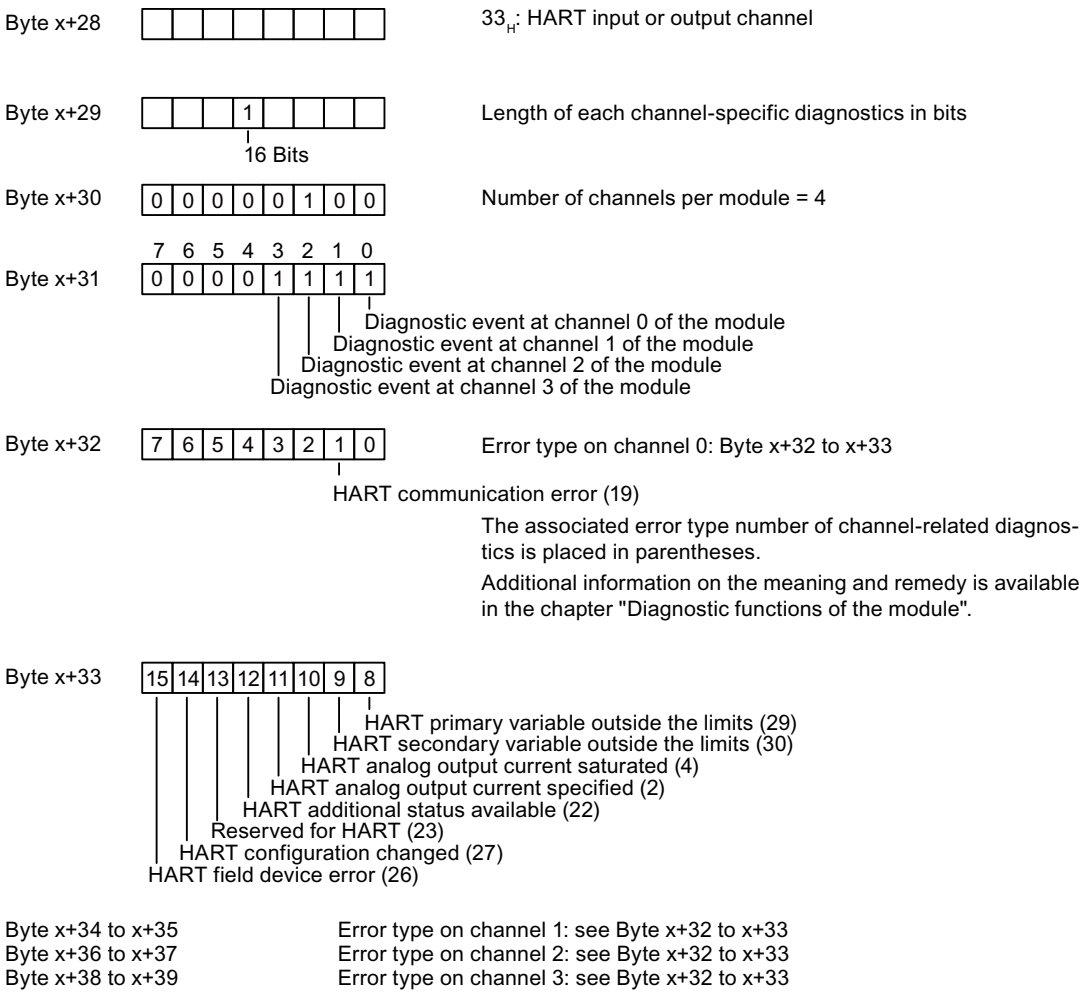


Figure 5-4 Structure as of Byte x+28 for diagnostic interrupt 4 F-AI Ex HART

Removal/insertion interrupt of the fail-safe modules

The following section supplements the corresponding chapter of Operating Instructions ET 200iSP distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789) with the SKF identifiers (*STEP 7*) of the fail-safe modules.

Table 5-2 SKF identifiers (*STEP 7*) of the fail-safe modules

Fail-safe electronic module	SKF identifier
8 F-DI Ex NAMUR	79 $F9_H$
4 F-DO Ex 17,4V/40mA	79 FC_H
4 F-AI Ex HART	79 FB_H

General technical specifications

6

6.1 Introduction

Definition

The general technical specifications include

- The standards and test values that the fail-safe modules comply with or fulfill when operated in an ET 200iSP
- The test criteria for fail-safe signal modules

6.2 Standards and Approvals

CE mark

The fail-safe modules of the ET 200iSP meet the requirements and protection objectives of the following EC directives.

- 2006/42/EC "Machinery directive"
- 2014/30/EU "Electromagnetic compatibility" (EMC directive)
- 2014/34/EU "Equipment and protective systems for use in hazardous areas" (Explosion protection directive, ATEX)

The EC Declaration of Conformity is available for download from the Internet (http://www.siemens.com/automation/service&support) (keyword "Declaration of Conformity").

ATEX approval

The module markings are described in the specifications.

IECEx approval

See the technical specifications for the fail-safe ET 200iSP modules.

cULus approval

HAZ. LOC.

Underwriters Laboratories Inc.

See the technical specifications for the fail-safe ET 200iSP modules.

FM approval

FM (Factory Mutual Research)

See the technical specifications for the fail-safe ET 200iSP modules.

⚠ WARNING

Personal injury and property damage can occur.

There is a risk of injury or damage if you disconnect any plug-in connections in potentially explosive areas while the ET 200iSP is in operation.

Be aware of which activities are permitted in potentially explosive areas. Refer to chapter "Activities during operation" in the operating instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789).

Marking for Australia and New Zealand

The fail-safe modules of the ET 200iSP satisfy the requirements of the EN 61000-6-4 standard.

INMETRO

See the technical specifications for the fail-safe ET 200iSP modules.

IEC 61131

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

PROFIBUS standard

The ET 200iSP distributed I/O device is based on standard, *IEC 61784-1:2002 Ed1 CP 3/1.*

Marine approval

Classification societies:

- 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 of the Distributed I/O Device ET 200iSP in device group I (mining) Category M2

The following conditions must be fulfilled if the ET 200iSP is used in device group I (underground mining operations and their overground systems) Category M2:

⚠ CAUTION

Use in Device group I

- To avoid ignitable sparks, the power supply PS and the mounting rail of the ET 200iSP must be packaged in shock-proof packaging for transportation and storage (e.g. for servicing) and immediately removed from the potentially explosive atmosphere.
- The enclosure in which the ET 200iSP is installed must be approved for device group I, category M2.
- Observe all other requirements concerning use of the ET 200iSP in the potentially explosive atmosphere given in this manual.

Use in industrial environment

SIMATIC products are designed for use in industrial environments.

Table 6-1 Use in industrial environment

Area of application	Requirement for	
	Interference emission	Immunity
Industrial environments	EN 61000-6-4: 2007 + A1:2011	EN 61000-6-2: 2005

Use in residential areas

Note

The ET 200iSP distributed I/O device is intended for use in industrial environments; when used in residential areas, it can be affected by radio/television reception or other wireless services.

ET 200iSP applications in residential areas must be compliant with values of EN 61000-6-3 for emission of radio interference.

Individual measures are, for example:

- Installation of the ET 200iSP in grounded switch control cabinets/boxes
- Use of filters in supply lines

TÜV certificate and standards (German Technical Inspectorate)

The fail-safe modules are certified to standards and guidelines for functional safety; for information, refer to the relevant safety certificate (TÜV certificate) report and corresponding annex 1. You can find the most recent TÜV documents in the Internet (http://support.automation.siemens.com/WW/view/en/11669702/134200).

Requesting a TÜV certificate

You can request copies of the TÜV certificate and of the included report at the following address:

Siemens AG
Process Industries and Drives Division
Process Automation
Automation and Engineering
PD PA AE R&D-I
Östliche Rheinbrückenstr. 50
78187 Karlsruhe

6.3 Electromagnetic compatibility

Definition of EMC

Electromagnetic compatibility is the ability of electrical equipment to function satisfactorily in its electromagnetic environment without influencing this environment.

The fail-safe modules meet requirements of EMC legislation for the internal European market. This requires that the ET 200iSP distributed I/O system meets the specifications and directives concerning electrical installation.

EMC according to NE21

The ET 200iSP distributed I/O device satisfies the EMC requirements of NAMUR directive NE21.

Pulseshaped interference

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

Pulse-shaped interference	Test voltage	corresponds with degree of severity
Electrostatic discharge according to IEC 61000-4-2.	8 kV air discharge 6 kV contact discharge	3
Burst pulses (high-speed transient interference) to IEC 61000-4-4.	2 kV (supply line) 2 kV (signal line)	3
Powerful single pulse (surge) according to IEC 61000-4-5 As of product version 3 of Power Supply PS (6ES7138-7EA01-0AA0), the overvoltage suppressor for the 24 VDC supply on Power Supply PS is no longer mandatory. Overvoltage suppressors are mandatory for all electronic modules with unshielded cables (for appropriate types, see Appendix Lightning protection and overvoltage protection (Page 157)).		3
• asymmetric connection	2 kV (supply line) 2 kV (supply line/data line)	
• asymmetric connection	1 kV (supply line) 1 kV (supply line/data line)	

Sinusoidal interference variables

The following table shows the electromagnetic compatibility of the fail-safe modules with respect to sinusoidal interference.

- HF irradiation

HF irradiation according to IEC 61000-4-3 Electromagnetic HF field, amplitude-modulated	
80 to 1000 MHz; 1.4 to 2 GHz	2.0 GHz to 2.7 GHz
10 V/m	3 V/m
80% AM (1 kHz)	

- HF coupling
-

HF injection according to IEC 61000-4-6	
10 kHz to 80 MHz	
10 V	
80% AM (1 kHz)	

Emission of radio interference

Interference emission of electromagnetic fields in accordance with EN 61000-6-4.

6.4 Transport and Storage Conditions

Transport and storage conditions for fail-safe modules

For the transport and storage conditions, refer to the Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789). The information given there also applies to the fail-safe electronic modules.

6.5 Mechanical and climatic ambient conditions

Conditions of use for fail-safe modules

For the mechanical and climatic environmental conditions refer to the Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789). The information given there also applies to the fail-safe electronic modules.

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

Specifications for fail-safe modules

For the specifications for rated voltages, insulation tests, protection class, and type of protection, see the Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789). The information given there also applies to the fail-safe electronic modules.

Digital electronic modules

7

Overview

Fail-safe digital modules are available for connecting digital sensors and actuators /loads to ET 200iSP. 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
- Applications with terminal diagrams and parameter assignment
- Wiring diagram and assignable parameters
- Diagnostic functions, including corrective measures
- Technical specifications

7.1 Digital electronic module 8 F-DI Ex NAMUR

7.1.1 Properties of the digital electronic module 8 F-DI Ex NAMUR

Order number

6ES7138-7FN00-0AB0

Properties

The digital electronic module 8 F-DI Ex NAMUR has the following properties:

- Suitable for connecting sensors from the hazardous area
- 8 inputs 1-channel (SIL3/Cat.3/PLe) or 4 inputs 2-channel (SIL3/Cat.4/PLe), electrically isolated from the power bus/backplane bus
- Suitable for the following sensors
  - In accordance with IEC 60947-5-6 and NAMUR (with diagnostic evaluation)
  - Connected mechanical contacts (with diagnostic evaluation)
  - Unconnected mechanical contacts (with deactivated diagnostics)
- 8 short-circuit-proof sensor supplies (8 VDC), for one channel each, electrically isolated from the power bus/backplane bus
- Group fault display (SF LED; red)
- Safety mode display (SAFE LED; green)

- Status display/channel fault display per channel (green/red LED)
- Assignable diagnostics
- Assignable diagnostic interrupt
- Module-internal diagnostic buffer available
- Firmware update
- I&M identification data
- Channel-by-channel passivation
- Supports time stamp
- Can only be used in safety mode

Note

The fail-safe performance characteristics in the technical specifications apply to a proof-test interval of 20 years and a mean time to repair of 100 hours.

Reference

For the I&M identification data, refer to the chapter of the same name in Operating Instructions ET 200iSP Distributed I/O Device (http://support.automation.siemens.com/WW/view/en/28930789).

7.1.2 Terminal assignment of electronic module 8 F-DI Ex NAMUR

Front view

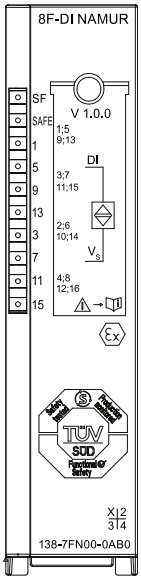
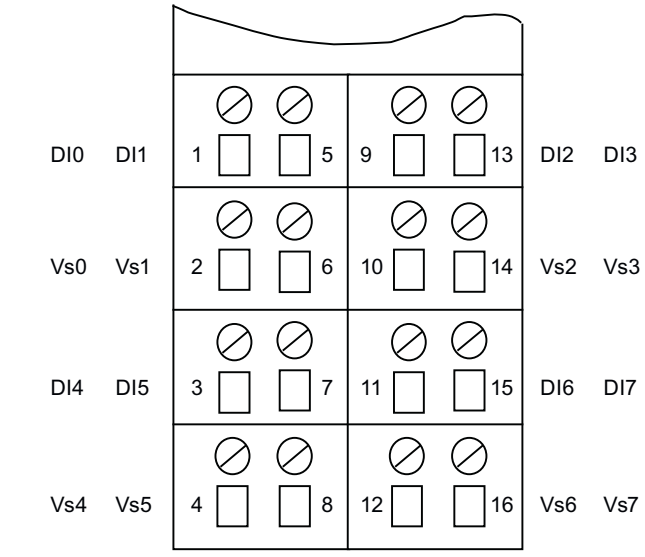


Figure 7-1 Front view 8 F-DI Ex NAMUR

Terminal assignment

The figure below shows the terminal assignment of the electronic module 8 F-DI Ex NAMUR for the supported terminal modules TM-IM/EM 60C, TM-EM/EM 60S and TM-EM/EM 60C.



DI Fail-safe digital input

Vs Sensor supply for DI

Figure 7-2 Terminal assignment TM-IM/EM 60C, TM-EM/EM 60S and TM-EM/EM 60C for 8 F-DI Ex NAMUR

7.1.3 Block diagram of electronic module 8 F-DI Ex NAMUR

Block diagram

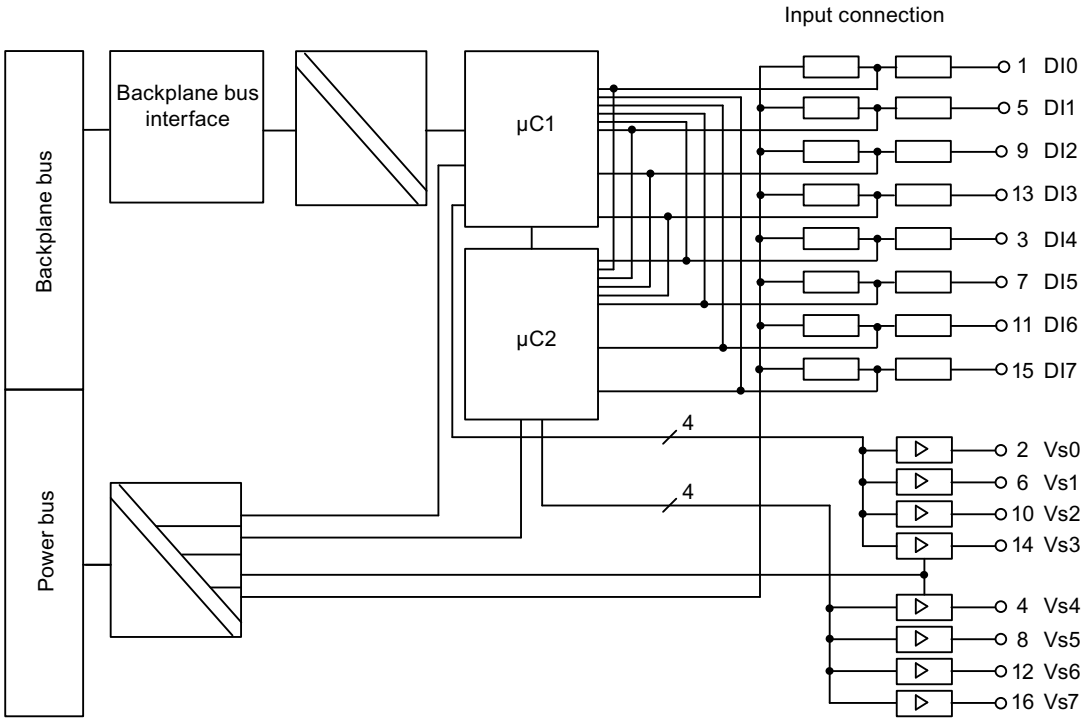


Figure 7-3 Block diagram 8 F-DI Ex NAMUR

7.1.4 Parameters for electronic module 8 F-DI Ex NAMUR

Parameters

The table below lists the parameters that can be set for electronic module 8 F-DI Ex NAMUR.

Table 7-1 Parameters of the 8 F-DI Ex NAMUR

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 (ms)	10 to 65535	2500	Static	Module
Module parameters:				
Behavior after channel fault[1)]	Passivate the entire module/Passivate the channel	Passivate the entire module	Static	Module

Parameter	Range	Default	Type of parameter	Effective range
Maximum test time (s)	100; 1000	1000	Static	Module
Channel n, n+4				
Sensor evaluation	1oo1 evaluation/ 1oo2 equivalent/1oo2 non-equivalent	1oo1 evaluation	Static	Channel pair
Behavior at discrepancy	Provide last valid value; Provide 0 value	Provide last valid value	Static	Channel pair
Discrepancy time (ms)	10 to 30000	10	Static	Channel pair
Reintegration after discrepancy error	Zero signal test not required/zero signal test required	Zero signal test not required	Static	Channel pair
Sensor supply for 1oo2	Separate Vs for each sensor/Vs0 for Sensor 0 and 4	Separate Vs for each sensor	Static	Channel pair
Channel n				
Sensor type	Channel blocked/ NAMUR sensor/ Single contact open/ Single contact with 10 kΩ parallel resistor/ Single contact with 1 kΩ series resistor	NAMUR sensor	Static	Channel
Input delay	1; 3; 15 ms	3 ms	Static	Channel
Sensor supply test	Activated/deactivated	Activated	Static	Channel
Time for sensor test	2; 4; 6; 8; 10; 20; 40; 60; 80; 100; 200; 400; 600; 800; 1000; 2000 ms	10 ms	Static	Channel
Ramp-up time of the sensor after sensor test	2; 4; 6; 8; 10; 20; 40; 60; 80; 100; 200; 400; 600; 800; 1000; 2000 ms	10 ms	Static	Channel
Diagnostics				
Wire break	Activated/deactivated[2)]	Activated	Static	Channel
Chatter monitoring	Activated/deactivated	Deactivated	Static	Channel
Number of signal changes	2; 3; 4; 5; ... 31	5	Static	Channel
Monitoring window (s)	0.5 s to 100 s	2	Static	Channel
Pulse stretching	Deactivated/ 0.5; 1; 2 sec	Deactivated	Static	Channel

[1)] This setting is only relevant when optional package *S7 Distributed Safety* V5.4 or higher is installed.

[2)] Only assignable for sensor type NAMUR sensor/Single contact with 10 kΩ parallel resistor

Maximum test period parameter

You can use the "Maximum test time (s)" parameter to set the time within which the sensor supply tests should be performed throughout the module. When this time expires, the tests are repeated.

Sensor evaluation parameter

In 1oo1 evaluation, there is one sensor, and it is connected to the fail-safe module via a single channel. There is no discrepancy analysis.

In 1oo2 evaluation, two input channels are occupied. The input signals are compared internally for equivalence or non-equivalence. Sensors of the same type (2 NC contacts or 2 NO contacts) are assigned the "equivalent" parameter. Different sensors (1 NC contact/1 NO contact) are assigned the "non-equivalent" parameter.

Discrepancy analysis

When a two-channel sensor or two single-channel sensors are used to measure the same process variable, the sensors will act with a slight time delay relative to one another due to the limited precision of their arrangement.

The discrepancy analysis for equivalence/non-equivalence 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 non-equivalence: same levels) are detected at two associated input signals. A test is conducted to determine whether the difference in levels (when testing for non-equivalence: the consistence) has disappeared within an assignable period known as the discrepancy time. If not, this means that a discrepancy error exists.

Behavior at discrepancy parameter

For "Behavior at 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. You assign the behavior at discrepancy as follows:

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

Requirements

Parameter settings:

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

"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.

That is, the discrepancy time of the connected sensors with 1oo2 evaluation for fast reactions must be tuned to short response times. It makes no sense, for example, if connected sensors with a discrepancy time of 500 ms trigger a time-critical shutdown.. In the worst 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 equivalent" or "1oo2 non-equivalent"

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

Response after discrepancy time expires

If the input signals are not equivalent following expiration of the assigned discrepancy time (when checking for nonequivalence: no inequality), for example due to wire break at a sensor line, a discrepancy error is detected and a "discrepancy error" diagnostic message is entered in the diagnostic buffer of the F-I/O module with information on 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 equivalent" or "1oo2 non-equivalent"

"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.

If you are using non-equivalent sensors, i.e., if you have set "Sensor evaluation" to "1oo2 non-equivalent", a 0 signal must be present again at the lower-order channel of the channel pair.

"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.

Sensor supply for 1oo2 parameter

Here you can set whether each sensor is fed with its own sensor supply for 1oo2 evaluation, or whether both sensors of the channel pair are connected to a common sensor supply.

This parameter is only relevant for 1oo2 evaluation.

Input delay

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

Interfering pulses of 0 ms up to the configured input delay (in ms) are thereby suppressed. The set input delay is subject to a tolerance (see Chapter "Technical specifications of electronic module 8 F-DI Ex NAMUR (Page 81)").

A high input delay suppresses longer interfering pulses, but results in a longer reaction time (see Chapter "Response times (Page 147)").

Parameter for sensor supply test

This parameter enables the sensor supply test for the selected channel. You can use the sensor supply test to detect short circuits between various channels within the module.

The following short circuits are detected:

- Short circuit between the input and the input of another channel
- Short circuit between the input and sensor supply of another channel
- Short circuit between the sensor supply and the sensor supply of another channel

If the sensor supply test is disabled, you must implement short-circuit-proof and cross-circuit-proof cabling.

During the execution time (time for sensor test + ramp-up time of the sensor after sensor test) of the sensor supply test, the last valid value before the start of the sensor supply test is passed to the F-CPU. The activation of the sensor supply test thus affects the reaction time of the respective channel or channel pair (see Chapter "Response times (Page 147)").

Note

You must use suitable sensors that tolerate the sensor supply being deactivated.

Time for sensor test

When the sensor supply test is enabled, the sensor supply of the respective channel or channel pair (with 1oo2 evaluation and common sensor supply) is switched off for a period not to exceed the assigned time. If the module has read back correctly before that, the sensor supply is applied again earlier. If the module does not correctly read back within the assigned time, the "Short circuit or sensor supply defective" error is triggered.

When assigning parameters, note that

- If the channel is passivated, this may also be due to too high capacitance between sensor supply and input. This consists of the capacitance per unit length of the cable and the capacitance of the utilized sensor. If the connected capacitance does not discharge within the assigned time, you must adjust the "Time for sensor test" parameter.
- Since the assigned time affects the response time of the module, we recommend that you set the time as short as possible, but long enough so that the channel is not passivated.
- The available time values depend on the assigned input delay.

Ramp-up time of the sensor after sensor test

In addition to the off time ("Time for sensor test"), a ramp-up time must be specified for performing the sensor supply test. You use this parameter to notify the module how long the utilized sensor needs to ramp up after connecting the sensor supply. This prevents an undefined input state due to transient events in the sensor.

When assigning parameters, note that

- this parameter must be greater than the settling time of the utilized sensor.
- Since the assigned time affects the response time of the module, we recommend that you set the time as short as possible, but long enough so that your sensor can settle safely.
- The available time values depend on the assigned input delay.

Short-circuit diagnostics

The short-circuit diagnostics cannot be assigned via a parameter, but is rather assigned automatically by *STEP 7*, in accordance with the specified sensor type:

- NAMUR sensor/ Single contact with 1 kΩ series resistor: Short-circuit diagnostics activated
- Single contact open/ Single contact with 10 kΩ parallel resistor: Short-circuit diagnostics deactivated

⚠ WARNING

Short-circuits in the wiring between activated and deactivated channels cannot be detected.

Remedy: Activate the deactivated channels, do not connect any wiring to the deactivated channels, or implement the cable routing in a short-circuit-proof and cross-circuit proof manner.

Wire break parameter

You can use a wire break test to monitor the connection of the sensor supply to the sensor and back to the input.

Selecting this check box enables the wire break monitoring for the relevant channel.

Wire break monitoring is available for the following sensor types:

- NAMUR sensor
- Single contact with 10 kΩ parallel resistor

Chatter monitoring parameter, number of signal changes and monitoring window

Chatter monitoring is a process control function for digital input signals. It detects and reports unusual process control signal characteristics, such as fluctuations of the input signal between "0" and "1" that occur too often. The occurrence of such signal characteristics is an indication of faulty sensors or process control instability.

Recognizing unusual signal patterns

An assigned "monitoring window" is available for each input channel. The monitoring window is started on the first signal change of the input signal. If the input signal changes within the monitoring window more often than the assigned "Number of signal changes", this is recognized as a chatter error. If no chatter error is detected within the monitoring window, the monitoring window is restarted at the next signal change.

Pulse stretching parameter

Pulse stretching is a function for altering a digital input signal. A pulse on a digital input is stretched in length up to the assigned length. If the input pulse already exceeds the assigned length, the pulse is not changed.

The fail-safe electronic module, 8 F-DI Ex NAMUR stretches pulses with the value "0" only because the basis of the safety concept is that there is a safe state for all process variables. For digital F-I/O, this is the value "0"; this applies to sensors as well to actuators.

With 1oo2 evaluation of sensors, the resulting value of the channel pair forms the reference for the pulse stretching.

Reference

For further information about the chatter monitoring and pulse stretching parameters and their interactions, refer to the Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789).

7.1.5 Applications of electronic module 8 F-DI Ex NAMUR

Selecting the application

The diagram below supports you in selecting an application which suits your fail-safe requirements. The following chapters provide information on how to wire the F-module and on the specific parameters you must set for each application.

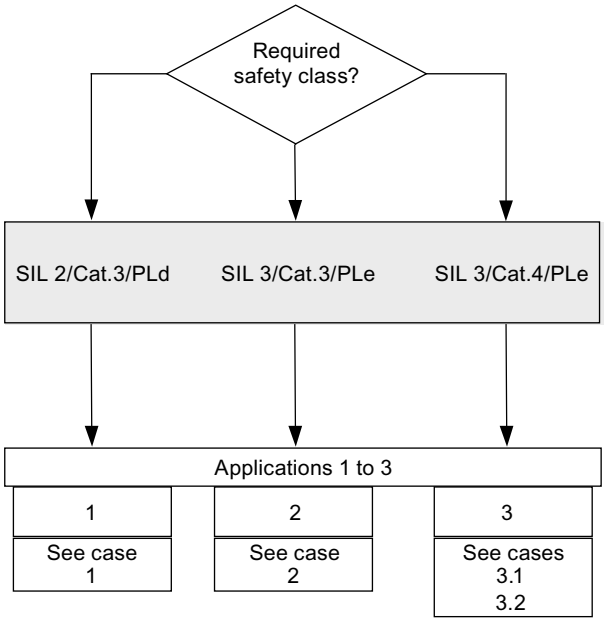


Figure 7-4 Use case selection - EM 8 F-DI Ex NAMUR electronic module

WARNING

The achievable safety class is determined by the sensor quality and the length of the proof-test interval in accordance with IEC 61508. If the sensor quality does not meet the requirements of the desired safety class, redundant sensors must be used and connected via two channels.

Conditions for achieving SIL/Cat./PL

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

Table 7-2 EM 8 F-DI Ex NAMUR: Conditions for achieving SIL/Cat./PL

Application	Achievable SIL/Cat./PL	Sensor evaluation	Sensor supply for 1oo2	Sensor type	Sensor supply test	Comment
1	2 / 3 / d	1oo1	-	Single contact open or single contact with 10 kΩ parallel resistor	Activated	You must implement the wiring in a short-circuit-proof and cross-circuit proof manner, otherwise only Cat. 2 is achieved.
				Single contact with 1 kΩ series resistor or NAMUR sensor	Activated	-
				All possible	Deactivated	You must implement the wiring in a short-circuit-proof and cross-circuit proof manner, otherwise only Cat. 2 is achieved.
2	3 / 3 / e	1oo1	-	Single contact open or single contact with 10 kΩ parallel resistor	Activated	You must implement the wiring in a short-circuit-proof and cross-circuit proof manner, otherwise only Cat. 2 is achieved.
				Single contact with 1 kΩ series resistor or NAMUR sensor	Activated	-
					Deactivated	You must implement the wiring in a short-circuit-proof and cross-circuit proof manner, otherwise only Cat. 2 is achieved.
3.1	3 / 4 / e	1oo2 equivalent	Common Vs	All possible	Activated or deactivated	You must implement the wiring in a short-circuit-proof and cross-circuit proof manner, otherwise only Cat. 3 is achieved.
			Separate Vs for each sensor	All possible	Activated	-
					Deactivated	You must implement the wiring in a short-circuit-proof and cross-circuit proof manner, otherwise only Cat. 3 is achieved.

Application	Achievable SIL/Cat./PL	Sensor evaluation	Sensor supply for 1oo2	Sensor type	Sensor supply test	Comment
3.2	3 / 4 / e	1oo2 non-equivalent	Common Vs or separate Vs for each sensor	All possible	Activated	-
					Deactivated	You must implement the wiring in a short-circuit-proof and cross-circuit proof manner, otherwise only Cat. 3 is achieved.

Note

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

Sensor requirements

For the safety-related use of sensors, refer also to Chapter

- "Requirements for Sensors and Actuators (Page 36)"
- "Diagnostic functions of electronic module 8 F-DI Ex NAMUR (Page 76)".

7.1.6 Application 1: Safety mode SIL2/Cat. 3/PLd

Introduction

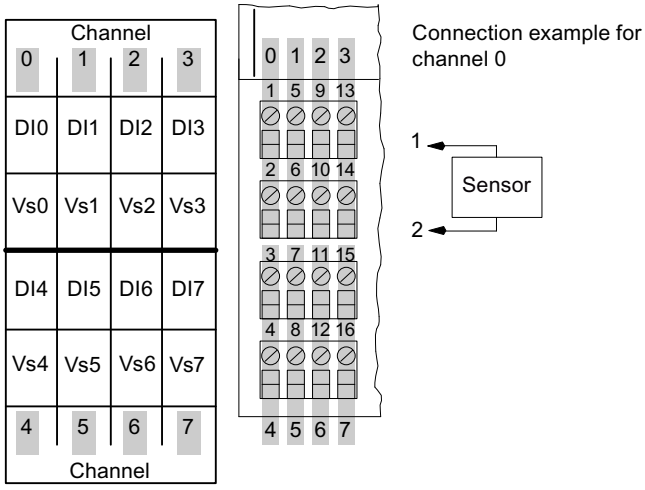
Below are the wiring scheme and the parameter assignment of the 8 F-DI Ex NAMUR module for Application 1: SIL2/Category 3/PLd safety mode

Diagnostic messages, possible causes of faults, and their corrective measures are found in the corresponding tables in Chapter "Diagnostic functions of electronic module 8 F-DI Ex NAMUR (Page 76)".

Wiring scheme for Application 1

One single-channel sensor is connected via one channel to the fail-safe module for each process signal (1oo1 evaluation). The sensor supply Vs is made available by the fail-safe module.

Table 7-3 Terminal assignment 1oo1 evaluation of the sensors

Terminal assignment and view	Remarks
	**Sensor 1**: Channel 0: Terminals 1 and 2 **Sensor 2**: Channel 1: Terminals 5 and 6 **Sensor 3**: Channel 2: Terminals 9 and 10 **Sensor 4**: Channel 3: Terminals 13 and 14 **Sensor 5**: Channel 4: Terminals 3 and 4 **Sensor 6**: Channel 5: Terminals 7 and 8 **Sensor 7**: Channel 6: Terminals 11 and 12 **Sensor 8**: Channel 7: Terminals 15 and 16 DI: Input signal Vs: Sensor supply

⚠ WARNING

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

Assignable module parameters for Application 1

Parameter	Range	Type of parameter	Effective range
Behavior after channel fault[1)]	Passivate the entire module/ Passivate the channel	Static	Module
Maximum test time (s)	100; 1000	Static	Module
Sensor evaluation	1oo1 evaluation	Static	Channel
Sensor type	All sensor types possible	Static	Channel
Input delay	1; 3; 15 ms	Static	Channel
Sensor supply test	Deactivated	Static	Channel
Diagnostics: Wire break	Activated[2)]/deactivated	Static	Channel
Chatter monitoring	Activated/deactivated	Static	Channel
Number of signal changes	2; 3; 4; 5; ... 31	Static	Channel

Parameter	Range	Type of parameter	Effective range
Monitoring window (sec)	0.5 s to 100 s	Static	Channel
Pulse stretching	Deactivated/ 0.5; 1; 2 sec	Static	Channel

1) This setting is only relevant when optional package *S7 Distributed Safety* V5.4 or higher is installed.

2) Only effective for single contact with 10 kΩ parallel resistor.

WARNING

Single contact open or single contact with 10 kΩ parallel resistor: You must implement the wiring in a short-circuit-proof and cross-circuit proof manner, otherwise only Cat.2 is achieved.

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

Introduction

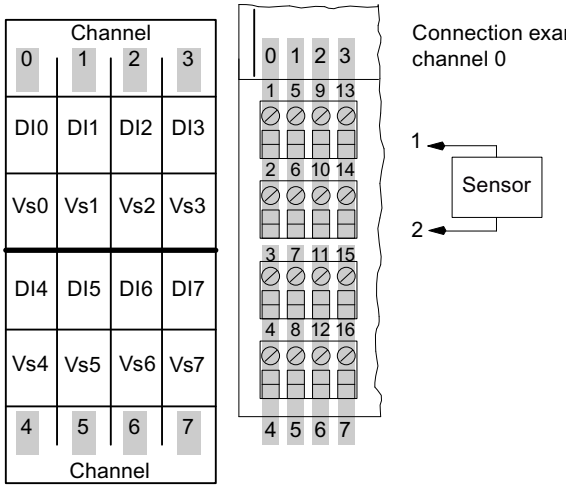
Below are the wiring scheme and the parameter assignment of the 8 F-DI Ex NAMUR module for Application 2: Safety mode SIL3/Cat.3/PLe

Diagnostic messages, possible causes of faults, and their corrective measures are found in the corresponding tables in Chapter "Diagnostic functions of electronic module 8 F-DI Ex NAMUR (Page 76)".

Wiring scheme for Application 2

One single-channel sensor is connected via one channel to the fail-safe module for each process signal (1oo1 evaluation). The sensor supply Vs is made available by the fail-safe module.

Table 7-4 Terminal assignment 1oo1 evaluation of the sensors

Terminal assignment and view	Remarks
	**Sensor 1**: Channel 0: Terminals 1 and 2 **Sensor 2**: Channel 1: Terminals 5 and 6 **Sensor 3**: Channel 2: Terminals 9 and 10 **Sensor 4**: Channel 3: Terminals 13 and 14 **Sensor 5**: Channel 4: Terminals 3 and 4 **Sensor 6**: Channel 5: Terminals 7 and 8 **Sensor 7**: Channel 6: Terminals 11 and 12 **Sensor 8**: Channel 7: Terminals 15 and 16 DI: Input signal Vs: Sensor supply

⚠ WARNING

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

Assignable module parameters for Application 2

Parameter	Range	Type of parameter	Effective range
Behavior after channel fault[1)]	Passivate the entire module/ Passivate the channel	Static	Module
Maximum test time (s)	100; 1000	Static	Module
Sensor evaluation	1oo1 evaluation	Static	Channel
Sensor type	NAMUR sensor/ Single contact open/ Single contact with 10 kΩ parallel resistor/ Single contact with 1 kΩ series resistor	Static	Channel
Input delay	1; 3; 15 ms	Static	Channel
Sensor supply test	Activated/deactivated[2)]	Static	Channel

Parameter	Range	Type of parameter	Effective range
Time for sensor test	2; 4; 6; 8; 10; 20; 40; 60; 80; 100; 200; 400; 600; 800; 1000; 2000 ms	Static	Channel
Ramp-up time of the sensor after sensor test	2; 4; 6; 8; 10; 20; 40; 60; 80; 100; 200; 400; 600; 800; 1000; 2000 ms	Static	Channel
Diagnostics: Wire break	Activated[3]/deactivated	Static	Channel
Chatter monitoring	Activated/deactivated	Static	Channel
Number of signal changes	2; 3; 4; 5; ... 31	Static	Channel
Monitoring window (sec)	0.5 s to 100 s	Static	Channel
Pulse stretching	Deactivated/ 0.5; 1; 2 sec	Static	Channel

[1] This setting is only relevant when optional package *S7 Distributed Safety* V5.4 or higher is installed.

[2] Can also be deactivated for NAMUR sensors and single contact with 1 kΩ series resistor.

[3] Only effective for NAMUR sensor and single contact with 10 kΩ parallel resistor

⚠ WARNING

Single contact open or single contact with 10 kΩ parallel resistor: You must implement the wiring in a short-circuit-proof and cross-circuit proof manner, otherwise only Cat.2 is achieved.

NAMUR sensor or single contact with 1 kΩ series resistor; if sensor supply test deactivated: You must implement the wiring in a short-circuit-proof and cross-circuit proof manner, otherwise only Cat. 2 is achieved.

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

Introduction

Below are the wiring scheme and the parameter assignment of the 8 F-DI Ex NAMUR module for Application 3: Safety mode SIL3/Cat.4/PLe.

Diagnostic messages, possible causes of faults, and their corrective measures are found in the corresponding tables in Chapter "Diagnostic functions of electronic module 8 F-DI Ex NAMUR (Page 76)".

Wiring scheme for Application 3

Two sensor signals are connected via two channels to each of two *opposite inputs* of the fail-safe module for each process signal (1oo2 evaluation). The sensor supply Vs is made available by the fail-safe module.

Table 7-5 Terminal assignment 1oo2 evaluation, every sensor connected to own sensor supply

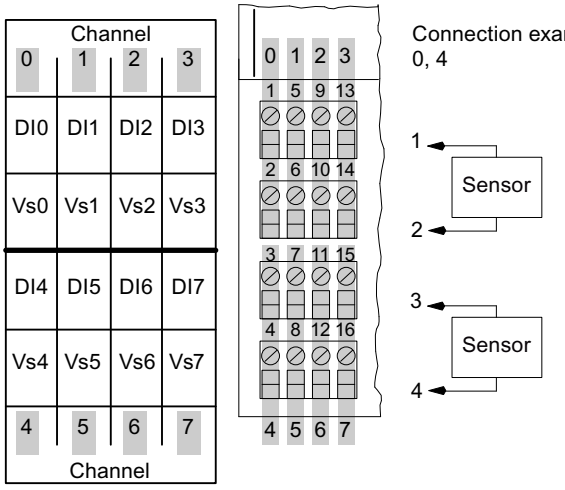
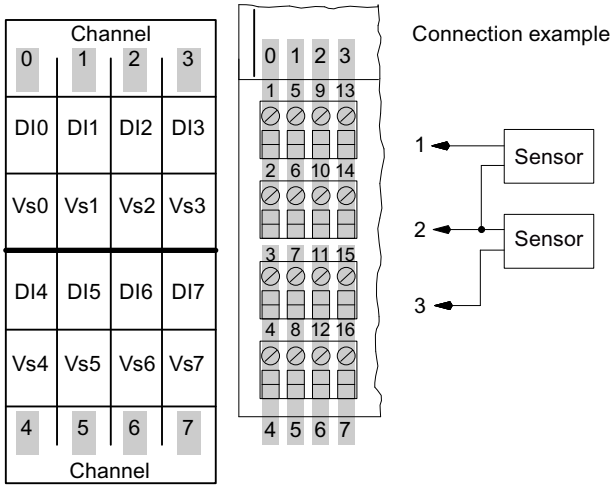
Terminal assignment and view	Remarks
	**Channel pair 0, 4**: Channel 0: Terminals 1 and 2 Channel 4: Terminals 3 and 4 **Channel pair 1, 5**: Channel 1: Terminals 5 and 6 Channel 5: Terminals 7 and 8 **Channel pair 2, 6**: Channel 2: Terminals 9 and 10 Channel 6: Terminals 11 and 12 **Channel pair 3, 7**: Channel 3: Terminals 13 and 14 Channel 7: Terminals 15 and 16 DI: Input signal Vs: Sensor supply

Table 7-6 Terminal assignment 1oo2 evaluation of the sensors with common sensor supply

Terminal assignment and view	Remarks
	**Channel pair 0, 4**: Channel 0: Terminals 1 and 2 Channel 4: Terminal 3 **Channel pair 1, 5**: Channel 1: Terminals 5 and 6 Channel 5: Terminal 7 **Channel pair 2, 6**: Channel 2: Terminals 9 and 10 Channel 6: Terminal 11 **Channel pair 3, 7**: Channel 3: Terminals 13 and 14 Channel 7: Terminal 15 DI: Input signal Vs: Sensor supply

⚠ WARNING

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

Assignable module parameters for Application 3

Parameter	Range	Type of parameter	Effective range
Behavior after channel fault[1)]	Passivate the entire module/ Passivate the channel	Static	Module
Maximum test time (s)	100; 1000	Static	Module
Sensor evaluation	1oo2 equivalent/1oo2 non-equivalent	Static	Channel pair
Behavior at discrepancy	Provide last valid value; provide 0 value	Static	Channel pair
Discrepancy time	10 to 30,000 ms	Static	Channel pair
Reintegration after discrepancy error	Zero signal test not required/ zero signal test required	Static	Channel pair
Sensor supply for 1oo2	Separate Vs for each sensor/ Vs0 for Sensor 0 and 4	Static	Channel pair
Sensor type	NAMUR sensor/ Single contact open/ Single contact with 10 kΩ parallel resistor/ Single contact with 1 kΩ series resistor	Static	Channel
Input delay	1; 3; 15 ms	Static	Channel
Sensor supply test	Activated/deactivated[2)]	Static	Channel
Time for sensor test	2; 4; 6; 8; 10; 20; 40; 60; 80; 100; 200; 400; 600; 800; 1000; 2000 ms	Static	Channel
Ramp-up time of the sensor after sensor test	2; 4; 6; 8; 10; 20; 40; 60; 80; 100; 200; 400; 600; 800; 1000; 2000 ms	Static	Channel
Diagnostics: Wire break	Activated[3)]/deactivated	Static	Channel
Chatter monitoring	Activated/deactivated	Static	Channel
Number of signal changes	2; 3; 4; 5; ... 31	Static	Channel
Monitoring window (sec)	0.5 s to 100 s	Static	Channel
Pulse stretching	Deactivated/ 0.5; 1; 2 sec	Static	Channel

1) This setting is only relevant when optional package *S7 Distributed Safety* V5.4 or higher is installed.

2) Can also be deactivated when "Separate Vs for each sensor" parameter is assigned and wiring is short-circuit-proof and cross-circuit-proof.

3) Only effective for NAMUR sensor and single contact with 10 kΩ parallel resistor

⚠ WARNING

For deactivated sensor supply test or equivalent 1oo2 sensor evaluation with common sensor supply: You must implement the wiring in a short-circuit-proof and cross-circuit proof manner, otherwise only Cat. 3 is achieved.

7.1.9 Diagnostic functions of electronic module 8 F-DI Ex NAMUR

Behavior after short circuits

When the sensor supply test parameter is assigned, short circuits **between** the channels (cross-circuit) are detected and signaled by the corresponding channel fault LED. The "Short circuit" diagnosis is signaled, and an entry is made in the diagnostic buffer.

Activation/deactivation of the short-circuit diagnostics for short circuit between sensor supply and input within a channel cannot be assigned with parameters, but rather depends on the type of sensor connected:

- Short-circuit diagnostics is activated for the sensor types NAMUR sensor/ single contact with 1 kΩ series resistor
- Short-circuit diagnostics is deactivated for the sensor types Single contact open/ Single contact with 10 kΩ parallel resistor. For these sensor types, the short circuit between sensor supply and input displays a valid "1".

Diagnostic functions

The table below provides an overview of the diagnostic functions of electronic module 8 F-DI Ex NAMUR. The diagnostic functions are assigned either to one channel or to the entire module.

Table 7-7 Diagnostic functions of electronic module 8 F-DI Ex NAMUR

Diagnostic function[1]	Fault number	LED	Signaled in application	Effective range of diagnostics	Can be assigned
Short circuit	1_H	Group fault, channel fault display	1, 2, 3	Channel	No[2]
Overtemperature	5_H	Group fault	1, 2, 3	Module	No[2]
Line break	6_H	Group fault, channel fault display	1, 2, 3	Channel	Yes[3]
Fault	9_H	Group fault	1, 2, 3	Module	No[2]
Parameter assignment error	10_H	Group fault	1, 2, 3	Module	No[2]
Sensor voltage or load voltage missing	11_H	Group fault	1, 2, 3	Module	No[2]
Safety-related shutdown	19_H	Group fault, channel fault display		Channel	
• Discrepancy error (1oo2 evaluation), channel status x/y			3		No[2]
• Sensor signal chatters			1, 2		Yes[4]
• Switching frequency too high			1, 2, 3		No[2]
• Input signal could not be detected clearly			1, 2, 3		No[2]

Diagnostic function[1]	Fault number	LED	Signaled in application	Effective range of diagnostics	Can be assigned
PROFIsafe communication error	$1C_H$	Group fault	1, 2, 3	Module	No[2]

[1] Display in *STEP 7*, see Figure "Channel-specific diagnostics" in Chapter "Slave diagnostics (Page 44)"

[2] Is always diagnosed for NAMUR sensor/ Single contact with 1 kΩ series resistor

[3] Only assignable for NAMUR sensor/ Single contact with 10 kΩ parallel resistor

[4] Only assignable with 1oo1 evaluation of the sensors

WARNING

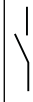
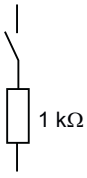
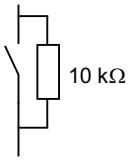
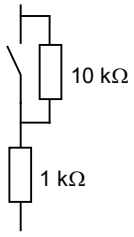
Before acknowledging the short-circuit diagnosis, remedy the respective error and validate your safety function. In this case, follow the steps described in Chapter "Fault reactions (Page 39)".

Special features of fault detection

The detection of certain faults (short circuits or discrepancy errors, for example) depends on the application, the wiring, the type of sensor assigned, and the parameter assignment of the sensor supply test.

Dependence of the diagnostic functions on the sensor type used

Table 7-8 Dependence of the diagnostic functions on the sensor type used

Sensor type						
	Single contact open	Single contact with 1 kΩ series resistor	Single contact with 10 kΩ parallel resistor	NAMUR sensor		
					or	

Diagnostic function				
Short circuit	No	Yes	No	Yes
Wire break	No	No	Yes	Yes

Note

Install the resistors as close as possible to the sensor, since short-circuit or wire break faults can only be recognized as a fault up to the resistors.

Causes of faults and corrective measures

The following table contains the possible causes of faults and their corrective measures for the individual diagnostic messages and diagnostic buffer entries of electronic module 8 F-DI Ex NAMUR.

Table 7-9 Diagnostic messages of electronic module 8 F-DI Ex NAMUR, causes of faults, and corrective measures

Diagnostic message	Diagnostic buffer	Possible causes of fault	Corrective measures
Short circuit	Short circuit between sensor line and sensor supply line	Sensor line short-circuited with sensor supply	Eliminate short circuit
		Fault at the external circuit (resistor)	Eliminate fault
		Sensor is defective	Replace the sensor
		Incorrect sensor type assigned	Correct the parameter assignment
		Internal error	Replace module
	Short circuit or sensor supply defective	Short circuit between two sensor lines	Eliminate short circuit
		Short circuit between two sensor supplies	Eliminate short circuit Check "Sensor supply for 1oo2" parameter
		Short circuit between input and sensor supply of another channel	Eliminate short circuit
		Electromagnetic interference has exceeded limits	Eliminate interferences, reduce interference, or extend the "Time for sensor test" parameter.
		Internal error	Replace module
Overtemperature	Temperature outside the permitted range	Shutdown due to violation of upper or lower temperature limit value in the module housing.	Check the ambient temperature. Once the fault has been eliminated, the module must be removed and inserted or the power switched off and on
Line break	Wire break	Signal line to a sensor interrupted	Correct the process interconnection
		Sensor supply line interrupted	Correct the process interconnection
		Fault at the external circuit (resistor)	Eliminate fault
		Sensor is defective	Replace the sensor
		Incorrect sensor type assigned	Correct the parameter assignment
		Input channel is unused	Set "Sensor type" parameter to "Channel blocked"
		Internal error	Replace module

Diagnostic message	Diagnostic buffer	Possible causes of fault	Corrective measures
Fault	Internal supply voltage of the module failed	Electromagnetic interference has exceeded limits	Eliminate the interferences. Once the fault has been eliminated, the module must be removed and inserted or the power switched off and on.
		Internal error	Replace module
	EPROM fault	Electromagnetic interference has exceeded limits	Eliminate the interferences. Once the fault has been eliminated, the module must be removed and inserted or the power switched off and on.
		Internal error	Replace module
	RAM fault	Electromagnetic interference has exceeded limits	Eliminate the interferences. Once the fault has been eliminated, the module must be removed and inserted or the power switched off and on.
		Internal error	Replace module
	Processor failure	Electromagnetic interference has exceeded limits	Eliminate the interferences. Once the fault has been eliminated, the module must be removed and inserted or the power switched off and on.
		Internal error	Replace module
		Setting of the address switch (DIP switch) not as expected	Check and correct DIP switch settings
Parameter assignment error	Parameter assignment error (19, 20, 21)	Faulty parameter assignment	Check communication paths Correct the parameters
	Parameter assignment error (18)	PROFIsafe address set incorrectly on the fail-safe module	Check whether the PROFIsafe address on the fail-safe module matches the configuration
Sensor voltage or load voltage missing	Internal supply voltage of the module failed	Electromagnetic interference has exceeded limits	Eliminate the interferences. Once the fault has been eliminated, the module must be removed and inserted or the power switched off and on.
		Internal supply voltage error	Replace module

Diagnostic message	Diagnostic buffer	Possible causes of fault	Corrective measures
Safety-related shut-down	DI: Discrepancy error, channel status 0/0	Process signal faulty, sensor may be defective Assigned discrepancy time too short Short circuit between unconnected sensor cable and the sensor supply cable Wire break in connected sensor cable or sensor supply cable	Check process signal, replace sensor if necessary Check the assigned discrepancy time Check the wiring
	DI: Discrepancy error, channel status 0/1		
	DI: Discrepancy error, channel status 1/0		
	DI: Discrepancy error, channel status 1/1		
	Sensor signal chatters	Process signal has exceeded the permitted number of signal changes	Eliminate cause of fault Correct the parameter assignment
	Switching frequency too high	Maximum permitted switching frequency exceeded	Eliminate cause of fault
	Input signal could not be detected clearly	Interference of input signal (e.g., caused by EMC) High-frequency input signal (signal lies above the sampling frequency of the input signal) Brief interruption/ brief short circuit of the sensor line (loose contact) Bouncing of the sensor/switch Internal error in module	Eliminate the error within 100 hours after its occurrence. Otherwise the module changes to the error state (diagnostic buffer message Processor failure). Use shielded line Reduce input frequency Check the contact points and the lines to the sensor Reduce bouncing Replace module
PROFIsafe communication error	CRC signature error	Communication interference between the F-CPU and the fail-safe module, e.g., due to electromagnetic interference in excess of limits or sign-of-life monitoring error.	Check the PROFIBUS connection Eliminate the interference
	Timeout of safety message frame monitoring	Assigned monitoring time exceeded	Check the monitoring time parameter assignment
			Once the fault is eliminated, the fail-safe module must be reintegrated in the safety program

For additional information about passivation and reintegration of F-I/O, refer to Manual S7 Distributed Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/22099875) or S7 F/FH Systems - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/2201072).

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 Chapter "Fault reactions and diagnostics (Page 39)" in this manual as well as to Manual S7 Distributed Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/22099875) and S7 F/FH Systems - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/2201072).

7.1.10 Technical specifications of electronic module 8 F-DI Ex NAMUR

Overview

Technical specifications		
Dimensions and Weight		
Dimensions W x H x D (mm)	30 x 129 x 136.5	
Weight	Approx. 288 g	
Module-specific data		
Supports time stamping	Yes	
Number of inputs		
• 1oo1	8, maximum	
• 1oo2	4, maximum	
Assigned address area		
• In the I/O input area	6 bytes	
• In the I/O output area	4 bytes	
Cable length		
• Unshielded	Max. 200 m (at input delay 3 ms and 15 ms)	
• Shielded [1] and twisted in pairs	Max. 500 m (at input delay 1 ms, 3 ms, 15 ms)	
Maximum achievable safety class in safety mode	1-channel	2-channel
• In accordance with IEC 61508	SIL3	SIL3
• In accordance with EN ISO 13849 -1:	Cat.3 / PLe	Cat.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-09	
Proof-test interval	20 years	
Approvals **Note** The currently valid standards and approvals are stated in the respective certificates available on the Internet (http://www.siemens.com/automation/service&support) and/or are specified on the rating plates.		

Technical specifications		
• ATEX		II 2 G (1) GD Ex ib[ia Ga][ia IIIC Da] IIC T4 Gb and I M2 Ex ib[ia Ma] I Mb KEMA 10 ATEX 0056 
• IECEx		IECEx KEM 10.0027
• INMETRO	 INMETRO  BR OCP-0029	BR-Ex ib [ia] IIC T4 / BR-Ex ib [ia] I
• FM		Class I, Zone 1, AEx ib [ia] IIC T4; Ex ib [ia] IIC T4 NI, Class I, DIV. 2, GP. A,B,C,D T4 AIS, Class I, II, III, DIV. 1, GP. A,B,C,D,E,F,G Class II, III, GP. E,F,G
• cULus		Ind. Cont. Eq. for Use in HAZ.LOC. Class I, Zone 1, AEx ib [ia] IIC T4; Ex ib [ia] IIC T4 ASSOC. APP. CL. I, DIV. 2, GP. A,B,C,D T4 PROVIDING INT. SAFE CIRCUITS FOR CL. I, GP. A,B,C,D; CL. II, III, GP. E,F,G

Voltages, Currents, Potentials	
Number of simultaneously controllable inputs	
• Horizontal installation -20°C to +70°C	8
• Vertical installation -20°C to +50°C	8
Electrical isolation	
• Between channels and backplane bus	Yes
• Between channels	No
• Between channels and power bus	Yes
Permitted potential difference Between different circuits	60 VDC 30 VAC
Test voltages	
• Isolation in the type test tested with	370 VAC for 1 min.
Current consumption	
• From supply voltage (power bus) with 8 x NAMUR sensors (without short circuit at NAMUR sensor)	Max. 135 mA
• From supply voltage (power bus) with unconnected contact	Max. 150 mA
Power dissipation of the module	
• With 8 x NAMUR sensors (without short circuit at NAMUR sensor)	Max. 1.4 W
• With unconnected contact	Max. 1.7 W
Status, Interrupts, Diagnostics	
Status display	

Technical specifications		
Safety mode display	Green LED (SAFE)	
Inputs	Red/green LED per channel	
Diagnostic functions		
• Group fault display	Red LED (SF)	
• Diagnostic information can be read out	Yes	
Sensor Supply Outputs		
Number of outputs	8	
Output voltage	8 VDC	
• Tolerance	±3%	
Sensor selection data[2)]		
Input current for NAMUR sensor • For "1" signal • For "0" signal	According to IEC 60947-5-6 and NAMUR min. 2.1 mA max. 1.2 mA	
Input current for 10 kΩ connected contact • For "1" signal • For "0" signal	 min. 2.1 mA max. 1.2 mA	
Input current for open contact • For "1" signal • Permissible quiescent current	 Typically 9.5 mA 0.5 mA	
Switching frequency	See the section "Requirements for the duration of the sensor signals" in the chapter "Requirements for Sensors and Actuators (Page 36)"	
Input delay	Can be assigned separately for each input (except with 1oo2 evaluation)	
• For "0" after "1"	Typically 1 ms	(0.7 ms to 1.4 ms)
	Typically 3 ms	(2.5 ms to 3.5 ms)
	Typically 15 ms	(14 ms to 16 ms)
• For "1" after "0"	Typically 1 ms	(0.7 ms to 1.4 ms)
	Typically 3 ms	(2.5 ms to 3.5 ms)
	Typically 15 ms	(14 ms to 16 ms)
Input characteristic	According to IEC 60947-5-6 and NAMUR	
Time, Frequency		
Internal processing times	Refer to chapter "Response times (Page 147)"	
Acknowledgment time	Max. 26 ms	
Minimum sensor signal duration	See the section "Requirements for the duration of the sensor signals" in the chapter "Requirements for Sensors and Actuators (Page 36)"	
[1)] Shielded cables must be used for the digital inputs and the sensor supply. [2)] For more information on the requirements for sensors and actuators, refer to chapter "Wiring and fitting modules (Page 33)".		
Safety notice		
See EC type-examination certificate	KEMA 10 ATEX 0056	

See also

Digital electronic modules (Page 57)
Electromagnetic compatibility (Page 54)

7.2 Digital electronic module 4 F-DO Ex 17.4V/40mA

7.2.1 Properties of digital electronic module 4 F-DO Ex 17.4V/40mA

Order number

6ES7138-7FD00-0AB0

Properties

The digital electronic module 4 F-DO Ex 17,4V/40mA has the following properties:

- Suitable for connecting actuators from the hazardous area
- 4 outputs, PP-switching (SIL3/Cat.4/PLe)
- Electrically isolated from the power bus/backplane bus
- Output current max. 40 mA
- Rated load voltage 17.4 VDC
- Short circuit, overload, and wire-break monitoring
- Suitable for Ex i solenoid valves, DC relays, and actuators
- To increase performance, you can connect two digital outputs in parallel for an actuator. This performance increase is **only allowed on the same module** and between the following channels:
  - Channel 0 and Channel 1: Jumper from Terminal 3 to 7; DO connection to Terminal 1
  - Channel 2 and Channel 3: Jumper from Terminal 11 to 15; DO connection to Terminal 9
- Group fault display (SF LED; red)
- Safety mode display (SAFE LED; green)
- Status/channel fault display per output (green/red LED)
- Assignable diagnostics
- Assignable diagnostic interrupt
- Module-internal diagnostic buffer available
- Firmware update
- I&M identification data

- Channel-by-channel passivation
- Can be used only in safety mode

Note

The fail-safe performance characteristics in the technical specifications apply to a proof-test interval of 20 years and a mean time to repair of 100 hours.

"Keep last valid value" parameter assignment

WARNING

When "Keep last valid value" is assigned, the last valid process value 0 *or* 1 is kept in the case of events such as interruption of the PROFIsafe communication or a stop of the F-CPU.

For more information, refer to Chapter "Response of the fail-safe output module with parameter setting "Keep last valid value" (Page 41)".

Reference

For the I&M identification data, refer to the chapter of the same name in Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789).

7.2.2 Terminal assignment of electronic module 4 F-DO Ex 17.4V/40mA

Front view

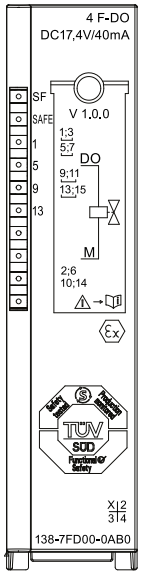
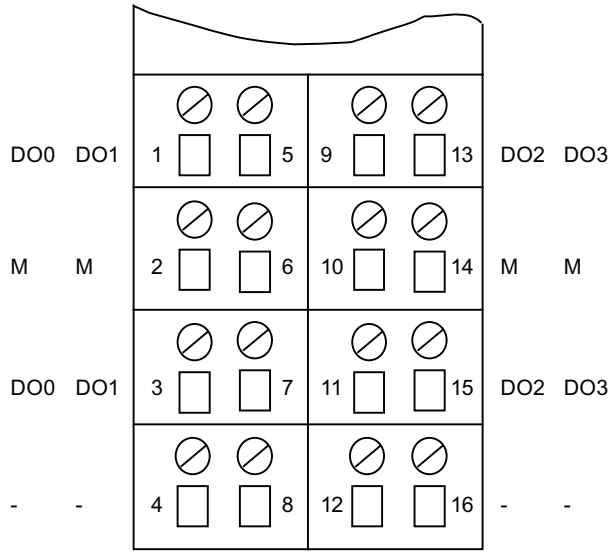


Figure 7-5 Front view 4 F-DO Ex 17,4V/40mA

Terminal assignment

The figure below shows the terminal assignment of electronic module 4 F-DO Ex 17,4V/40mA for the supported terminal modules TM-IM/EM 60C, TM-EM/EM 60S and TM-EM/EM 60C.



DO Fail-safe digital output

M Ground

Figure 7-6 Terminal assignment TM-IM/EM 60C, TM-EM/EM 60S and TM-EM/EM 60C for 4 F-DO Ex 17,4V/40mA

7.2.3 Block diagram of electronic module 4 F-DO Ex 17.4V/40mA

Block diagram

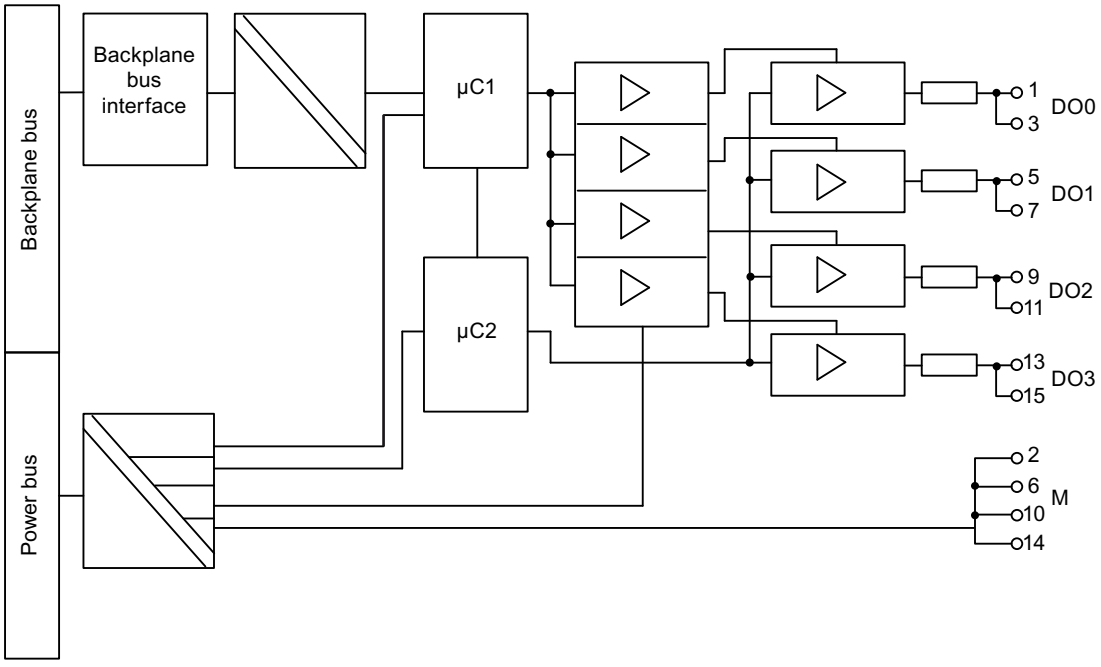


Figure 7-7 Block diagram 4 F-DO Ex 17,4V/40mA

7.2.4 Parameters for electronic module 4 F-DO Ex 17.4V/40mA

Parameters

The table below lists the parameters that can be set for electronic module 4 F-DO Ex 17,4V/ 40mA.

Table 7-10 Parameters of the 4 F-DO Ex 17,4V/40mA

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 (ms)	10 to 65535	2500	Static	Module
Module parameters:				
Behavior after channel fault[1)]	Passivate the entire module/Passivate the channel	Passivate the entire module	Static	Module

Parameter	Range	Default	Type of parameter	Effective range
Behavior at CPU STOP	Switch to fail-safe value "0"/Keep last valid value	Switch to fail-safe value "0"	Static	Module
Maximum test time (s)	100; 1000	1000	Static	Module
Parallel connection Channel 0-1 / 2-3	Yes/No	No	Static	Channel
Channel n				
Activated	Activated/deactivated	Activated	Static	Channel
Light test activated	Activated/deactivated	Deactivated	Static	Channel
Light test time (ms)	0.8 ...5.0	0.8	Static	Channel
Max. readback time dark test (ms)	0.8; 1; 5; 10; 20; 50	1	Static	Channel
Diagnostics				
Short-circuit level (Ω)	Single-channel: 40, 80, 160, 200 Parallel connection: 40, 80	Single-channel: 80 Parallel connection: 40	Static	Channel
Overload	Activated/deactivated	Deactivated	Static	Channel
Wire break	Activated/deactivated	Activated	Static	Channel
Channel n+1				
Activated	Activated/deactivated	Activated	Static	Channel
Light test activated	Activated/deactivated	Deactivated	Static	Channel
Light test time (ms)	0.8 ...5.0	0.8	Static	Channel
Max. readback time dark test (ms)	0.8; 1; 5; 10; 20; 50	1	Static	Channel
Diagnostics				
Short-circuit level (Ω)	Single-channel: 40, 80, 160, 200 Parallel connection: 40, 80	Single-channel: 80 Parallel connection: 40	Static	Channel
Overload	Activated/deactivated	Deactivated	Static	Channel
Wire break	Activated/deactivated	Activated	Static	Channel

[1] This setting is only relevant when optional package *S7 Distributed Safety* V5.4 or higher is installed.

Maximum test time parameter

You can use the "Max test time (ms)" parameter to set the time within which the light and dark tests should be performed throughout the module. When this time expires, the tests are repeated.

Parallel connection Channel 0-1 / 2-3 parameter

To increase performance, you can connect two digital outputs in parallel for an actuator. This performance increase is **only allowed on the same module** and between the following channels:

- Channel 0 and Channel 1: Jumper from Terminal 3 to 7; DO connection to Terminal 1
- Channel 2 and Channel 3: Jumper from Terminal 11 to 15; DO connection to Terminal 9

Activated parameter

If you select this check box, the corresponding channel is enabled for signal processing in the safety program.

If you clear the check box, an unused channel is disabled.

Parameters for light test and dark test

The light test and dark test are part of the module-internal bit pattern test. Each output channel has its own two assignable times for the light test and max. readback dark test. This time specifies the maximum duration of the switch-on/switch-off test for the corresponding channel and, thus, also the readback time for the switch-off operation of the channel.

Light test

During the light test, the fail-safe output module switches test-conditioned 1 signals to the output while the output is inactive (process value = 0).

Typically, two light pulses (in case of parallel connection, three light pulses) with the assigned duration occur within the assigned maximum test time at an interval of at least 250 ms for each channel.

If a light pulse returns an error, the same light pulse (i.e., the same bit pattern) is repeated once after 50 ms. If the error continues to occur, the maximum test time is automatically reduced to 60 seconds, a diagnostic message is generated, and the fail-safe output module continues with the next light pulse. If the error has cleared, the fail-safe output module continues immediately with the next light pulse.
In the most unfavorable situation, therefore, up to four light pulses (in case of parallel connection, six light pulses) can occur for each channel within 60 seconds.

The following times can be assigned for the light test (if enabled):

- 0.8 ms - 5.0 ms in 0.1-ms increments

The light test can be disabled per parameter assignment.

You should set a sufficiently long light test time if the relevant channel switches large capacitive loads. If the light test time for an energized capacitive load is set too low, the output channel is passivated with the "Short circuit" diagnostic message because the capacitor does not charge within the switch-on test.

Dark test

During the dark test, the fail-safe output module switches test-conditioned 0 signals to the output while the output is active (process value = 1).

Typically 16 dark pulses with the assigned duration occur within the maximum test time at an interval of at least 50 ms for each channel.

If a dark pulse returns an error, the same dark pulse (i.e., the same bit pattern) is repeated once after 50 ms. If the error continues to occur, the maximum test time is automatically reduced to 60 seconds, a diagnostic message is generated, and the fail-safe output module continues with the next dark pulse. Once the error has gone out, the fail-safe output module will immediately continue with the next dark pulse.
In the worst case scenario, you may have up to 32 dark pulses within 60 seconds per channel.

The following readback times can be assigned for the dark test:

- 0.8 ms, 1 ms, 5 ms, 10 ms, 20 ms, 50 ms

You should set a sufficiently long readback time if the relevant channel switches large capacitive loads. If the readback time for an energized capacitive load is set too low, the output channel is passivated with the "Short circuit" diagnostic message because the capacitor does not discharge within the switch-off test.

Test cycle

A bit pattern is switched simultaneously to the channels. A bit pattern is finished when all the (possibly differently configured) channels have carried out the switch test. Then there is a pause of 50 ms and the next bit pattern is switched to the channels, meaning that the execution duration of a bit pattern depends on the slowest channel (or the largest capacitive load).

However, the "Maximum test time (s)" parameter is a module parameter, i.e., the test cycle for the entire fail-safe output module is performed within the assigned maximum test time. If the bit pattern test is not performed within the assigned time (or the shortened test time in case of error), the module goes into the error state.

In addition to the diagnostic message, the output channel is passivated, but only after a repeated bit pattern error. This is a recognized channel fault and the module behaves correspondingly (either the channel or the entire module is passivated, depending on the parameter assignment).

Effect of the set light and dark test times on the response time of the module

No new process values are switched to the outputs until a bit pattern is active (switch test is carried out). Thus a higher light test time or readback time for the dark test increases the response time of the module.

⚠ WARNING

Through the assigned readback time, short circuits (cross-circuits) to a noise signal with a frequency > 1 / (2 x assigned readback time) Hz can be suppressed (50:50 sampling ratio).

Short circuits (cross-circuits) to an output of the same module are recognized.

Short-circuit level and overload parameters

The electronic current limiting of the individual channels of the fail-safe module monitors the amount of flowing current. When the rated value of the current has been reached (40 mA; with parallel connection, 80 mA), the current limiting is activated. The current limiting circuit increases the internal resistance of the channel by electronic means until the maximum value of the current is reached. However, the increasing internal resistance of the channel at the same time causes the voltage to decrease with decreasing load resistance. This means the less the load resistance, the lower the voltage at the load with the same constant current.

Short-circuit level parameter

The "Short circuit level" parameter determines the value of the load below which the module detects a short circuit and shuts down the channel. That is,

- In the range from where the current limiting becomes active (break point of the output curve) up to the short circuit level, no diagnosis is triggered. The channel remains enabled until the load falls below the short circuit level.

Note

Please note that short-circuits are only diagnosed as such if the short-circuit level is fallen below (200 to 40 Ω). Take the resistance of the signal line to the load into account here, as well.

Short-circuit level and overload parameters

If you use the "Overload" parameter in addition to the "Short circuit level" parameter, the following happens:

- In the range from where the current limiting becomes active (break point of the output curve) up to the short circuit level, an "Overload" diagnosis is triggered and an entry is made in the diagnostic buffer, without the module switching off the channel.
- The "Short circuit level" parameter in turn determines the value of the load below which the module detects a short circuit and shuts down the channel.

⚠ WARNING

Cross-circuits with a resistance > 20 Ω may not be detected with an assigned "short-circuit level" of 40 Ω or 80 Ω.
Also take the resistance of the signal cable into consideration.

Wire break parameter

You can use a wire break test to monitor the connection from the output channel to the actuator.

Selecting this check box enables the wire break monitoring for the relevant channel.

7.2.5 Applications of electronic module 4 F-DO Ex 17.4V/40mA

Applications 1 and 2

Applications 1 and 2 are not applicable since the fail-safe module supports SIL3/Cat.4/PLe (see Chapter "Applications of electronic module 8 F-DI Ex NAMUR (Page 67)").

Application 3

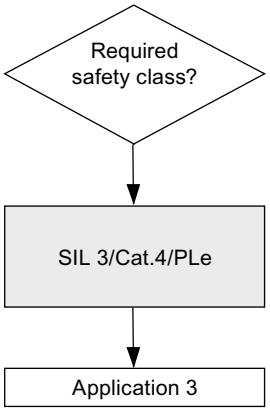


Figure 7-8 Application 3 - electronic module 4 F-DO Ex 17.4V/40mA

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

Introduction

Below are the wiring scheme and the parameter assignment of the 4 F-DO Ex 17,4V/40mA module for Application 3: Safety mode SIL3/Cat.4/PLe.

Diagnostic messages, possible causes of faults, and their corrective measures are found in the corresponding tables in Chapter "Diagnostic functions of electronic module 4 F-DO Ex 17.4V/40mA (Page 95)".

Note

In case of parameter setting with SIL3

The signal at the output has to change at least every 100 hours. If this is not the case with the "0" signal, you will have to activate the light test that meets this condition.

Wiring scheme for Application 3

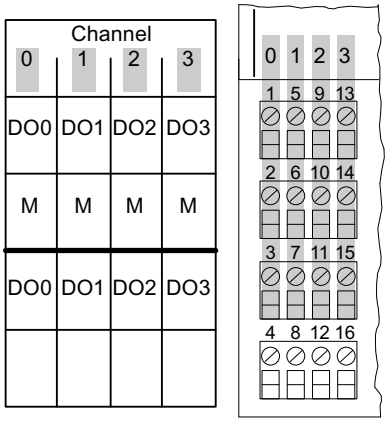
Single-channel connection of one sensor for each process signal. In the ET 200iSP the reference potential M of the supply voltage with respect to the protective conductor is floating.

⚠ WARNING

If you connect the ground of F-DO modules with each other (for example, to control valve terminals with a common ground), you must lay the channels of the F-DO modules in a short-circuit-proof and cross-circuit-proof manner with respect to one another. Alternatively, you can interlink the safety-related shutdown of the F-DO modules by programming means.

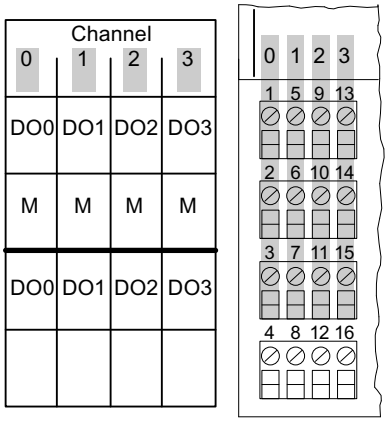
Terminal assignment of the actuators

Table 7-11 Terminal assignment of the actuators

Terminal assignment and view	Remarks
	**Actuator connections**: Channel 0: Terminals 1 and 2 Channel 1: Terminals 5 and 6 Channel 2: Terminals 9 and 10 Channel 3: Terminals 13 and 14 DO: Digital outputs M: Ground

Terminal assignment for performance increase

Table 7-12 Terminal assignment for performance increase

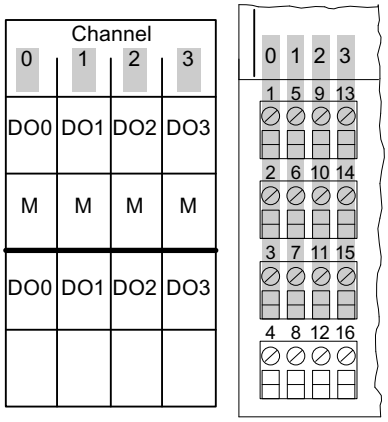
Terminal assignment and view	Remarks
	**Performance increase:** Parallel connection Channel 0 and Channel 1: Actuator to 1 and 2, jumper from 3 to 7 Parallel connection Channel 2 and Channel 3: Actuator to 9 and 10, jumper from 11 to 15 DO: Digital outputs M: Ground

Connecting two actuators to one digital output

One fail-safe digital output can be used to switch two actuators (or more, limitation is based on total current, see "Technical specifications of electronic module 4 F-DO Ex 17.4V/40mA (Page 98)").

The actuators can be wired to any one of the 4 digital outputs. The figure below shows an example of an output wiring. This circuit is compliant with SIL 3/Cat.4/PLe.

Table 7-13 Terminal assignment 2 actuators to 1 digital output

Terminal assignment and view	Remarks
	**Actuator connections**: Channel 0: Terminals 1 and 2 Channel 1: Terminals 5 and 6 Channel 2: Terminals 9 and 10 Channel 3: Terminals 13 and 14 DO: Digital outputs M: Ground

Assignable module parameters for Application 3

Parameter	Range	Type	Effective range
Behavior after channel fault[1)]	Passivate the entire module/ Passivate the channel	Static	Module
Behavior at CPU STOP	Switch to fail-safe value "0"/ Keep last valid value	Static	Module
Maximum test time (s)	100, 1000	Static	Module
Parallel connection Channel 0-1 / 2-3	Yes/No	Static	Channel
Channel: Activated	Activated	Static	Channel
Light test activated	Activated/deactivated	Static	Channel
Light test time (ms)	0.8 ...5.0	Static	Channel
Max. readback time dark test (ms)	0.8; 1; 5; 10; 20; 50	Static	Channel
Diagnostics: Short-circuit level (Ω)	Single-channel: 40, 80, 160, 200 Parallel connection: 40, 80	Static	Channel
Overload	Activated/deactivated	Static	Channel
Wire break	Activated/deactivated	Static	Channel

1) This setting is only relevant when optional package *S7 Distributed Safety* V5.4 or higher is installed.

7.2.7 Diagnostic functions of electronic module 4 F-DO Ex 17.4V/40mA

Diagnostic functions

The table below provides an overview of the diagnostic functions of electronic module 4 F-DO Ex 17,4V/40mA. The diagnostic functions are assigned either to one channel or to the entire module.

Table 7-14 Diagnostic functions of electronic module 4 F-DO Ex 17,4V/40mA

Diagnostic function[1]	Fault number	LED	Effective range of diagnostics	Can be assigned
Short circuit	1_H	Group fault, channel fault display	Channel	No[2]
Overload	4_H	Group fault	Channel	Yes
Overtemperature	5_H	Group fault	Module	No[2]
Line break	6_H	Group fault, channel fault display	Channel	Yes
Fault	9_H	Group fault	Module	No[2]
Parameter assignment error	10_H	Group fault	Module	No[2]
Sensor voltage or load voltage missing	11_H	Group fault	Module	No[2]
Safety-related shutdown	19_H	Group fault, channel fault display	Channel	
• Switching frequency too high				No[2]
PROFIsafe communication error	$1C_H$	Group fault	Module	No[2]

[1] Display in *STEP 7*, see Figure "Channel-specific diagnostics" in Chapter "Slave diagnostics (Page 44)"

[2] Is always diagnosed

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 "Fault reactions (Page 39)".

Note

In case of a capacitative load on the output, a line break will not be reported as of a certain size of the capacity.
Make sure that you take into consideration the capacitance of the signal line (see Chapter "Switching of loads (Page 151)").

Causes of faults and corrective measures

The following table contains the possible causes of the faults and corrective measures for the individual diagnostic messages of EM 4 F-DO Ex 17,4V/40mA.

Table 7-15 Diagnostic messages of electronic module 4 F-DO Ex 17,4V/40mA, causes of faults, and corrective measures

Diagnostic message	Diagnostic buffer	Possible causes of fault	Corrective measures
Short circuit	External short circuit to L+ or cross-circuit between channels	Short circuit of the output	Eliminate the short-circuit within 100 hours after the error has occurred.
		Short circuit between channels with different signals	Eliminate the short-circuit within 100 hours after the error has occurred.
		Defective output driver	Replace module
	Short circuit of output to M, or output driver failure	Output overload	Check the assigned value for "Short-circuit level". Eliminate the overload within 100 hours after the error has occurred.
		Short circuit of output to M	Check the assigned value for "Short-circuit level". Eliminate the short-circuit within 100 hours after the error has occurred.
		Defective output driver	Replace module
Overload (for "1" output signal only)[1)]	Overcurrent at output driver	Overload at output	Eliminate overload
Overtemperature	Temperature outside the permitted range	Shutdown due to violation of upper or lower temperature limit value in the module housing.	Check the ambient temperature. Once the fault has been eliminated, the module must be removed and inserted or the power switched off and on
Line break (for "1" output signal only)[1)]	Wire break	Wire break between the module and actuator	Reestablish the cable connection
		Channel not connected (open)	Disable the "Wire break" diagnostics for the channel in the parameter settings.
		Short circuit between channels with different signals	Eliminate short circuit

Diagnostic message	Diagnostic buffer	Possible causes of fault	Corrective measures
Fault	EPROM fault	Electromagnetic interference has exceeded limits	Eliminate the interferences. Once the fault has been eliminated, the module must be removed and inserted or the power switched off and on.
		Internal error	Replace module
	RAM fault	Electromagnetic interference has exceeded limits	Eliminate the interferences. Once the fault has been eliminated, the module must be removed and inserted or the power switched off and on.
		Internal error	Replace module
	Processor failure	Electromagnetic interference has exceeded limits	Eliminate the interferences. Once the fault has been eliminated, the module must be removed and inserted or the power switched off and on.
		Internal error	Replace module
	Internal error in read/test circuit	Several fault messages exist for the channel. Faults cannot be clearly assigned	Eliminate causes of fault
		Internal error	Replace module
Parameter assignment error	Parameter assignment error (19, 20, 21)	Faulty parameter assignment	Check communication paths Correct the parameters
	Parameter assignment error (18)	PROFIsafe address set incorrectly on the fail-safe module	Check whether the PROFIsafe address on the fail-safe module matches the configuration
Sensor voltage or load voltage missing	Internal supply voltage of the module failed	Electromagnetic interference has exceeded limits	Eliminate the interferences. Once the fault has been eliminated, the module must be removed and inserted or the power switched off and on.
		Internal supply voltage error	Replace module
Safety-related shutdown	Switching frequency too high	Maximum permitted switching frequency exceeded	Eliminate cause of fault
PROFIsafe communication error	CRC signature error	Communication interference between the F-CPU and the fail-safe module, e.g., due to electromagnetic interference in excess of limits or sign-of-life monitoring error.	Check the PROFIBUS connection Eliminate the interference
	Timeout of safety message frame monitoring	Assigned monitoring time exceeded	Check the monitoring time parameter assignment
			Once the fault is eliminated, the fail-safe module must be reintegrated in the safety program

1) Also with output signal "0" if light test is activated.

For additional information about passivation and reintegration of F-I/O, refer to Manual S7 Distributed Safety - Configuring and Programming (http://support.automation.siemens.com/

WW/view/en/22099875) or S7 F/FH Systems - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/2201072).

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 Chapter "Fault reactions and diagnostics (Page 39)" in this manual as well as to Manual S7 Distributed Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/22099875) and S7 F/FH Systems - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/2201072).

See also

Technical specifications of electronic module 4 F-DO Ex 17.4V/40mA (Page 98)

7.2.8 Technical specifications of electronic module 4 F-DO Ex 17.4V/40mA

Overview

Technical specifications	
Dimensions and Weight	
Dimensions W x H x D (mm)	30 x 129 x 136.5
Weight	Approx. 285 g
Module-specific data	
Number of outputs	4
Assigned address area	
• In the I/O input area	5 bytes
• In the I/O output area	5 bytes
Cable length	
• Unshielded	max. 500 m
• Shielded	max. 500 m (see note at end of table)
Maximum achievable safety level in safety mode	
• According to IEC 61508	SIL 3
• In accordance with EN ISO 13849 -1:	Cat. 4 / PLe
Fail-safe performance characteristics	SIL 3
• 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
Proof-test interval	20 years

Technical specifications		
Approvals **Note** The currently valid standards and approvals are stated in the respective certificates available on the Internet (http://www.siemens.com/automation/service&support) and/or are specified on the rating plates.		
• ATEX		II 2 G (1) GD Ex ib[ia Ga][ia IIIC Da] IIC T4 Gb and I M2 Ex ib[ia Ma] I Mb KEMA 10 ATEX 0056  0344
• IECEx		IECEx KEM 10.0028
• INMETRO		BR-Ex ib [ia] IIC T4 / BR-Ex ib [ia] I
• FM		Class I, Zone 1, AEx ib [ia] IIC T4; Ex ib [ia] IIC T4 NI, Class I, DIV. 2, GP. A,B,C,D T4 AIS, Class I, II, III, DIV. 1, GP. A,B,C,D,E,F,G Class II, III, GP. E,F,G
• cULus		Ind. Cont. Eq. for Use in HAZ.LOC. Class I, Zone 1, AEx ib [ia] IIC T4; Ex ib [ia] IIC T4 ASSOC. APP. CL. I, DIV. 2, GP. A,B,C,D T4 PROVIDING INT. SAFE CIRCUITS FOR CL. I, GP. A,B,C,D; CL. II, III, GP. E,F,G

Voltages, Currents, Potentials	
Total current of outputs	172 mA
• Horizontal installation -20°C to +70°C	Min. 40 mA at load voltage min. 10 V
• Vertical installation -20°C to +50°C	Min. 40 mA at load voltage min. 10 V
• With parallel connection	Min. 80 mA at load voltage min. 10 V
Electrical isolation	
• Between channels and backplane bus	Yes
• Between channels	No
• Between channels and power bus	Yes
Permitted potential difference Between different circuits	60 VDC 30 VAC
Test voltages	
• Isolation in the type test tested with	370 V AC for 1 min.
Current consumption	
• From load voltage L + (power bus)	Max. 510 mA
Power dissipation of the module	Max. 5.3 W
Status, Interrupts, Diagnostics	
Status display	
Safety mode display	Green LED (SAFE)

Technical specifications	
Outputs	Red/green LED per channel
Diagnostic functions	
• Group fault display	Red LED (SF)
• Diagnostic information can be read out	Yes
Fail-safe values	Switch to fail-safe value "0"/Keep last valid value
Monitoring for	
• Short circuit	R < 200 Ω (one output) R < 80 Ω (outputs connected in parallel)
• Wire break	I < 500 µA (one output) I < 1 mA (outputs connected in parallel)
Actuator selection data	
No-load voltage U_{AO}	Min. 17.4 V
Internal resistance R_i	167.1 Ω
Curve transition points E	
• Voltage U_E	Min. 10 V
• Current I_E	Min. 40 mA
Output delay (with resistive load)	
• For "0" after "1"	1 ms
• For "1" after "0"	1 ms
Parallel switching of 2 outputs	
• For redundant load control	Not permitted
• For power increase	Possible
Control of a digital input	Not permitted
Switching frequency (See chapter "Switching of loads (Page 151)")	
• With resistive load	30 Hz
• With inductive load in accordance with IEC 60947-5-1, DC13	2 Hz
Short-circuit protection of output	Yes, electronic
• Response threshold	depending on the "Short-circuit level" parameter (see chapter "Parameters for electronic module 4 F-DO Ex 17.4V/40mA (Page 87)")
Output voltage	
• For "1" signal	Max. 17.4 V
Output current	
• For "0" signal (residual current)	< 10 µA
Load resistance range	
• Up to 40 °C	270 Ω to 18 kΩ
• Up to 60 °C	

Technical specifications		
Actuator timing requirements	Actuator must not respond if: • Dark period < 0.9 ms • Light period < 0.9 ms (also refer to chapter "Requirements for Sensors and Actuators (Page 36)")	
Time, Frequency		
Internal Preprocessing Time	7 - 12 ms	depending on the parameters "Light test time/max. maximum readback time dark test" (see chapter "Parameters for electronic module 4 F-DO Ex 17.4V/40mA (Page 87)" and "Response times (Page 147)") and load response (see chapter "Switching of loads (Page 151)")
Acknowledgment time	9.8 - 59 ms	
Safety notice		
See EC type-examination certificate	KEMA 10 ATEX 0057	

Note

To reach the specified maximum cable length, it may be necessary to increase the settings for the light test time or maximum readback time dark test.

We also recommend a more detailed consideration of the boundary conditions, such as EMC, cables used, cable guide, etc. You may have to routes the channels in various cables

The channels of fail-safe output modules must be wired separately from the channels of fail-safe input modules.

The switching frequency for process value change must not exceed the response time (see chapter "Response times of fail-safe digital output modules (Page 149)").

Output characteristics of electronic module 4 F-DO Ex 17,4V/40mA

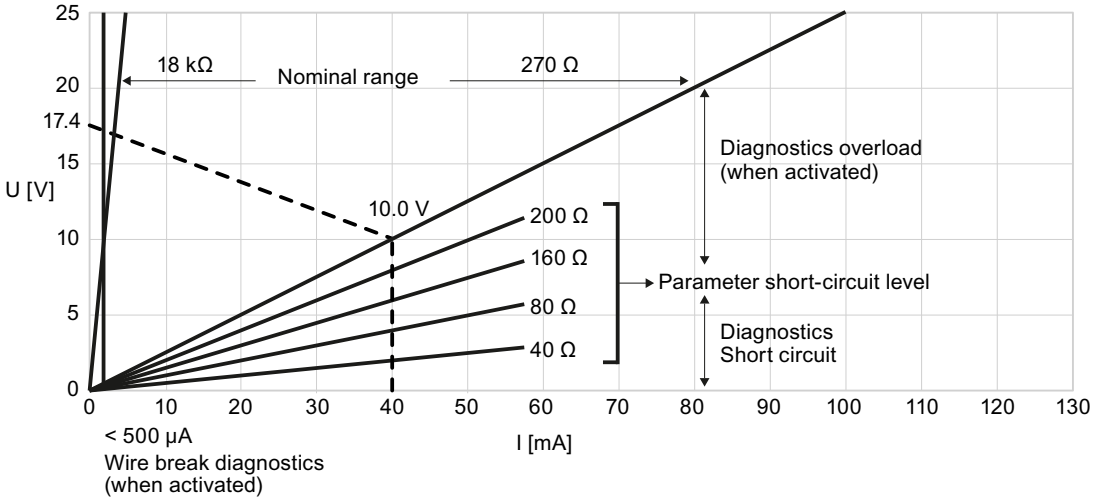


Figure 7-9 Output characteristics for electronic module 4 F-DO Ex 17,4V/40mA - one output

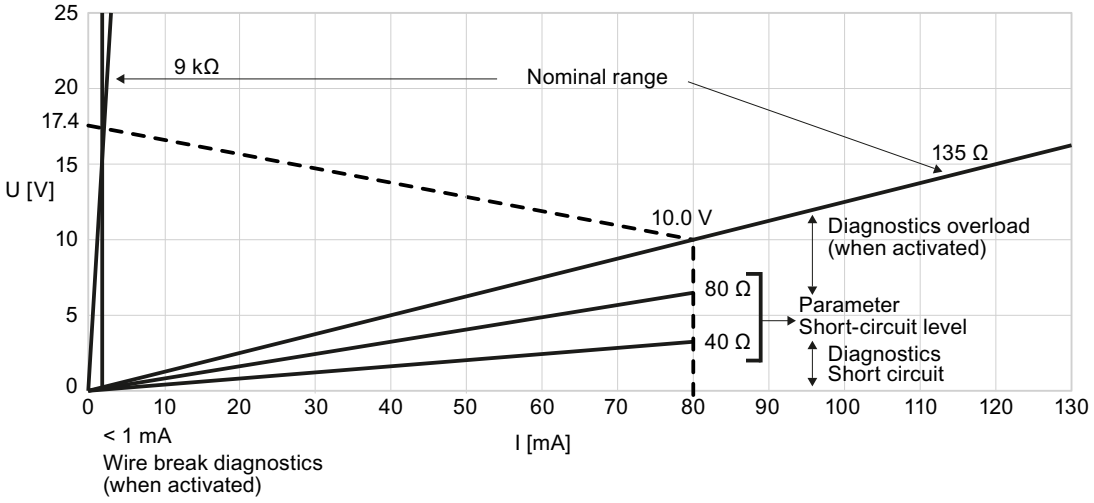


Figure 7-10 Output characteristics for electronic module 4 F-DO Ex 17,4V/40mA - two outputs connected in parallel

Analog electronic modules

8

8.1 Analog electronic module 4 F-AI Ex HART

8.1.1 Properties of analog electronic module 4 F-AI Ex HART

Order number

6ES7138-7FA00-0AB0

Properties

The 4 F-AI Ex HART analog electronic module has the following properties:

- Suitable for connecting sensors from the hazardous area
- 4 analog inputs via 1-channel (SIL3/Cat.3/PLe) or 4 inputs via 2-channel (SIL3/Cat.4/PLe, with two 4 F-AI Ex HART modules), with electrical isolation between channels and backplane bus
- Input ranges:
  - 0 to 20 mA
  - 4 to 20 mA
- Suitable for the following sensors
  - 2-wire measuring transducer
  - HART field devices
- 4 short-circuit-proof sensor supplies (min. 12 VDC/ max. 26 VDC), for one channel each, electrically isolated from the backplane bus
- Group fault display (SF LED; red)
- Safety mode display (SAFE LED; green)
- Channel fault display for each channel (red LED)
- Display for HART status for each channel (green LED)
  (If you have activated HART communication for a channel and HART communication is running, the green HART status display lights up.)
- Assignable diagnostics
- Assignable diagnostic interrupt
- Module-internal diagnostic buffer available
- HART communication (HART protocol Versions 5, 6, 7)
- Firmware update

- I&M identification data
- Can be used only in safety mode

Note

The fail-safe performance characteristics in the technical specifications apply to a proof-test interval of 20 years and a mean time to repair of 100 hours.

Use of inputs

You can use the inputs as follows:

- Each of the 4 channels for current measurement
  - 0 to 20 mA (without HART utilization)
  - 4 to 20 mA (with/without HART utilization)
- Functional range of HART communication: 1.17 to typ. 26 mA

Note

The fail-safe performance characteristics in the technical specifications apply to a proof-test interval of 20 years and a mean time to repair of 100 hours.

Reference

For the I&M identification data, refer to the chapter of the same name in Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789).

8.1.2 Terminal assignment of electronic module 4 F-AI Ex HART

Front view

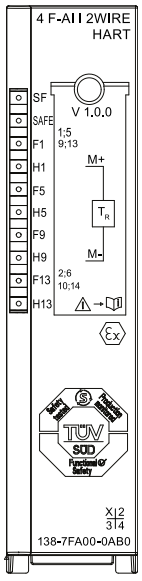
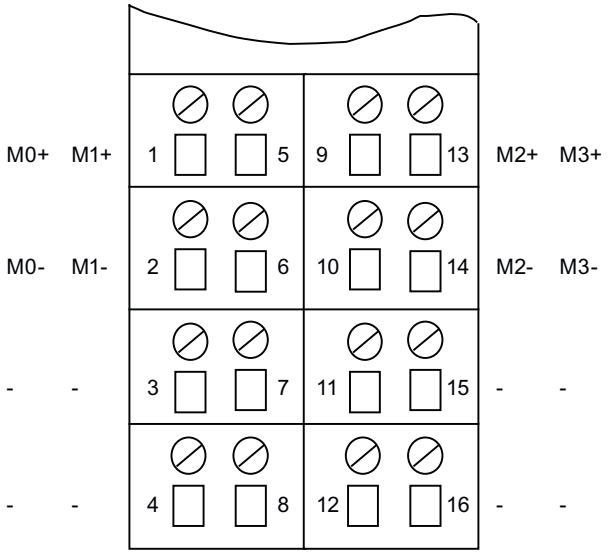


Figure 8-1 Front view 4 F-AI Ex HART

Terminal assignment

The figure below shows the terminal assignment of electronic module 4 F-AI Ex HART for the supported terminal modules TM-IM/EM 60C, TM-EM/EM 60S and TM-EM/EM 60C.



M Measuring transducer

Figure 8-2 Terminal assignment TM-IM/EM 60C, TM-EM/EM 60S and TM-EM/EM 60C for 4 F-AI Ex HART

8.1.3 Block diagram of electronic module 4 F-AI Ex HART

Block diagram

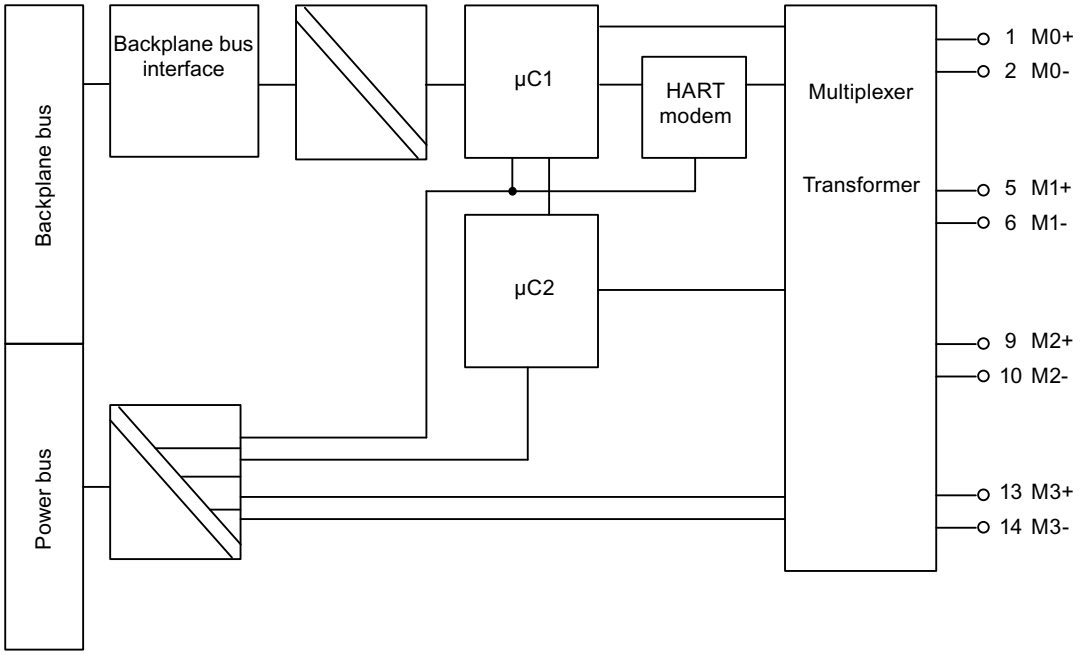


Figure 8-3 Block diagram 4 F-AI Ex HART

8.1.4 Parameters for electronic module 4 F-AI Ex HART

Parameters

The table below lists the parameters that can be set for electronic module 4 F-AI Ex HART.

Table 8-1 Parameters of the 4 F-AI Ex HART

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 (ms)	10 to 65535	2500	Static	Module
Module parameters:				
Behavior after channel fault[1)]	Passivate the entire module/Passivate the channel	Passivate the entire module	Static	Module

Parameter	Range	Default	Type of parameter	Effective range
Interference frequency suppression	50 Hz/60 Hz	Is taken from configuration of the IM	Static	Module
HART Fast Mode	On/Off	Off	Static	Module
Channel 0 - 3				
Activated	Activated/deactivated	Activated	Static	Channel
Measuring range	4..20 mA / 0..20 mA	4...20 mA	Static	Channel
Smoothing	1, 4, 16, 64 conversion cycles	1 conversion cycle	Static	Channel
HART gate	On/Off/Can be switched	Off	Static	Channel
HART repetitions	0 to 10	1	Static	Channel
Diagnostics				
Wire break	Activated/deactivated	Activated	Static	Channel
HART diagnostics	Activated/deactivated	Deactivated	Static	Channel
HART warning	Activated/deactivated	Deactivated	Static	Channel
HART secondary variables				
Secondary value 1 - 4				
IEEE variables	None/ Primary variable/ 1st secondary variable/ 2nd secondary variable / 3rd secondary variable	None	Static	Channel
Channel	0 / 1 / 2 / 3	0	Static	Channel

[1] This setting is only relevant when optional package *S7 Distributed Safety* V5.4 or higher is installed.

Interference frequency suppression parameter

The frequency of your alternating voltage system can have an interfering effect on the measured value in particular when measuring in low voltage ranges and with thermocouples. Enter the power frequency here that is used in your system (50 Hz or 60 Hz).

The interference frequency suppression parameter is valid for all the analog electronic modules. Through the parameter, the integration time and also the conversion time of the individual modules are also specified.

Reference

For further information refer to Chapter "Technical specifications of electronic module 4 F-AI Ex HART (Page 137)".

HART Fast Mode parameter

When HART Fast Mode is enabled, HART electronic modules support processing of HART commands as SHC sequences (Successive HART Command).

Device data is loaded faster in HART Fast Mode.

When a HART command with set SHC bit for a channel is detected by the electronic module, the complete HART command processing is reserved on the electronic module for that channel for about 2 seconds. No HART command processing is performed for any other channels of the electronic module during this time.

For each subsequent HART command with set SHC bit, the electronic module reserves the HART command processing for that channel again for another 2 seconds. If a HART command without set SHC bit is detected for this channel, or if no other command for the channel occurs within 2 seconds of the previous HART command, the electronic module returns to "normal" HART command processing. Result: All HART channels are processed again.

Note

- While a HART channel of the electronic module processes an SHC string, i.e., the complete HART processing of the electronic module for this channel is reserved, the HART variables of all HART channels are no longer updated. They remain unchanged in the value and quality code.
- HART commands for other channels are not processed and are acknowledged accordingly.
- If a HART channel is operated by several clients (e.g., SIMATIC PDM, user program), the answer provided by the electronic module cannot be reliably assigned to a specific client. The HART electronic modules do not support client management.

As of V6.0 SP5, PDM supports processing of HART commands with SHC strings. For this you need to additionally activate "HART RIO SHC Mode" in PDM in the "Communication" tab under "**Options > Settings**".

Activated parameter

If you select this check box, the corresponding channel is enabled for signal processing in the safety program.

If you clear the check box, an unused channel is disabled.

Measuring range parameter

You can set the measuring range for the channel here:

- 4 ... 20 mA
- 0 ... 20 mA

When a channel is disabled, the corresponding measuring range cannot be selected.

Smoothing parameter

Smoothing of analog values provides a stable analog signal for further processing.

You configure smoothing in a maximum of 4 levels (1, 4, 16, 64). The level determines the number of analog signals that are averaged.

WARNING

The stronger the smoothing, the more stable the smoothed analog value is, and the longer it takes to apply the smoothed analog signal following a step response and for the module to react (response time to error).

Reference

For further information and an example of smoothing, refer to Chapter "Smoothing" in Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789).

HART gate parameter and HART parameter in the HART parameter records 131 to 134

See Chapter "HART for safety-related applications (Page 114)".

HART repetitions parameter

With this parameter you can set the number of repetitions until the output of a diagnosis when a HART communication error occurs.

Note

If HART communication is not established, the repeated attempts to establish a HART communication can take up more time, depending on the assigned number of repetitions.

Wire break parameter

Here you can specify if a wire break can be detected for each channel within a configured measuring range of 4 ... 20 mA.

In the case of an assigned measurement range of 4 ... 20 mA:

- With assigned fail-safe wire break detection and currents < 3.6 mA, a wire break is detected and a diagnostic interrupt is triggered in the F-CPU.
- Without fail-safe wire break detection and currents < 0.4444 mA, "underflow" is detected and a diagnostic interrupt is triggered in the F-CPU.

In the case of an assigned measurement range of 0 ... 20 mA, the fail-safe wire break detection is permanently set by default. With currents < 0.4442 mA, a wire break is detected and a diagnostic interrupt is triggered in the F-CPU.

If you do not need an open channel and wire break diagnostics is not assigned for this channel, disable it.

HART diagnostics parameter

If this parameter is enabled, a diagnostic interrupt is triggered for the following HART diagnostics (see Table "Possible error types of fail-safe modules" in Chapter "Slave diagnostics (Page 44)"):

- HART analog output current specified
- HART analog output current saturated
- HART communication error
- HART primary variable outside the limits
- HART secondary variable outside the limits
- Faults of the HART field device

HART warning parameter

If this parameter is enabled, a diagnostic interrupt is triggered for the following HART warnings (see Table "Possible error types of fail-safe modules" in Chapter "Slave diagnostics (Page 44)"):

- Additional HART status available (is deleted after 30 s)
- HART configuration changed

IEEE variable parameter (HART secondary variable)

With the 4 F-AI Ex HART electronic module you can additionally read the analog value of up to 4 IEEE variables. These variables are shown in IEEE 754 format. This is the float format according to IEEE Standard 754 Short Real Number (floating point format).

HART command 3 is used to read HART variables.

Each IEEE variable is accompanied by a status byte "Quality Code". The status provides information on the validity of the measurement result.

The meaning of the IEEE variables depends on the HART field device, whereby IEEE Variable 1 always corresponds to the analog value.

A secondary value contains one of the possible IEEE variables (including the status byte) for an arbitrary channel. For each secondary value (1, 2, 3, and 4), a specific area is reserved in the process image input.

By assigning an IEEE variable and channel for a secondary value, you set the addresses for this IEEE variable (including the status byte).

There is a HART variable record 121 containing the 4 HART variables for each 4 F-AI Ex HART electronic module. These HART variables can be freely ordered through the HART mapping data record 140 using the channel-specific parameters "IEEE-variable" and "Channel". See Chapter "HART data record interface (Page 119)".

Channel parameter

Use this parameter to assign the channels to IEEE variables.

You can find additional information and an example for assigning IEEE variables in the section "Assigning channel and IEEE variables" of Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789).

Additional information

Further information is available in Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789):

- About HART communication generally in Chapter "HART basics"
- About the parameter assignment of HART variables in Chapter "Parameter description of the analog electronic modules"

8.1.5 User data interface

8.1.5.1 Structure of the user data

Input user data area

The figure below shows the structure of the input user data area of the HART analog module.

You can read in the data of the user data area from the process image and evaluate it in your user program. For this purpose, see Chapter "F-I/O access" in Manual "S7 F/FH Systems - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/2201072) or S7 Distributed Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/22099875).

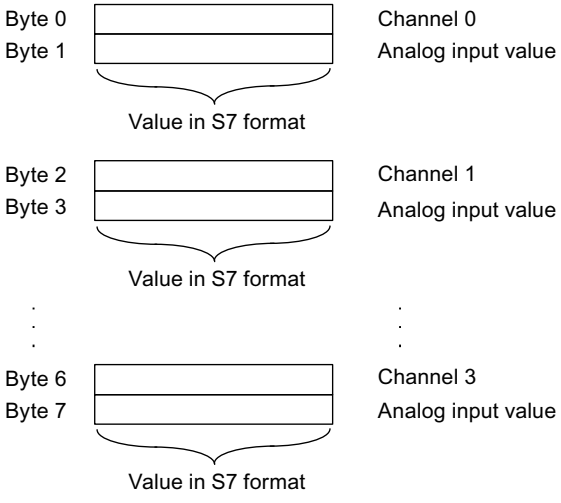


Figure 8-4 Input user data area of the HART analog module

8.1.5.2 Analog value representation

Measuring value range 0 to 20 mA

Table 8-2 Measuring value range 0 to 20 mA

Measuring range	Unit		Wire-break check: Yes	
0 to 20 mA	Decimal	Hexadecimal	Diagnostic message	Value
> 23.518 mA	32512	7F00	Overflow	$7FFF_H$
23.518 mA : 20.0007 mA	32511 : 27649	7EFF : 6C01		
20 mA : 0.4442 mA	27648 : 614	6C00 : 266		
< 0.4442 mA : 723.4 nA **0 mA**	613 : 1 0	265 : 1 0	Wire break	$7FFF_H$

Wire-break check in the range of 0 to 20 mA

In the range 0 to 20 mA, a wire-break check is always performed:

- Wire break at < 0.4442 mA is signaled in *S7 F/FH Systems* with $7FFF_H$, and the fail-safe value assigned in the SUBS_V input of the F-channel driver is output. In *S7 Distributed Safety*, the fail-safe value "0" is provided in the PII for the safety program in place of $7FFF_H$.

Measuring value range 4 to 20 mA

Table 8-3 Measuring value range 4 to 20 mA

Measuring range	Unit		Wire-break check: No		Wire-break check: Yes	
4 to 20 mA	**Decimal**	**Hexadecimal**	**Diagnostic message**	**Value**	**Diagnostic message**	**Value**
> 22.814 mA	32512	7F00	Overflow	$7FFF_H$	Overflow	$7FFF_H$
22.814 mA : 20.0006 mA	32511 : 27649	7EFF : 6C01				
20 mA : 4 mA + 578.7 nA **4 mA**	27648 : 1 0	6C00 : 1 0				
3.9994 mA : 3.6 mA	-1 : -691	FFFF : FD4D				
< 3.6 mA : 0.4444 mA	-692 : -6144	FD4C : E800			Wire break	$7FFF_H$
< 0.4444 mA	-6145	E7FF	Underflow	8000_H		

Wire-break check and underflow check in the range 4 to 20 mA

In the range 4 to 20 mA, a check is made to determine whether wire-break check is assigned.

- If wire-break check is assigned, an underflow check is not performed. Wire break at < 3.6 mA is signaled in *S7 F/FH Systems* with $7FFF_H$, and the fail-safe value assigned in the SUBS_V input of the F-channel driver is output. In *S7 Distributed Safety*, the fail-safe value "0" is provided in the PII for the safety program in place of $7FFF_H$.
- If no wire break check is assigned, an underflow at < 0.4444 mA is signaled in *S7 F/FH Systems* with 8000_H, and the fail-safe value will be output as assigned in the SUBS_V input of the F-channel driver. In *S7 Distributed Safety*, the fail-safe value "0" is provided in the PII for the safety program in place of 8000_H (for underflow).

See also Operating Instructions "ET 200iSP distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789)".

Measured value resolution

The 4 F-AI Ex HART electronic module has a 15-bit resolution.

Table 8-4 Representation of the bit pattern

Bit number	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Bit significance	SN*	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

* = Sign

Table 8-5 Resolution

Measuring range	% of nominal range	Resolution (1 digit)
0 to 20 mA	0.0036	723.4 nA
4 to 20 mA	0.0036	578.7 nA

8.1.6 HART for safety-related applications

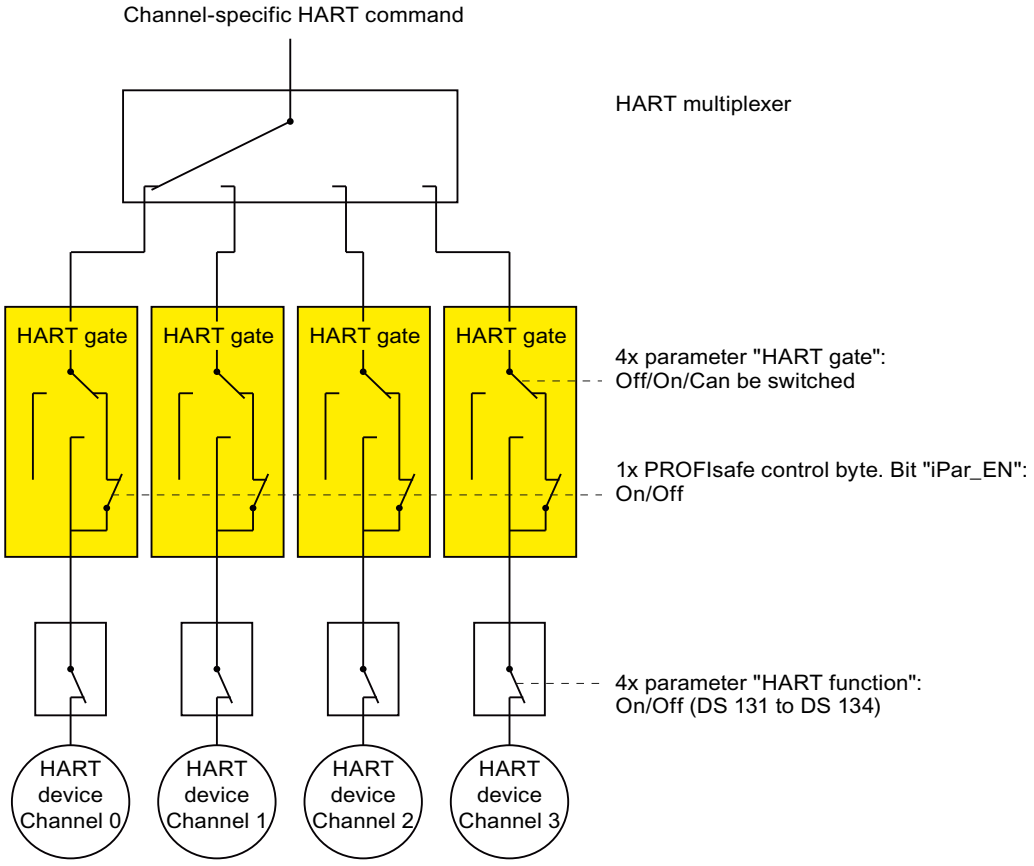
Introduction

You assign the HART function with the following parameters.

WARNING
The HART protocol is not a safety-related protocol!

"HART gate" parameter

The "HART gate" parameter is used to enable the HART communication channel-specifically. The "HART gate" parameter acts as a **fail-safe** "main switch".



The following parameters of "HART gate" can be assigned:

- **"Off"**: HART communication is disabled.
- **"On"**: HART communication is enabled.
- **"Can be switched"**: The HART communication can be activated and deactivated from the safety program (*S7 Distributed Safety* or *S7 F Systems*), provided the modules are in RUN mode. This means that the HART communication with HART field devices can be activated and deactivated during operation of the F-CPU (e.g. for maintenance purposes).
  If you set the IPAR_EN variable of the F-I/O DB or of the F_CH_AI F-channel driver to "1" in the safety program, HART communication is enabled for the channels with "can be switched" assignment. If the setting is "0", HART communication is disabled. The module acknowledges the enabled or disabled HART communication with variable IPAR_OK = "1" or "0" in the F-I/O DB or in the F_CH_AI F-channel driver.
  Do not enable the HART communication until the status of your system allows the parameters of the associated HART field device to be safely reassigned (for example monitored operation).
  If you are using redundantly configured modules in *S7 F Systems*, you must set the IPAR_ENR variable of the F_CH_AI F-channel driver to "1" to enable the HART communication to the redundant HART field device. The redundantly configured module acknowledges the enabled or disabled HART communication with variable IPAR_OK = "1" or "0" in the F_CH_AI F-channel driver.

⚠ WARNING

For module channels with HART devices **without** write protection, the following applies to an SIL 2/3 application: as soon as you assign the HART gate to "on", the input values of the channels must be checked for plausibility, e.g., by performing a comparison with the equivalent value of a further module in monitored operation in the user program. Optionally, the module can also be taken out of the safety function of the system for this time.

⚠ WARNING

In the case of a HART gate with "On" assignment, a connected HART communicator can be used to reassign the HART field device of this channel.

Note: The use of a HART communicator to reassign the HART field device parameters is **not** a safety-related operation and is therefore only permitted in safety mode under monitoring ("monitored operation").

Example of enabling HART communication in S7 F Systems

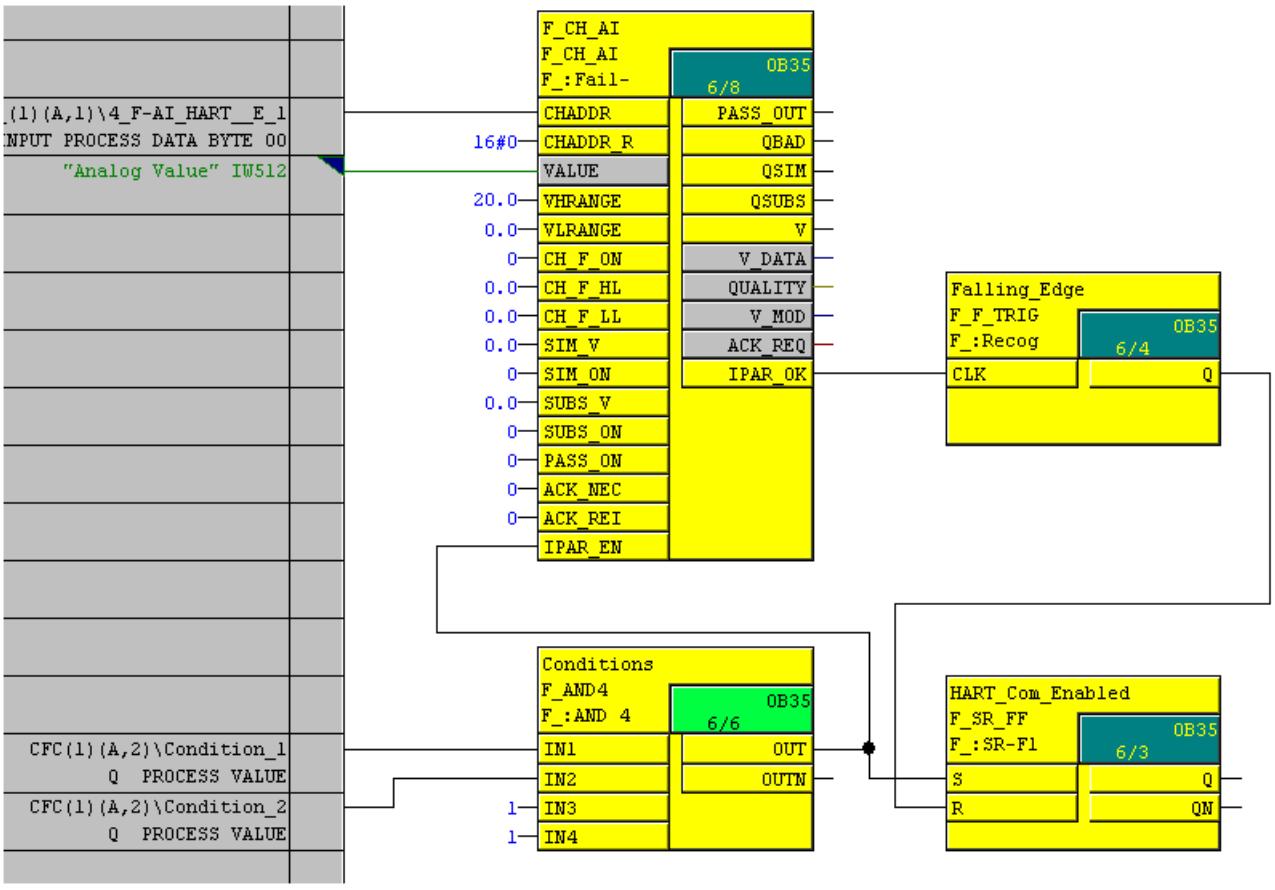


Figure 8-5 Example of enabling HART communication in *S7 F Systems*

Example of enabling HART communication in S7 Distributed Safety

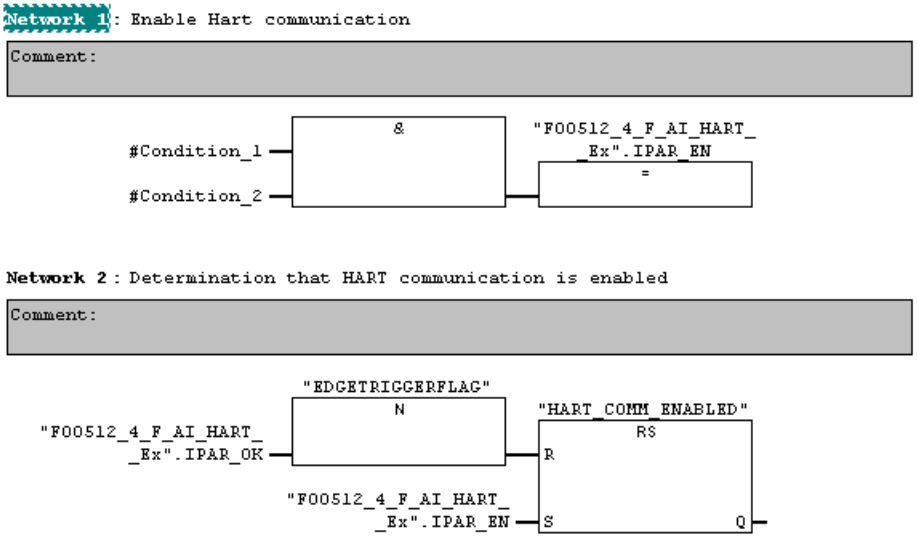


Figure 8-6 Example of enabling HART communication in *S7 Distributed Safety*

Note

HART diagnostics is only available when HART communication is possible. This also applies to *PCS 7* maintenance stations.

However, the module diagnostics is always available.

HART parameter in the parameter records 131 to 134

Use the "HART" parameter (Byte 6, Bit 0 in DS 131 - 134) to switch the HART communication for the respective channel of the module to the HART field device (= default) on or off. The parameter is **not safety-related**, which means you cannot use this parameter for **fail-safe shutdown** of the HART communication.

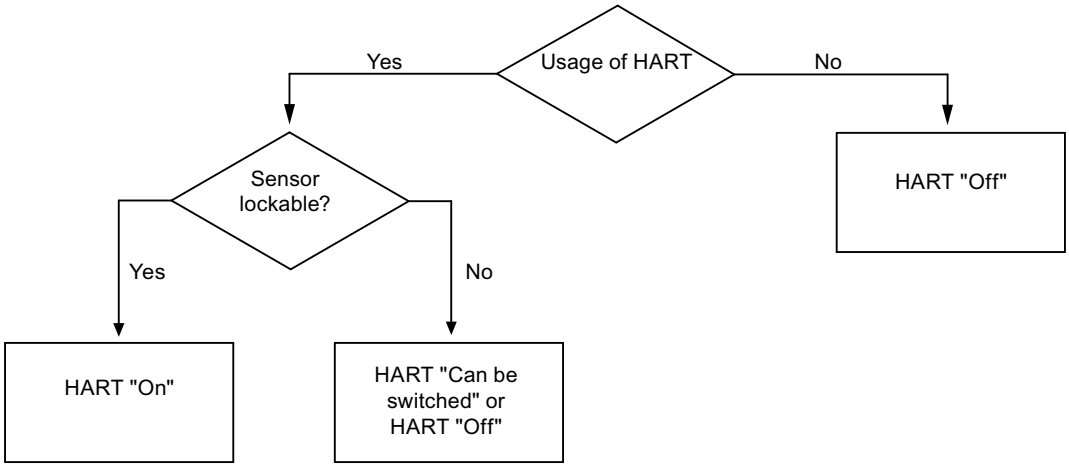
See Chapter "HART data record interface (Page 119)".

Activating HART according to the sensor used

The use of HART communication in safety-related applications is dependent on the HART-capable sensors you are using. There are two applications:

- Only HART field devices with write protection switches are used.
- HART field devices without write protection switches are used.

The following figure shows the HART communication parameter assignment permissible for safety mode as a function of the sensor:



Procedure

HART field devices with write protection switch

In normal safety mode of the fail-safe module the write protection of all the HART field devices has to be activated.

Only use the HART communication to write HART commands if this is possible without any danger (for example in monitored operation).

If a write operation is required (for example for parameter assignment), proceed as follows:

1. Set the channel-specific parameter "HART gate" to "On".
2. Deactivate the write protection at the HART field device.

After the HART commands have been written, you must

1. Activate the write protection at the HART field device again
2. Check whether the HART field device functions properly.

HART field devices without write protection switch

In normal safety mode of the fail-safe module, the HART communication has to be deactivated for all the channels with HART field devices without write protection ("HART gate" parameter in the "Off" setting).

Only use the HART communication to write HART commands if this is possible without any danger (for example in monitored operation).

If a write operation is required (for example for parameter assignment), proceed as follows:

1. Set the channel-specific "HART gate" parameter to "Can be switched".
2. Set the channel-specific "HART" parameter in the parameter records 131 to 134 to "1" (= default).
3. Set the IPAR_EN variable of the F-I/O DB or of the fail-safe channel driver F_CH_AI in the safety program to "1". You must evaluate the acknowledgement by the fail-safe module with the variable IPAR_OK = 1 in your safety program (see above).

After the HART commands have been written, you must

1. Disable the HART communication again (variable IPAR_EN = 0). Here, you also evaluate the acknowledgement by the fail-safe module with the variable IPAR_OK = 0 in your safety program.
2. Check the correct functioning of **all** the HART field devices connected to this fail-safe module, because the IPAR_EN variable enables HART communication for the complete module, meaning that all the channels whose "HART gate" parameter is set to "Can be switched" are affected.

Additional information

The Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789) provides additional information:

- About HART communication generally in Chapter "HART basics"
- About the parameter assignment of HART variables in Chapter "Parameter description of the analog electronic modules"

For further information about the F-I/O DB refer to Manual S7 Distributed Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/22099875).

For further information about the F_CH_AI fail-safe channel driver, refer to Manual SIMATIC Industry Software S7 F/FH Systems - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/2201072).

8.1.7 HART data record interface

8.1.7.1 Overview of the HART data record interface

Introduction

In this chapter you will find the specific data that you require for parameter assignment, diagnostics, and HART communication if you go beyond the standard applications of *STEP 7* or want to use your own configuration tool for HART communication.

Overview of the data record interface

The module uses data records as an input/output interface. They are used for the following applications:

- For writing parameters to the module
- For transferring the HART communication data
- For reading the HART variables from the module
- For reading the information data from the module

The mapping of the HART commands and HART replies to the PROFIBUS DP data records is based on the *PROFIBUS Profile HART Version 1.0*. Further information on the HART protocol can be found in the *PROFIBUS DP HART Profile Application Guidelines*.

The documentation indicated above is available from PI (PROFIBUS International) on the Internet (http://www.profibus.com).

Table 8-6 Additional parameters of the HART analog modules

Data record number	Read/write	Size in bytes	Description
80, 82, 84, 86	Write	240	HART Request Write Process Data
	HART request data records to field devices: These data records contain the transfer data for the command from the client to the HART field device by channel (0 - 3).		
81, 83, 85, 87	Read	240	HART Response Read Process Data
	HART reply data records from field devices: These data records contain the transfer data for the reply from the HART field device to the client by channel (0 - 3).		
121	Read	20	HART variables
	HART variable data record: This data record makes the HART variables of all the HART channels available in accordance with the mapping data record DS 140.		
131 - 134	Read/write	8	HMD Parameter Process Data
	HART parameter data records: These data records contain the HART parameters for the module by channel.		
140	Read/write	12	Mapping Data
	HART mapping data record: This data record specifies the mapping of the 4 HART variables to the DS 121		

Configure and assign parameters with *STEP 7*

The module is configured and parameters assigned in *STEP 7*.

Note

Please note that when the parameters are loaded into the F-CPU in *STEP 7* the HART parameter data records 131 - 134 and the HART mapping data record 140 are always also transferred to the F-CPU, stored there, and passed by the F-CPU to the fail-safe module.

You can integrate certain additional functions for writing parameters and reading diagnostic data in your S7 program by means of SFCs.

Reading and writing data records

To read and write data records, use the following SFCs / SFBs:

- Read data record:
  - SFC 59 "RD_REC".
  - SFB 52 "RDREC"
- Write data record:
  - SFC 58 "WR_REC"
  - SFB 53 "WRREC"

Further information about the SFCs / SFBs is available in the Reference Manual System and Standard Functions for S7-300/400 (http://support.automation.siemens.com/WW/view/en/1214574).

8.1.7.2 HART communication data records

Transfer data records

HART communication may be controlled by only one client per channel. Each channel has a separate transfer area available. Each transfer area consists of the command and reply data records.

If a channel is operated by several clients, the answer provided by the module cannot be assigned reliably to a specific client. The module does not support client management.

Coordination rules for HART communication

- Fixed data record numbers are assigned to each client/channel:

Table 8-7 Assignment of client / channel to data record numbers

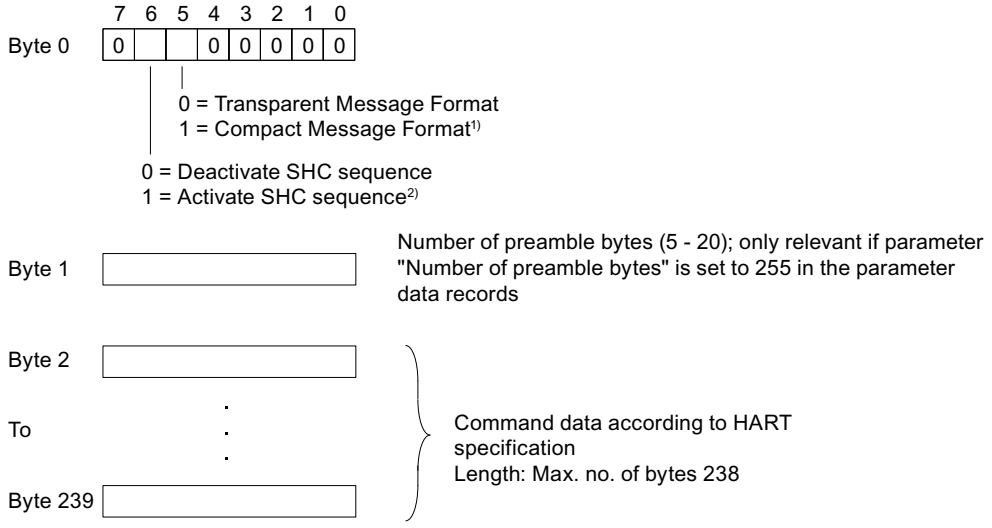
Channel	Client	Data record
0	Command	80
0	Reply	81

Channel	Client	Data record
1	Command	82
1	Reply	83
2	Command	84
2	Reply	85
3	Command	86
3	Reply	87

- After writing a command data record, a client has to read the reply data record before writing another command data record.
- The client has to evaluate the "Processing status" in the reply data record. If the processing status is "successful" or "faulty", the data record contains current reply data or error displays.
- The data record must always be read in its entirety, since after it is first read with a successful or faulty status, the data record can be changed by the module.
- The status component in the reply data record (= HART status bytes) provides information on whether and which errors have occurred.
- If you read the HART reply immediately after writing a HART command, the received response may still be an "old" response.
  Because the interpretation of the HART command and the structure of the associated reply data record requires some time, you should wait approx. 100 ms before reading the response.

Structure of the command data record

The figure below shows the command data record with which you can write a command to a client's transfer area. The HART analog module sends the command to the connected HART field device.



1) HART commands are processed both in the Transparent Message Format and in the Compact Message Format (see technical specification for HART). The reply data from the module are however always made available in Transparent Format.

2) A processing of a sequence of HART commands as a SHC sequence (Successive HART Command Mode) is only processed when "HART Fast Mode" is assigned.

Figure 8-7 Structure of the HART command data record

Structure of the reply data record

The figure below shows the structure of the reply data record that contains the reply to the previously sent HART command.

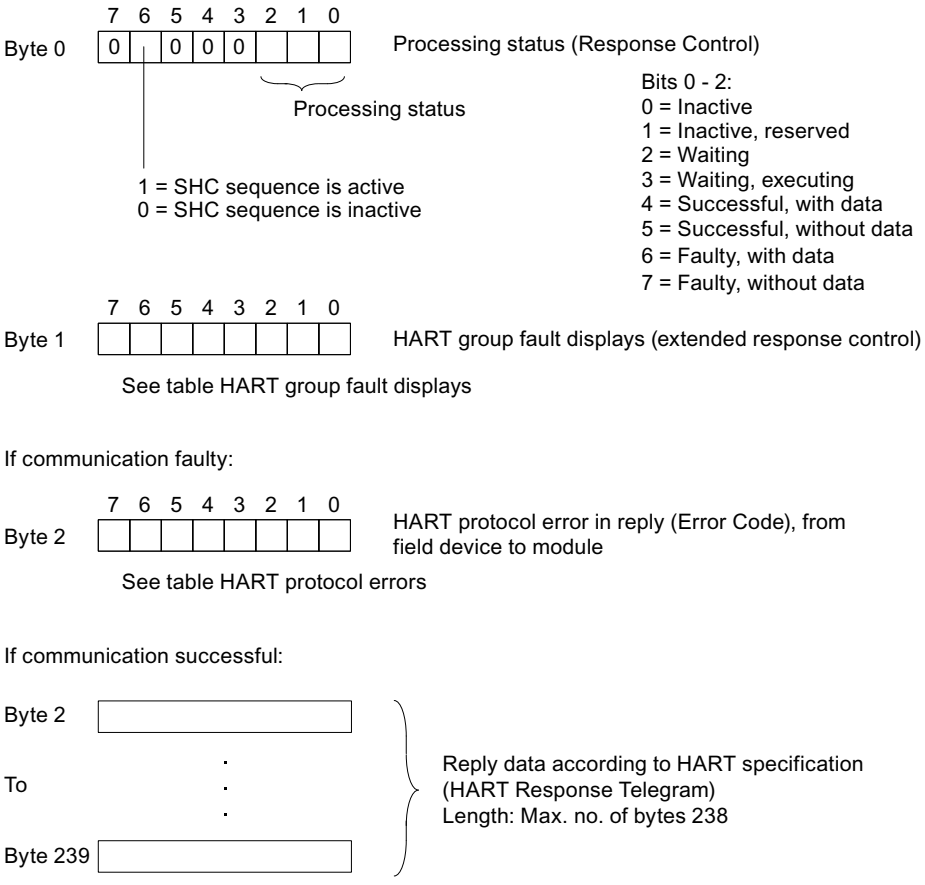


Figure 8-8 Structure of the HART reply data record

Notes on the reply

When the reply data record is read, you must make sure that a current reply data record has arrived:

- If the processing status is "successful" or "faulty", the data record contains current reply data or error displays.

Table 8-8 HART group fault displays in reply byte 1 (extended response control)

Bit no.	HART group fault display	Meaning
0	Further status information available	Corresponds to bit 4 in the channel-specific error bytes in diagnostic data record 1 (2nd HART status byte). The HART command 48 provides you with further status information, if required.
1	HART communication error --> HART communication error entry in diagnostic data record 1	Here the field device has identified a communication error on receiving the command. The error information is contained in the 1st HART status byte (in the reply data record or diagnostic data record 1) . This is accepted without being changed.
2	Parameter check	0: HMD parameters unchanged 1: Check HMD parameters
3	Always 0	Reserved
4 - 7	HART protocol error for reply --> HART communication error entry in diagnostic data record 1	Error during HART communication from the field device to the module (i.e. there was an error in receiving the reply). 0: Unspecified error 1: HMD error 2: Channel fault 3: Command error 4: Query error 5: Reply error 6: Query rejected 7: Profile query rejected 8: Vendor-specific query rejected 9 - 15: Not used You will find information on the cause of the problem in reply byte 2. See the table below.

Table 8-9 HART protocol error in reply byte 2 for the reply from the field device to the module (error code)

Fault	HART protocol error in byte 2	Meaning
0	Unspecified error	0: Not specified
1	HMD error	0: Unspecified 1: Internal communication error 2: Parameter assignment error 3: HW error 4: Wait time expired 5: HART timer expired
2	Channel fault	0: Unspecified 1: Line error 2: Short circuit 3: Open line 4: Low current output 5: Parameter assignment error
3	Command error	0-127: HART protocol, Bit 7=0

Fault	HART protocol error in byte 2	Meaning
4	Query error	HART protocol, Bit 7=1 Bit 0: Reserved Bit 1: Receive buffer overflow Bit 2: Reserved Bit 3: Checksum error Bit 4: Frame error Bit 5: Overflow error Bit 6: Parity error Bit 7: 1
5	Reply error	HART protocol, Bit 7=1 Bit 0: GAP timeout Bit 1: Receive buffer overflow Bit 2: Timeout Bit 3: Checksum error Bit 4: Frame error Bit 5: Overflow error Bit 6: Parity error Bit 7: 1
6	Query rejected	0: Unspecified 1: Short format not supported 2: SHC not supported 3: Impermissible command 4: No resources
7	Profile query rejected	0: Not specified (not supported)
8	Vendor-specific query rejected	0: Not specified (not supported)

8.1.7.3 Parameter data records of the HART channels

Structure of parameter data records 131 to 134

The figure below shows the structure of parameter data records 131 to 134 for HART channels 0 to 3. The settings apply to the assigned channel:

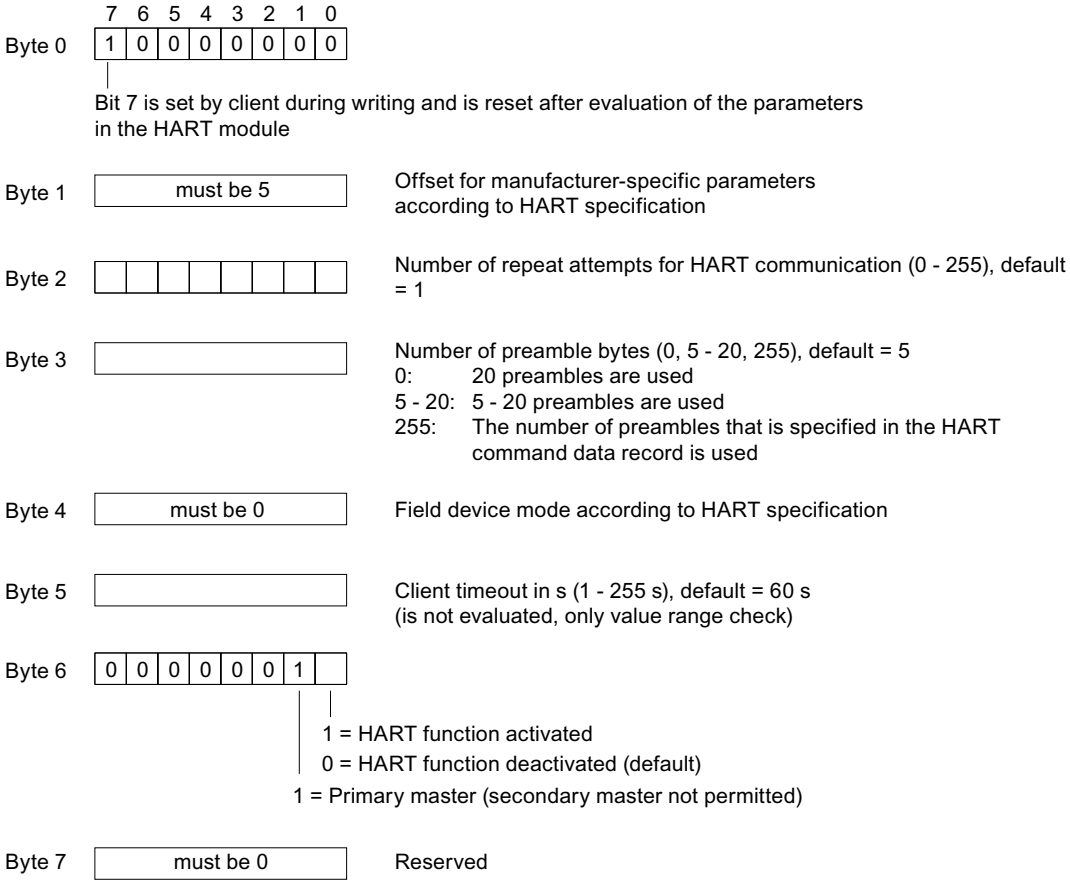


Figure 8-9 Parameter data records 131 to 134 of the HART analog module

Notes on the parameter data records of the HART channels

The parameter data records contain parameters that you normally do not have to change, since the optimum value is already set.

8.1.7.4 Data records for the HART variables

Structure of the mapping data record 140

The following figure shows the structure of the mapping data record 140 that specifies the mapping of the 4 HART variables to the DS 121.

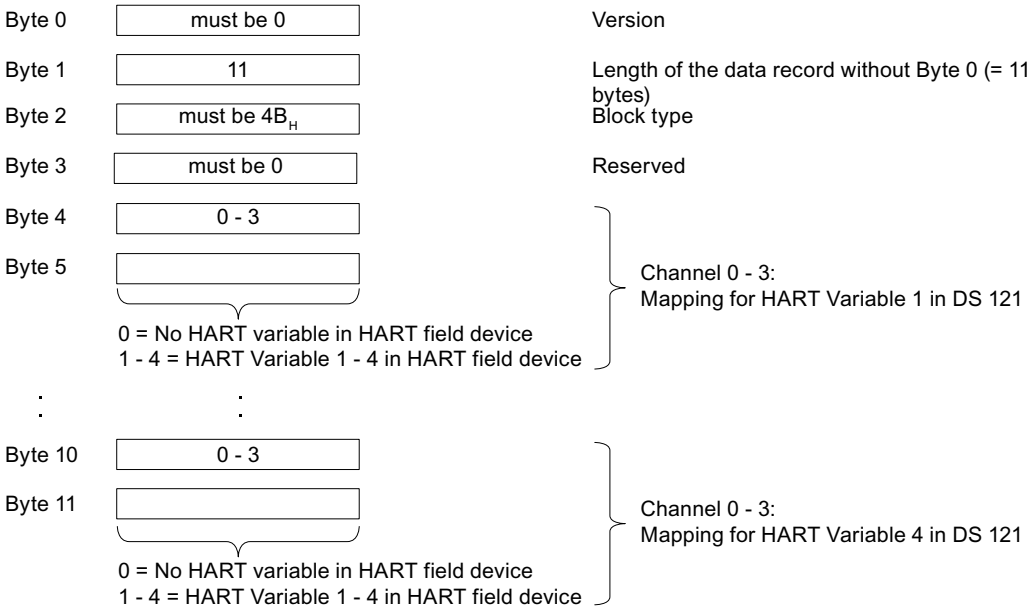


Figure 8-10 HART mapping data record 140

Structure of the variable data record 121

The following figure shows the structure of the variable data record 121 that provides the HART variables of all the HART channels in accordance with the mapping data record DS 140.

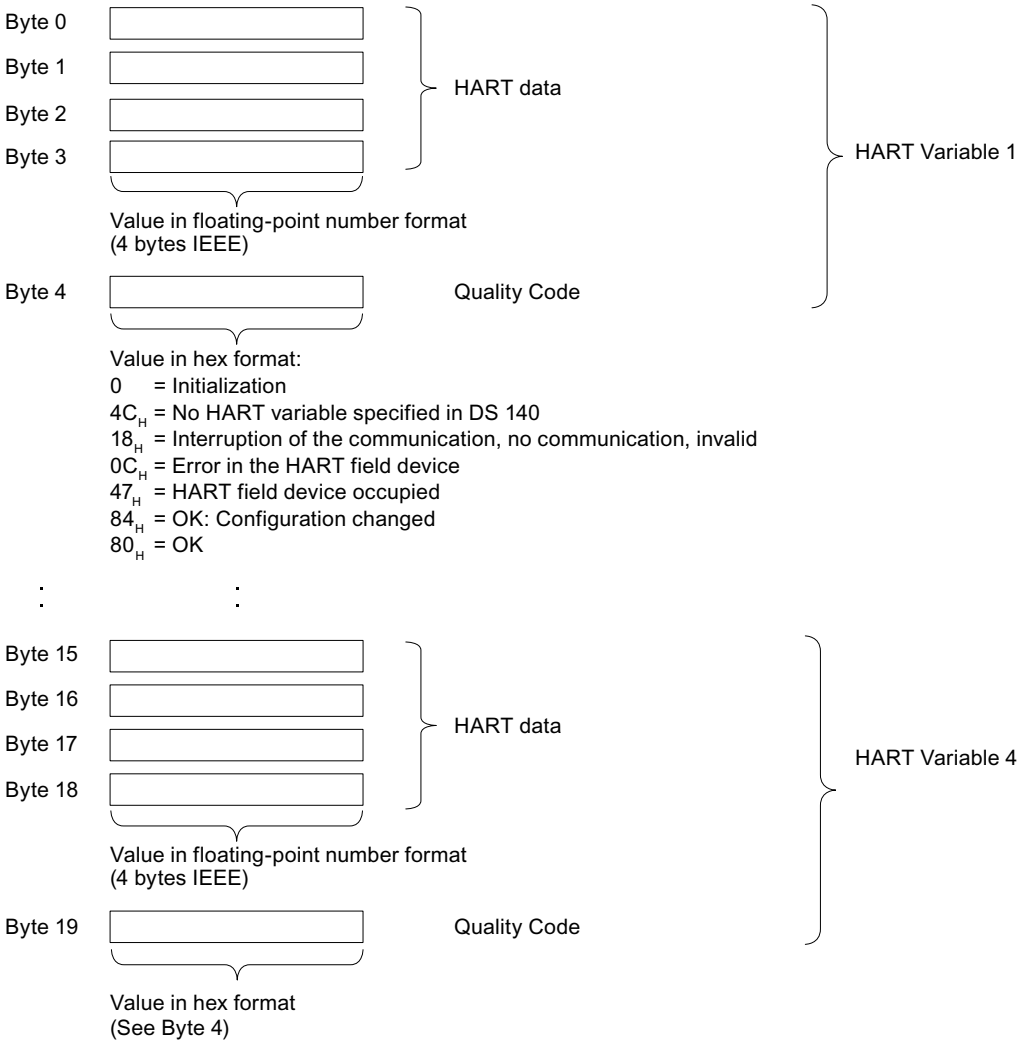


Figure 8-11 HART variable data record 121

The length of the variable data record 121 is independent of the mapping with the mapping data record 140.

The Quality Code (QC) is provided by the HART master.

8.1.8 Applications of electronic module 4 F-AI Ex HART

Applications 1 and 3

Applications 1 and 3 are not applicable since the fail-safe module supports SIL3/Cat.3/PLe (see Chapter "Applications of electronic module 8 F-DI Ex NAMUR (Page 67)").

Application 2

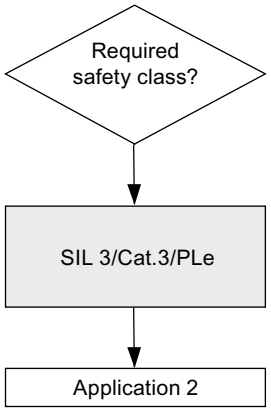


Figure 8-12 Application 2 - 4 F-AI Ex HART electronic module

Note

You can achieve SIL3/Cat.4/PLe by connecting two or three sensors to **several** F-AI Ex HART modules (each 1oo1 evaluation) per process signal, and programming the 1oo2 or 2oo3 evaluation in the F-CPU. If you connect two or three sensors to **one** F-AI Ex HART module, you achieve SIL3/Cat.3/PLe.

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

Introduction

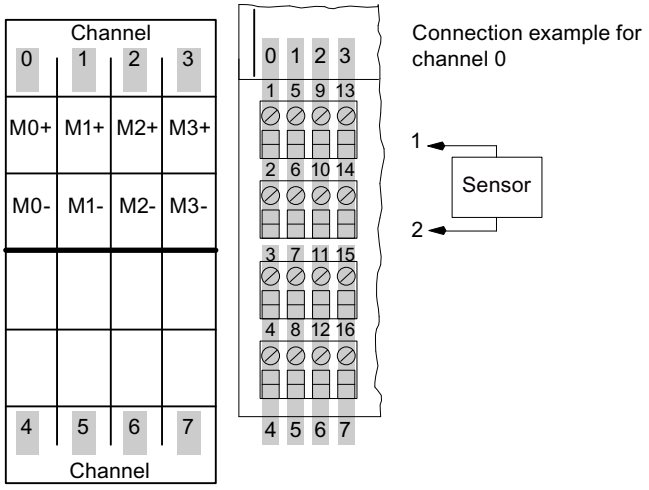
Below are the wiring scheme and the parameter assignment of the 4 F-AI Ex HART module for Application 2: Safety mode SIL3/Cat.3/PLe

Diagnostic messages, possible causes of faults, and their corrective measures are found in the corresponding tables in Chapter "Diagnostic functions of electronic module 4 F-AI Ex HART (Page 131)".

Wiring scheme for Application 2

One single-channel sensor is connected via one channel to the fail-safe module for each process signal (1oo1 evaluation). The sensor supply Mx+ is made available by the fail-safe module.

Table 8-10 Terminal assignment 1oo1 evaluation of the sensors

Terminal assignment and view	Remarks
	**Sensor 1**: Channel 0: Terminals 1 and 2 **Sensor 2**: Channel 1: Terminals 5 and 6 **Sensor 3**: Channel 2: Terminals 9 and 10 **Sensor 4**: Channel 3: Terminals 13 and 14 Mx+: Sensor supply Mx-: Input

⚠ WARNING

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

Assignable module parameters for Application 2

Parameter	Range	Type of parameter	Effective range
Behavior after channel fault[1)]	Passivate the entire module/ Passivate the channel	Static	Module
Interference frequency suppression	50 Hz/60 Hz	Static	Module
HART Fast Mode	On/Off	Static	Module
Channel: Activated	Activated/deactivated	Static	Channel
Measuring range	4..20 mA / 0..20 mA	Static	Channel
Smoothing	1, 4, 16, 64 conversion cycles	Static	Channel
HART gate	On/Off/Can be switched	Static	Channel
HART repetitions	0 to 10	Static	Channel
Diagnostics: Wire break	Activated/deactivated	Static	Channel
HART diagnostics	Activated/deactivated	Static	Channel

Parameter	Range	Type of parameter	Effective range
HART warning	Activated/deactivated	Static	Channel
HART secondary variable: IEEE variable	None/ Primary variable/ 1st secondary variable/ 2nd secondary variable/ 3rd secondary variable	Static	Channel

1) This setting is only relevant when optional package *S7 Distributed Safety* V5.4 or higher is installed.

8.1.10 Diagnostic functions of electronic module 4 F-AI Ex HART

Behavior after short circuits

Short circuits within channels are recognized irrespective of a parameter assignment and signaled by the corresponding channel fault LED. The "Short circuit" diagnosis is signaled, and an entry is made in the diagnostic buffer.

Short circuits between the channels (cross-circuit) are only recognized in the startup of the module or after reassignment of the module parameters.

Diagnostic functions

The table below provides an overview of the diagnostic functions of electronic module 4 F-AI Ex HART. The diagnostic functions are assigned either to one channel or to the entire module.

Table 8-11 Diagnostic functions of electronic module 4 F-AI Ex HART

Diagnostic function[1)]	Fault number	LED	Effective range of diagnostics	Can be assigned
Short circuit	1_H	Group fault, channel fault display	Channel	No[2)]
Undervoltage (HART diagnostics)	2_H	Group fault, channel fault display	Channel	Yes
Overload (HART diagnostics)	4_H	Group fault, channel fault display	Channel	Yes
Overtemperature	5_H	Group fault	Module	No[2)]
Line break	6_H	Group fault, channel fault display	Channel	Yes[3)]
Upper limit exceeded	7_H	Group fault, channel fault display	Channel	No[2)]

Diagnostic function[1]	Fault number	LED	Effective range of diagnostics	Can be assigned
Lower limit fallen below	8_H	Group fault, channel fault display	Channel	No[2]
Fault	9_H	Group fault	Module	No[2]
Parameter assignment error	10_H	Group fault	Module	No[2]
Sensor voltage or load voltage missing	11_H	Group fault	Module	No[2]
HART communication error	13_H	Group fault, channel fault display	Channel	No[2]
Additional HART status available (HART warning)	16_H	Group fault, channel fault display	Channel	Yes
Safety-related shutdown	19_H	Group fault, channel fault display	Channel	No[2]
External fault (HART diagnostics)	$1A_H$	Group fault, channel fault display	Channel	No[2]
HART configuration changed (HART warning)	$1B_H$	Group fault, channel fault display	Channel	Yes
PROFIsafe communication error	$1C_H$	Group fault	Module	No[2]
HART primary variable outside the limits (HART diagnostics)	$1D_H$	Group fault, channel fault display	Channel	Yes
HART secondary variable outside the limits (HART diagnostics)	$1E_H$	Group fault, channel fault display	Channel	Yes

[1] Display in *STEP 7*, see Figure "Channel-specific diagnostics" in Chapter "Slave diagnostics (Page 44)"

[2] Is always diagnosed

[3] Is always diagnosed for sensors 0 to 20 mA

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 "Fault reactions (Page 39)".

Causes of faults and corrective measures

The following table contains the possible causes of the faults and corrective measures for the individual diagnostic messages of EM 4 F-AI Ex HART.

Table 8-12 Diagnostic messages of electronic module 4 F-AI Ex HART, causes of faults, and corrective measures

Diagnostic message	Diagnostic buffer	Possible causes of fault	Corrective measures
Short circuit	Short circuit or sensor supply defective	Wiring incorrect	Check the wiring. Once the fault has been eliminated, the module must be removed and inserted or the power switched off and on.
		Applied external voltage	Eliminate the external voltage influence. Once the fault has been eliminated, the module must be removed and inserted or the power switched off and on
		Excessive starting current of the sensor	User other sensor
		Sensor is defective	Replace the sensor
		Internal error	Replace module
Undervoltage (HART diagnostics)	HART: Analog output current specified	• Incorrect parameters in the HART field device • HART field device has simulation, and simulation is set to a measured value that is too high or HART field device is undergoing the measuring circuit test.	• Check the parameter assignment of the HART field device • Correct/deactivate simulation • Check whether the correct sensor is connected • End the measuring circuit test
Overload (HART diagnostics)	HART: Analog output current saturated	• Incorrect parameters in the HART field device • HART field device has simulation, and simulation is set to a measured value that is too high • Assigned primary variable is outside the limits	
Overtemperature	Temperature outside the permitted range	Shutdown due to violation of upper or lower temperature limit value in the module housing.	Check the ambient temperature. Once the fault has been eliminated, the module must be removed and inserted or the power switched off and on.
Line break	Wire break	Interruption of the measuring lead between the module and sensor	Reestablish the cable connection
		Incorrect measuring range setting	Check the measuring range setting
		Sensor is defective	Replace the sensor
		Sensor polarity reversed	Check the wiring

Diagnostic message	Diagnostic buffer	Possible causes of fault	Corrective measures
Upper limit exceeded	Value lies above the overrange	An overflow of the measured value of a module has occurred	Use suitable sensor
Lower limit fallen below	Value is below the underrange	An underflow of the measured value of a module has occurred	• Use suitable sensor • Check the wiring • Check sensor setting
Fault	EPROM fault	Electromagnetic interference has exceeded limits	Eliminate the interferences. Once the fault has been eliminated, the module must be removed and inserted or the power switched off and on.
		Internal error	Replace module
	RAM fault	Electromagnetic interference has exceeded limits	Eliminate the interferences. Once the fault has been eliminated, the module must be removed and inserted or the power switched off and on.
		Internal error	Replace module
	Processor failure	Electromagnetic interference has exceeded limits	Eliminate the interferences. Once the fault has been eliminated, the module must be removed and inserted or the power switched off and on.
		Internal error	Replace module
		Setting of the address switch (DIP switch) not as expected	Check and correct DIP switch settings
	Internal error in the HART deactivation	Electromagnetic interference has exceeded limits	Eliminate the interferences. Once the fault has been eliminated, the module must be removed and inserted or the power switched off and on.
		Internal error	Replace module
	ADC/DAC error	Internal error	Replace module
Parameter assignment error	Parameter assignment error (19, 20, 21)	Faulty parameter assignment	Check communication paths Correct the parameters
	Parameter assignment error (18)	PROFIsafe address set incorrectly on the fail-safe module	Check whether the PROFIsafe address on the fail-safe module matches the configuration
	HART: Parameter assignment error	Faulty HART parameters transferred to the module (DS 131 – 134, 140)	Correct HART parameter data record
		Error during dynamic parameter reassignment (HART)	• Check the parameter assignment in the user program Contact SIMATIC Customer Support if necessary

Diagnostic message	Diagnostic buffer	Possible causes of fault	Corrective measures
Sensor voltage or load voltage missing	Internal supply voltage of the module failed	Electromagnetic interference has exceeded limits	Eliminate the interferences. Once the fault has been eliminated, the module must be removed and inserted or the power switched off and on.
		Internal supply voltage error	Replace module
HART communication error	HART: Communication error	• HART field device does not reply • Signal fault (level, timing, noise)	• Check the process wiring • Check measuring current • Check the current consumption of the field device • Replace sensor • Increase the number of retries
HART additional status available	HART: Further status information available	HART field device supplies additional status	Read out status of the field device and correct, if necessary
Safety-related shutdown	Internal error in the HART deactivation	Electromagnetic interference has exceeded limits	Eliminate the interferences. Once the fault has been eliminated, the module must be removed and inserted or the power switched off and on.
		Internal error	Replace module
	Analog input signal could not be detected clearly	Interference of input signal (e.g. caused by EMC) High-frequency input signal (signal lies above the sampling frequency of the input signal) Brief interruption/ brief short circuit of the sensor line (loose contact)	Eliminate the error within 100 hours after its occurrence. Otherwise the module changes to the error state (diagnostic buffer message Processor failure). Use shielded line Reduce input frequency Check the contact points and the lines to the sensor
		Internal error in module	Replace module
External fault	HART field device malfunction	Electromagnetic interference has exceeded limits	Eliminate the interferences. Once the fault has been eliminated, the module must be removed and inserted or the power switched off and on.
		Error occurred in the HART field device	Replace HART field device
HART configuration changed	HART: Configuration has changed	The identifier for reassignment of HART field device parameters has been set in the HART field device status (=HART status bytes).	-

Diagnostic message	Diagnostic buffer	Possible causes of fault	Corrective measures
PROFIsafe communication error	CRC signature error	Communication interference between the F-CPU and the fail-safe module, e.g., due to electromagnetic interference in excess of limits or sign-of-life monitoring error.	Check the PROFIBUS connection Eliminate the interference
	Timeout of safety message frame monitoring	Assigned monitoring time exceeded	Check the monitoring time parameter assignment
HART primary variable outside the limits	HART: Primary variable outside the limits	Primary variable assigned outside the limits Incorrect parameters in the HART field device HART field device has simulation, and simulation setting is "Primary variable outside the limits"	• Check the parameter assignment of the HART field device • Correct/deactivate simulation • Check whether the correct sensor is connected • End the measuring circuit test
HART secondary variable outside the limits	HART: Secondary variable outside the limits	Secondary variable assigned outside the limits Incorrect parameters in the HART field device HART field device has simulation, and simulation setting is "Secondary variable outside the limits"	
			Once the fault is eliminated, the F-module must be reintegrated in the safety program

For additional information about passivation and reintegration of F-I/O, refer to Manual S7 Distributed Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/22099875) or Safety Engineering in SIMATIC S7 (http://support.automation.siemens.com/WW/view/en/12490443).

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 Chapter "Fault reactions and diagnostics (Page 39)" in this manual as well as to Manual S7 Distributed Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/22099875) and Safety Engineering in SIMATIC S7 (http://support.automation.siemens.com/WW/view/en/12490443).

8.1.11 Technical specifications of electronic module 4 F-AI Ex HART

Overview

Technical specifications		
Dimensions and Weight		
Dimensions W x H x D (mm)	30 x 129 x 136.5	
Weight	Approx. 299 g	
Module-specific data		
Supports isochronous mode	No	
Number of inputs	4	
Assigned address area		
• In the I/O input area	12 bytes	
• In the I/O output area	4 bytes	
Cable length		
• Shielded and twisted in pairs	500 m, maximum	
Maximum achievable safety class in safety mode	1oo1 evaluation	1oo2 or 2oo3 evaluation (inputs on several F-AI Ex HART modules, evaluation in the F-CPU)
• According to IEC 61508	SIL3	SIL3
• In accordance with EN ISO 13849 -1:	Cat.3 / PLe	Cat.4 / PLe
Fail-safe performance characteristics	SIL3	SIL3
• low demand mode (average probability of failure on demand)	< 1.00E-04	< 1.00E-05
• high demand/continuous mode (probability of a dangerous failure per hour)	< 1.00E-08	< 1.00E-09
Proof-test interval	20 years	
Approvals **Note** The currently valid standards and approvals are stated in the respective certificates available on the Internet (http://www.siemens.com/automation/service&support) and/or are specified on the rating plates.		

Technical specifications		
• ATEX		II 2 G (1) GD Ex ib[ia Ga][ia IIIC Da] IIC T4 Gb and I M2 Ex ib[ia Ma] I Mb KEMA 10 ATEX 0056 CE 0344
• IECEx		IECEx KEM 10.0029
• INMETRO	 INMETRO  BR OCP-0029	BR-Ex ib [ia] IIC T4 / BR-Ex ib [ia] I
• FM		Class I, Zone 1, AEx ib [ia] IIC T4; Ex ib [ia] IIC T4 NI, Class I, DIV. 2, GP. A,B,C,D T4 AIS, Class I, II, III, DIV. 1, GP. A,B,C,D,E,F,G Class II, III, GP. E,F,G
• cULus		Ind. Cont. Eq. for Use in HAZ.LOC. Class I, Zone 1, AEx ib [ia] IIC T4; Ex ib [ia] IIC T4 ASSOC. APP. CL. I, DIV. 2, GP. A,B,C,D T4 PROVIDING INT. SAFE CIRCUITS FOR CL. I, GP. A,B,C,D; CL. II, III, GP. E,F,G

Voltages, Currents, Potentials	
Number of simultaneously controllable inputs	
• Horizontal installation -20°C to +70°C	4
• Vertical installation -20°C to +50°C	4
Electrical isolation	
• Between channels and backplane bus	Yes
• Between channels	No
• Between channels and power bus	Yes
Permitted potential difference Between different circuits	60 VDC 30 VAC
Test voltages	
• Isolation in the type test tested with	370 V AC for 1 min.
Power supply of the measuring transducers	Yes
• Supply current	Max. 25 mA + 4 mA per channel
• Short-circuit proof	Yes
Current consumption	
• From load voltage L + (power bus)	Max. 490 mA
Power dissipation of the module	Max. 5.4 W
Analog value generation	
Measuring principle	DELTA-SIGMA
Integration/conversion time	
• Assignable	Yes

Technical specifications	
• Integration time At 50 Hz At 60 Hz	 20 ms 16.67 ms
• Response time per channel At 50 Hz At 60 Hz	 23 ms 20 ms
• Basic response time	17 ms
• Conversion cycle time	Basic response time + (n x response time per channel) (n = number of active channels)
• Conversion cycle time at 50 Hz, all channels active	109 ms
• Resolution	15 Bit + sign
Smoothing of measured values per channel	Yes, can be assigned in 4 levels[1)]
Level:	Time constant:
• None	1 x conversion cycle time
• Weak	4 x conversion cycle time
• Medium	16 x conversion cycle time
• Strong	64 x conversion cycle time
Noise suppression, error limits	
Interference voltage suppression for f = n x (f1±0.5%), f1 = interference frequency	
• Common mode interference (peak interference value < rated value of input range)	Min. 50 dB
• Series-mode interference (peak value of interference < rated value of input range)	Min. 40 dB
Crosstalk between inputs	Min. 50 dB
Operational error limit (across the temperature range, relative to full-scale value 20 mA)	±0.35%
Basic error limit (operational limit at 25°C, relative to full-scale value 20 mA)	±0.1%
Temperature error (relative to full-scale value 20 mA)	±0.005%/K
Linearity error (relative to full-scale value 20 mA)	±0.015%
Repeatability (in steady state at 25 °C, relative to full-scale value 20 mA)	±0.015%
Influence of a HART signal superimposed on the input signal (relative to full-scale value 20 mA, in addition to the basic error)	
• 20 ms integration time	± 0.12%
• 16.67 ms integration time	± 0.12%
Status, Diagnostics	
Status display	
• Safety mode display	Green LED (SAFE)
• HART communication	Green LED per channel
Diagnostic functions	
• Group fault display	Red LED (SF)

Technical specifications	
• Inputs	Red LED per channel
• Diagnostic information can be read out	Yes
Monitoring for	
• Short circuit	I_{Load} > 25 mA[2)]
• Wire break	Measuring range 0 mA to 20 mA: I_{Load} < 0.4442 mA Measuring range 4 mA to 20 mA: I_{Load} < 3.6 mA (see chapter "Analog value representation (Page 112)")
Sensor selection data	
Input ranges (rated values) / input resistance	
• Current	0 to 20 mA and 4 to 20 mA
Signal sensor connection	Possible
• For current measurement As 2-wire transducer	Possible
• Load of 2-wire transducer	Max. 600 Ω
HART communication	
Monodrop/multidrop operation	Monodrop operation
Functional range of HART Communication	1.17 to approx. 26 mA
HART shutdown threshold	1.17 mA
Protocol version	7
Safety notice	
See EC type-examination certificate	KEMA 10 ATEX 0058
Use the operational error limits across the entire temperature range when carrying out safety-specific considerations.	

1) Time until 63% of the jump value has been reached

2) I is undergoing current limiting. The current limiting is initiated at approx. 27 mA.

Diagnostic data of fail-safe modules

A

The structure of the diagnostic data of the fail-safe electronic modules corresponds to that of the standard ET 200iSP modules. This is described in the Chapter "Diagnostics with *STEP 7*" in Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789).

Particular characteristics compared to the standard ET 200iSP modules

- Channel-specific diagnostics for fail-safe modules is structured differently, see Chapter "Slave diagnostics (Page 44)".
- The diagnostic interrupt for the fail-safe modules is structured differently, see Chapter "Alarms of the fail-safe modules (Page 47)". This also contains the SKF identifiers (*STEP 7*) of the fail-safe modules for the removal/insertion interrupt.

Additional references

For a detailed description of the principle of evaluating diagnostics data of electronic modules in the standard user program and of the SFCs that can be used for this purpose, refer to Reference Manual System and Standard Functions for S7-300/400 (http://support.automation.siemens.com/WW/view/en/1214574).

Dimensional drawings

B

The dimensions of the fail-safe electronic modules correspond to those of the standard ET 200iSP modules. The dimensional drawings of the most important components of the ET 200iSP are included in the appendix of the Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789).

Order numbers

C

The table below lists the order numbers of the fail-safe modules.

Component	Order number
Fail-safe modules:	
Digital electronic module 8 F-DI Ex NAMUR	6ES7138-7FN00-0AB0
Digital electronic module 4 F-DO Ex 17,4V/40mA	6ES7138-7FD00-0AB0
Analog electronic module 4 F-AI Ex HART	6ES7138-7FA00-0AB0

Reference

All the other order numbers of the ET 200iSP distributed I/O device and of the PROFIBUS accessories that you require for the use of ET 200iSP are contained in the appendix of Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789).

Response times

D

D.1 Response times of the ET 200iSP fail-safe modules

Introduction

The response times of the ET 200iSP fail-safe modules are listed below. The response times of the fail-safe modules are included in the calculation of the fail-safe system response time.

For information on the calculated response time of the fail-safe system, refer to System Description Safety Engineering in SIMATIC S7 (http://support.automation.siemens.com/WW/view/en/12490443).

The elements used in the formulae below are available in the technical specifications of the relevant fail-safe module.

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 provision 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.

For fail-safe analog inputs: The response time results from the number of channels, the response time per channel, the basic response time, and in the case of the electronic module 4 F-AI Ex HART, also the assigned smoothing.

Note

Please note that the Excel files for calculating the maximum response times (*s7fcotia.xls* and *s7ftimea.xls*) included with the S7 Distributed Safety (http://support.automation.siemens.com/WW/view/en/11669702/133100) and S7 F/FH Systems (http://support.automation.siemens.com/WW/view/en/26091594/133100) optional packages already support calculation of the extension of the "Maximum response time in the event of a fault" by the programmed discrepancy time.

D.2 Response times of fail-safe digital input modules

Response time of electronic module 8 F-DI Ex NAMUR

The response times of the EM 8 F-DI Ex NAMUR are dependent on the parameter assignment of the individual channels or channel pairs. The response times of the individual channels or channel pairs are calculated independent of the other channels or channel pairs.

One component of the response time is the internal preprocessing time of the module. This depends on the parameters of the corresponding channel or channel pair. You insert the values in accordance with your parameter assignment into the equations for the response time. The values are listed in the following table.

Table D-1 Internal preprocessing time of the 8 F-DI Ex NAMUR electronic module as a function of the parameter assignment

	Sensor supply test deactivated	Sensor supply test activated
1oo1 evaluation	22 ms	25 ms
1oo2 evaluation with behavior at discrepancy = "Provide 0 value"	22 ms	25 ms
1oo2 evaluation with behavior at discrepancy = "Provide last valid value"	35 ms	48 ms

- Response time for 1oo1 evaluation (fault-free and faulty operation)
  Response time = internal preprocessing time[1] + input delay + {time for sensor test + ramp-up time of the sensor after sensor test}[2]
- Response time for 1oo2 evaluation with behavior at discrepancy = "Provide 0 value" (fault-free and faulty operation)
  Response time = internal preprocessing time[1] + input delay + MAX { (time for sensor test$_{CHANNEL(n)}$ + ramp-up time of the sensor after sensor test$_{CHANNEL(n)}$)[2], (time for sensor test$_{CHANNEL(n+4)}$ + ramp-up time of the sensor after sensor test$_{CHANNEL(n+4)}$)[2),3)] }
- Response time for 1oo2 evaluation with behavior at discrepancy = "Provide last valid value" (fault-free operation)
  Response time = internal preprocessing time[1] + input delay + discrepancy time + (time for sensor test$_{CHANNEL(n)}$ + ramp-up time of the sensor after sensor test$_{CHANNEL(n)}$)[2] + (time for sensor test$_{CHANNEL(n+4)}$ + ramp-up time of the sensor after sensor test$_{CHANNEL(n+4)}$)[2),3)]
  If the sensor supply test fails, the test is repeated. This repetition only affects the response time for 1oo2 evaluation with behavior at discrepancy = "Provide last valid value".
- Response time for 1oo2 evaluation with behavior at discrepancy = "Provide last valid value" (faulty operation)
  Response time = internal preprocessing time[1] + input delay + discrepancy time + 2 x { (time for sensor test$_{CHANNEL(n)}$ + ramp-up time of the sensor after sensor test$_{CHANNEL(n)}$)[2] + (time for sensor test$_{CHANNEL(n+4)}$ + ramp-up time of the sensor after sensor test$_{CHANNEL(n+4)}$)[2),3)] }

Definitions

[1] Internal preprocessing time in accordance with parameter assignment – see table above "Internal preprocessing time of the 8 F-DI Ex NAMUR electronic module as a function of the parameter assignment"

[2] Response time depending on the **Sensor supply test** parameter:

- Deactivated: Zero values are to be used for the times within the parenthesized expression
- Activated: The values in accordance with the parameter assignment are to be used for the times within the parenthesized expression

[3] Response time depends on the **Sensor supply for 1oo2** parameter:

- Vs n for sensor n and n+4: Zero values are to be used for the times within the parenthesized expression
- Separate Vs for each sensor: The values in accordance with the parameter assignment are to be used for the times within the parenthesized expression

Example

An example for the calculation of the response time of the 8 F-DI Ex NAMUR electronic module is given below.

- Parameter assignment:
  - 1oo2 evaluation (equivalent or non-equivalent)
  - Behavior at discrepancy: Provide last valid value
  - Discrepancy time: 400 ms
  - Sensor supply for 1oo2: Vs n for sensor n and n+4:
  - Input delay: 3 ms
  - Sensor supply test: Activated
  - Time for sensor test: 10 ms
  - Ramp-up time of the sensor after sensor test: 100 ms
- Response time (fault-free operation):
  Response time = internal preprocessing time + input delay + discrepancy time + (time for sensor $test_{CHANNEL(n)}$ + ramp-up time of the sensor after sensor $test_{CHANNEL(n)}$) + (time for sensor $test_{CHANNEL(n+4)}$ + ramp-up time of the sensor after sensor $test_{CHANNEL(n+4)}$)
  Result: Response time = 48 ms + 3 ms + 400 ms + (10 ms +100 ms) + (0) = 561 ms
- Response time (faulty operation):
  Response time = internal preprocessing time + input delay + discrepancy time + 2 x { (time for sensor $test_{CHANNEL(n)}$ + ramp-up time of the sensor after sensor $test_{CHANNEL(n)}$) + (time for sensor $test_{CHANNEL(n+4)}$ + ramp-up time of the sensor after sensor $test_{CHANNEL(n+4)}$) }
  Result: Response time = 48 ms + 3 ms + 400 ms + 2x{(10 ms +100 ms) + (0) } = 671 ms

D.3 Response times of fail-safe digital output modules

Maximum response time of electronic module 4 F-DO Ex 17,4V/40mA

The maximum cycle and response times of the 4 F-DO Ex 17,4V/40mA (in fault-free and faulty operation) are calculated as follows:

- Cycle time = 7 ms + assigned light test time
- Response time = 9 ms + max { assigned light test time; assigned max. readback time dark test }

Example

- Parameter assignment:
  - Light test time: 3 ms
  - Max. readback time dark test 10 ms
- Cycle time: 7 ms + 3 ms = 10 ms
- Response time: 9 ms + max { 3, 10 } = 9 ms + 10 ms = 19 ms

Note

The maximum response time is calculated by inserting the maximum values from Chapter "Technical specifications of electronic module 4 F-DO Ex 17.4V/40mA (Page 98)" and the configuration of the fail-safe modules in the above equation.

D.4 Response times of fail-safe analog input modules

Response time of electronic module 4 F-AI Ex HART

- Calculation of the response time (conversion time) of the 4 F-AI Ex HART electronic module in fault-free operation in accordance with the following equation:
  Typical response time (in fault-free operation) = Conversion cycle time × Smoothing
  Max. response time (in fault-free operation) = 2 × Conversion cycle time × Smoothing
  Example
  Interference frequency 50 Hz, Smoothing = 1 conversion cycle, 4 active channels:
  Max. response time (in fault-free operation) = 2 × 109 ms × 1 = 218 ms
- If a channel fault occurred, the maximum response time is calculated according to the following equation:
  Maximum response time (in case of a channel fault) = 2 × Conversion cycle time
  Example
  Interference frequency 50 Hz, 4 active channels:
  Maximum response time (in case of a channel fault) = 2 × 109 ms = 218 ms

Note

You calculate the response time by using the values from Chapter "Technical specifications of electronic module 4 F-AI Ex HART (Page 137)" in the above equations.

Switching of loads

E

E.1 Switching of capacitive loads

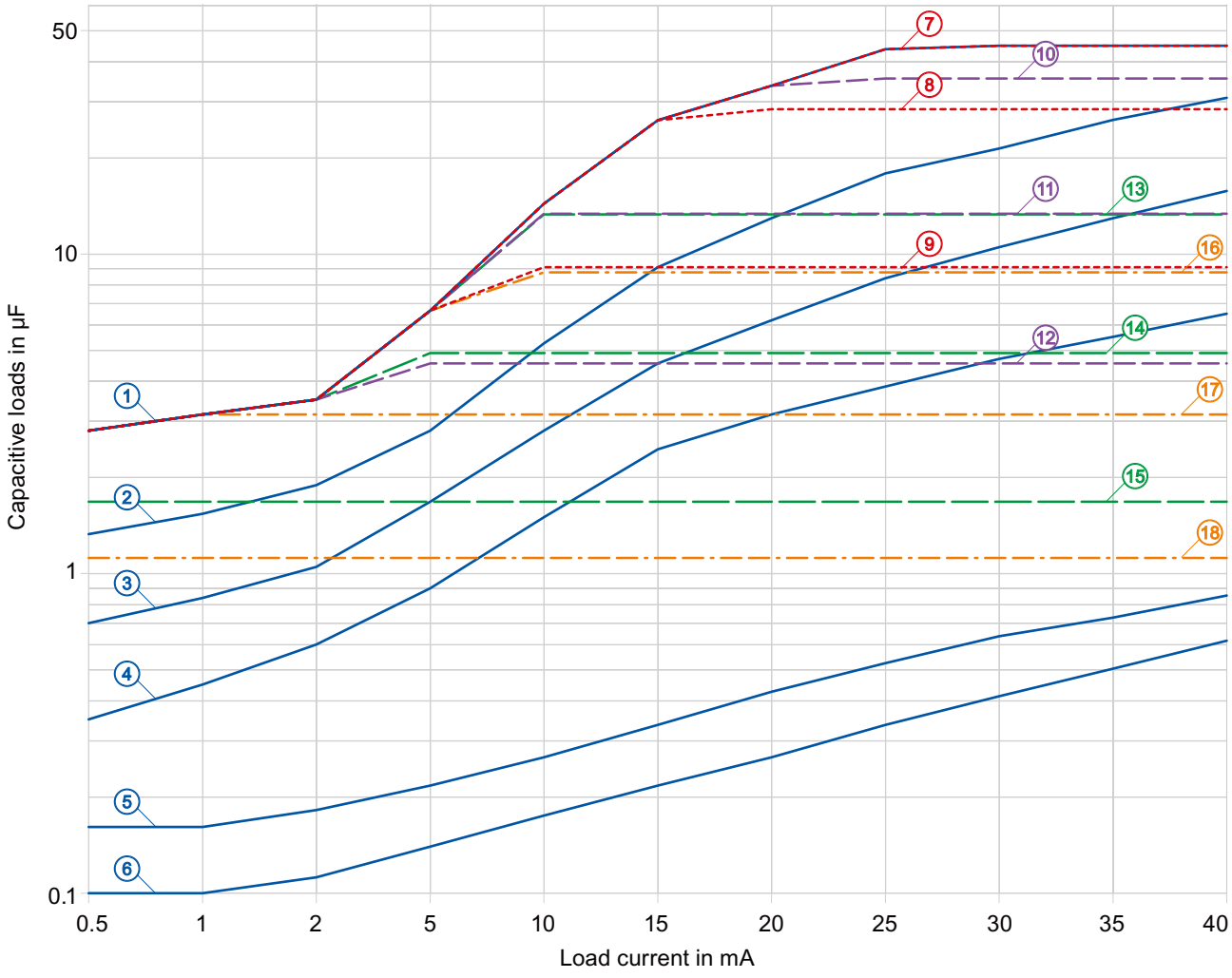
Switching capacitive loads for electronic module 4 F-DO Ex 17,4V/40mA

If the electronic outputs of electronic module 4 F-DO Ex 17,4V/40mA are connected to loads that require little current and have capacitance, this can lead to the "short circuit" error message. Reason: Capacitances are not sufficiently discharged within the assigned readback time during the self-test.

Remedy:

1. Determine the load current and the capacitance of the load.
2. Determine the operating point in the following figure.
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.

The figure below shows the maximum permitted capacitive load as a function of the assignable light test times and maximum readback times for dark test.



Assigned max. readback time dark test		
① 50 ms	③ 10 ms	⑤ 1 ms
② 20 ms	④ 5 ms	⑥ 0.8 ms

Assigned light test time	Assigned short-circuit level			
	40 Ω	80 Ω	160 Ω	200 Ω
5 ms	⑦	⑩	⑬	⑯
2 ms	⑧	⑪	⑭	⑰
0.8 ms	⑨	⑫	⑮	⑱

Figure E-1 Maximum permitted capacitive load as a function of light test time and maximum readback time dark test

Please note:

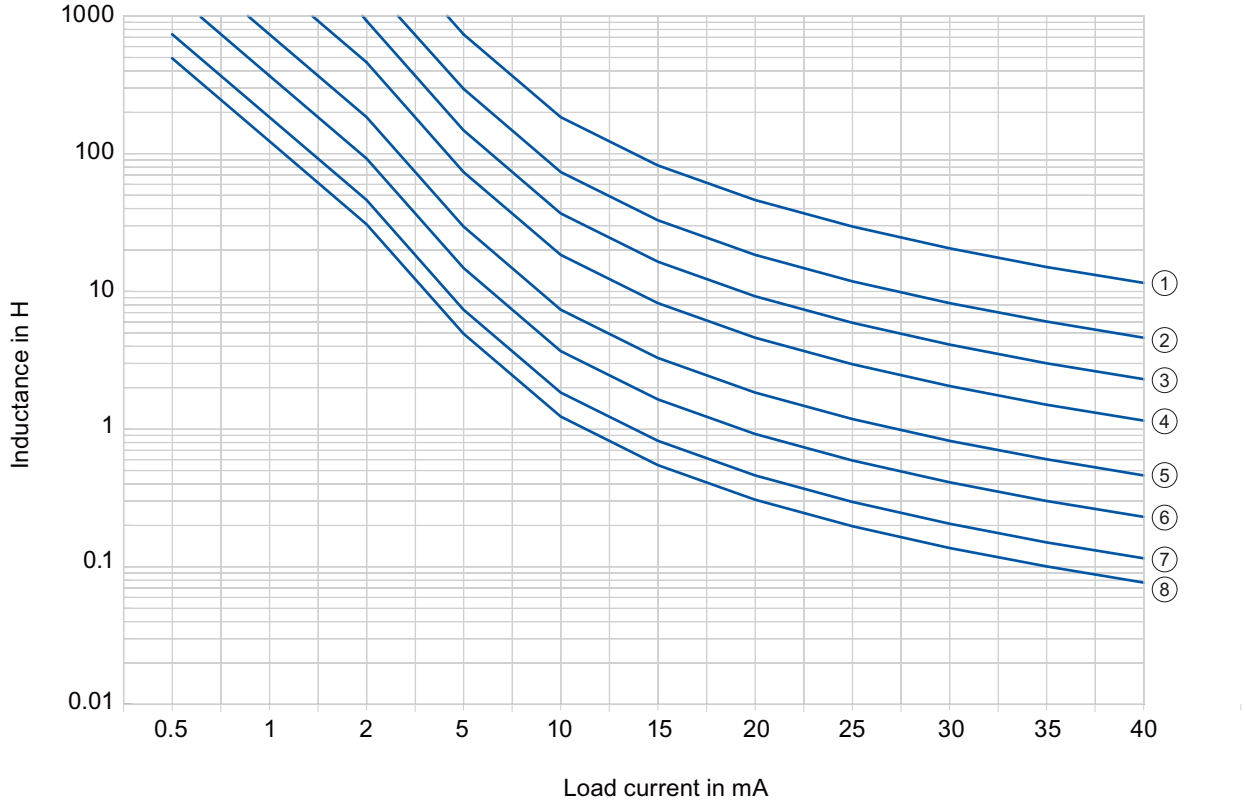
- In the case of large capacitive loads it is possible that the "Overload" diagnosis will be signaled while switching on.
- The capacitances specified in the above figure also apply in the case of channels connected in parallel and activated light test.
- In the case of channels connected in parallel and deactivated light test, the module can have double the capacitance applied at double the current.

E.2 Switching of inductive loads

Switching of inductive loads for electronic module 4 F-DO Ex 17,4V/40mA

The diagram below shows the maximum permitted inductive load as a function of the load current and switching frequency.

Switching characteristics for electronic module 4 F-DO Ex 17,4V/40mA



①	0.2 Hz	③	1 Hz	⑤	5 Hz	⑦	20 Hz
②	0.5 Hz	④	2 Hz	⑥	10 Hz	⑧	30 Hz

Figure E-2 Max. permitted inductive load as a function of load current and switching frequency

Please note:

- In the case of channels connected in parallel, the module can have a quarter of the inductance applied at double the current.

Type Examination Certificate and Declaration of Conformity

F

The EC type examination certificates and EC declarations of conformity for the ET 200iSP distributed I/O device and its fail-safe electronic modules are available under Service & Support on the Internet (http://www.siemens.com/automation/service&support).

Lightning protection and overvoltage protection

G

Overvoltage suppressors for the fail-safe electronic modules

Note

This chapter lists only those overvoltage suppressors that may be used for the protection of the fail-safe modules.

Be sure to observe the detailed information about lightning protection and overvoltage protection of the ET 200iSP distributed I/O device in Operating Instructions ET 200iSP Distributed I/O (http://support.automation.siemens.com/WW/view/en/28930789).

Components for the overvoltage protection

Table G-1 Components for the overvoltage protection (only for unshielded lines)

Seq. Number	Modules	Connecting of the lines to interface 0_B to 1 with:	Order number
1	8 F-DI Ex NAMUR	4 pc. Blitzductor basic part BXT BAS EX	920 301[1)]
		4 pc. Blitzductor module BXT ML4 BD EX 24	920 381[1)]
2	4 F-DO Ex 17,4V/40mA	2 pc. Blitzductor basic part BXT BAS EX	920 301[1)]
		2 pc. Blitzductor module BXT ML4 BD EX 24	920 381[1)]
[1)] Direct ordering of the components from: DEHN + SÖHNE GmbH + Co. KG Hans-Dehn-Str. 1 D-92318 Neumarkt			

Glossary

HART Communication Foundation

The HART Communication Foundation (HCF) was founded in 1993 to publish and further develop the HART protocol. HCF is a non-profit organization financed by its members.

NAMUR sensor

Monitoring of the line for a short-circuit or wire break is possible with a NAMUR sensor in accordance with IEC 60947-5-6.

Redundancy, availability-enhancing

Multiple instances of components with the objective of maintaining component functionality in the event of hardware faults.

Index

B

C

D

E

F

G

H

I

K

L

M

N

O

P

R

S

T

U

V

W