The Drive & Control Company

Rexroth
Bosch Group

Rexroth Inline Module with

safe digital inputs

R-IB IL 24 PSDI 16-PAC

Application Description
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safe digital inputs
R-IB IL 24 PSDI 16-PAC

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Purpose of Documentation This document describes the Rexroth Inline Module with safe digital inputs R-IB IL 24 PSDI 16-PAC as of the version HW/FW 00/100.

Record of revision

Edition	Release date	Note
01	06.2014	First edition
02	02.2015	Addition of HW/FW Version
03	05.2018	HW/FW version updated (as of...) Chapters updated: Use of the Safety Instructions, Disposal, Service and Support Information about safety seals removed (Chapter General Safety Notes and Chapter Repair) EMC Directive updated Conditions for Use at Altitudes greater than 2000 m above Sea Level inserted

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Editorial department Engineering automation systems control hardware, SB

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1 Use of the Safety Instructions

1.1 Structure of the Safety Instructions

The safety instructions are structured as follows:

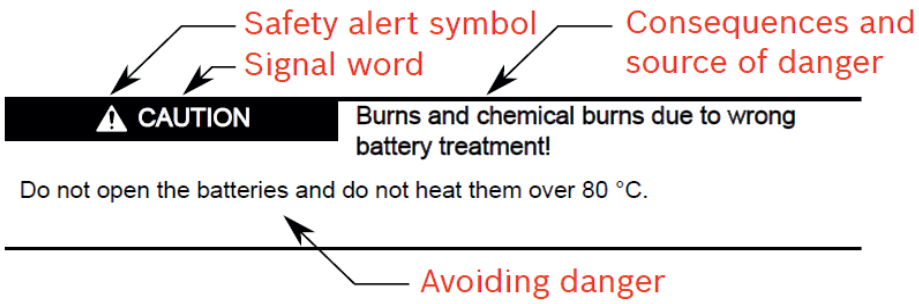


Abb. 1-1 Structure of the safety instructions

1.2 Explaining Signal Words and Safety Alert Symbol

The safety instructions in this documentation contain specific signal words (danger, warning, caution, notice) and, if necessary, a safety alert symbol (according to ANSI Z535.6-2006).

The signal word is used to draw attention to the safety instruction and also provides information on the severity of the hazard.

The safety alert symbol (a triangle with an exclamation point), which precedes the signal words danger, warning and caution is used to alert the reader to personal injury hazards.

⚠ DANGER

In case of non-compliance with this safety instruction, death or serious injury **will** occur.

⚠ WARNING

In case of non-compliance with this safety instruction, death or serious injury **can** occur.

⚠ VCAUTION

In case of non-compliance with this safety instruction, minor or moderate injury can occur.

NOTICE

In case of non-compliance with this safety instruction, material damage can occur.

Use of the Safety Instructions

1.3 Symbols used

Hints are represented as follows:

This is an information.

Tips are represented as follows:

This is a tip for the user.

1.4 Signal Graphic Explanation on the Device

Prior to the installation and commissioning of the device, refer to the device documentation.

2 For Your Safety

Purpose of this application description

The information in this document is designed to familiarize you with how the R-IB IL 24 PSDI 16-PAC safety module works, its operating and connection elements, and its parameter settings. This information will enable you to use the R-IB IL 24 PSDI 16-PAC module within a PROFIsafe system according to your requirements.

Validity of the application description

This application description is only valid for the R-IB IL 24 PSDI 16-PAC module in the version indicated on the inner cover page.

2.1 General Safety Notes

⚠ WARNING **Depending on the application, incorrect handling of the safety module can pose serious risks for the user**

When working with the safety module within the PROFIsafe system, please observe all the safety notes included in this chapter.

Requirements

Knowledge of the following is required:

- The non-safety-related target system (e.g., PROFIBUS, PROFINET)
- The PROFIsafe system
- The components used in your application
- The Inline product range
- Operation of the software tools used
- Safety regulations in the field of application

Qualified personnel

In the context of the use of the PROFIsafe system, the following operations may only be carried out by qualified personnel:

- Planning
- Configuration, parameterization, programming
- Installation, startup, servicing
- Maintenance, decommissioning

This application description is therefore aimed at:

- Qualified personnel who plan and design safety equipment for machines and systems and are familiar with regulations governing occupational safety and accident prevention.
- Qualified personnel who install and operate safety equipment in machines and systems.

In terms of the safety notes in this application description, qualified personnel are persons who, because of their education, experience and instruction, and their knowledge of relevant standards, regulations, accident prevention, and service conditions, have been authorized to carry out any required operations, and who are able to recognize and avoid any possible dangers.

For Your Safety

Documentation

You must observe all information in this application description as well as in the documents listed in Chapter “Documentation” on page 12.

Safety of personnel and equipment

The safety of personnel and equipment can only be assured if the safety module is used correctly (see Chapter “Correct Usage” on page 11).

Error detection

Depending on the wiring and the corresponding setting of the safe input module parameters, the PROFIsafe system can detect various errors within the safety equipment.

Do not carry out any repairs

Repair work may not be carried out on the safety module.

In the event that an error cannot be removed, please contact Bosch Rexroth immediately, engage a service engineer or send the faulty module directly to Bosch Rexroth.

Do not open the housing

It is strictly prohibited to open the housing. If the housing is opened, correct operation of the module can no longer be ensured.

Measures to prevent mismatching and polarity reversal

Take measures to prevent the mismatching, polarity reversal, and manipulation of connections.

2.2 Electrical Safety

⚠ WARNING **Hazardous shock currents and the loss of functional safety**

Disregarding instructions for electrical safety may result in hazardous shock currents and the loss of functional safety.

In order to ensure electrical safety, please observe the following points.

Direct/indirect contact

Protection against direct and indirect contact according to VDE 0100 Part 410 must be ensured for all components connected to the system. In the event of an error, parasitic voltages must not occur (single-fault tolerance).

This can be achieved by:

- Using power supply units with safe isolation (PELV).
- Decoupling circuits, which are not PELV systems, using optocouplers, relays, and other components which meet the requirements of safe isolation.

Power supply units for 24 V supply

Only use power supply units with safe isolation and PELV according to EN 50178/VDE 0160 (PELV). This prevents short circuits between primary and secondary sides.

Make sure that the output voltage of the power supply does not exceed 32 V even in the event of an error.

Insulation rating

When selecting the equipment, please take into consideration the dirt and surge voltages which may occur during operation.

The R-IB IL 24 PSDI 16-PAC module is designed for surge voltage category II (according to DIN EN 60664-1). If you expect surge voltages in the system, which exceed the values defined in surge voltage category II, take into consideration additional measures for voltage limitation.

Installation and configuration

Please observe the instructions for installing and configuring the system (see Chapter “Documentation” on page 12).

⚠ WARNING **Depending on the application, incorrect installation and upgrades can pose serious risks for the user**

The user is obliged to design the devices used and their installation in the system according to these requirements. This also means that existing plants and systems retrofitted with PROFIsafe must be checked and tested again in this respect.

2.3 Safety of the Machine or System

The machine/system manufacturer and the operator are solely responsible for the safety of the machine or system and the implemented application, in which the machine or system is used. The Machinery Directive must therefore be observed.

Draw up and implement a safety concept

In order to use the safety module described in this document, you must have drawn up an appropriate safety concept for your machine or system. This includes a hazard and risk analysis according to the directives and standards specified in Chapter “Directives and Standards” on page 11, as well as a test report (checklist) for validating the safety function (see “Checklists” on page 99).

The target safety integrity level (SIL according to EN 61508, SIL CL according to EN 62061 or performance level and category according to EN ISO 13849-1) is ascertained on the basis of the risk analysis. The safety integrity level ascertained determines how to connect and parameterize the safety module within the overall safety function.

Within a PROFIsafe system, the safety module can be used to achieve safety functions with the following requirements depending on the conditions of use:

- Up to SIL 3 according to standard EN 61508
- Up to SIL CL 3 according to standard EN 62061
- Up to Cat. 4/PL e according to standard EN ISO 13849-1

Check hardware and parameterization

Carry out a **validation** every time you make a safety-related modification to your overall system.

Use your test report to ensure that:

- The safe devices are connected to the correct safe sensors and actuators.
- The safe input and output channels have been parameterized correctly.
- The variables have been linked to the safe sensors and actuators correctly (single-channel or two-channel).

2.4 Directives and Standards

The manufacturers and operators of machines and systems, in which the R-IB IL 24 PSDI 16-PAC module is used, are responsible for adhering to all applicable directives and legislation.

For the standards observed by the module, please refer to the certificate issued by the approval body and the EC declaration of conformity. These documents are available on the Internet at www.boschrexroth.com/electrics.

2.5 Correct Usage

Only use the PROFIsafe system in accordance with the instructions in this chapter.

The R-IB IL 24 PSDI 16-PAC safety module is designed exclusively for use in a PROFIsafe system.
It can only perform its safety-related tasks within the system if it has been integrated into the execution process correctly and in such a way as to avoid errors.

You must observe all information in this application description as well as in the documents listed in “Documentation” on page 12. In particular, only use the module according to the technical data and ambient conditions specified in Chapter 12, “Technical Data and Ordering Data” on page 85 and onwards.

Within a PROFIsafe system, the safety module can be used to achieve safety functions with the following requirements depending on the conditions of use:

- Up to SIL 3 according to standard EN 61508
- Up to SIL CL 3 according to standard EN 62061
- Up to Cat. 4/PL e according to standard EN ISO 13849-1

It is designed for connecting single-channel or two-channel sensors, which can be used in association with safety technology.
For example, the module can be used in the following applications:

- Single or two-channel emergency stop or safety door equipment
- Applications with enable button
- Applications with two-hand control devices
- Applications with mode selector switches
- As secondary switchgear for safety-related photoelectric barriers
- Safety circuits according to EN 60204 Part 1

2.6 Documentation

Latest documentation

Make sure you always use the latest documentation. Changes or additions to this document can be found on the Internet at www.boschrexroth.com/electrics.

PROFIsafe

When working on the PROFIsafe system and its components, you must always keep this application description and other items of product documentation to hand and observe the information therein.

Application descriptions:

- For the safe controller used
- For PROFIsafe I/O modules
- For PROFIsafe function blocks

Please also observe the relevant information about PROFIBUS, PROFINET, and PROFIsafe, which is available on the Internet at www.profisafe.net.

Inline product range

DOK-CONTRL-ILSYSINS***-AW..-EN-P
Automation Terminals of the Rexroth Inline Product Range (Configuration and Installation)

Documentation for the bus coupler used

2.7 Abbreviations Used

Abbreviation	Meaning	Standard	Example
SIL	Safety integrity level	EN 61508	SIL 2, SIL 3
SIL CL	SIL claim limit	EN 62061	SIL CL 3
Cat.	Category	EN ISO 13849-1	Cat. 2, Cat. 4
PL	Performance level	EN ISO 13849-1	PL e, PL d

Fig. 2-1 Abbreviations used

Abbreviation	Meaning
PELV	Protective extra-low voltage according to EN 611316-2
EUC	Equipment under control
OSSD	Output signal switching device OSSD is the part of electrosensitive protective equipment, which is connected to the machine control system and switches off if the sensor part responds during correct operation.

Fig. 2-2 Abbreviations used

For terms and abbreviations used for PROFIsafe, please refer to “PROFIsafe Terms Used in the Application Description” on page 93.

2.8 Safety Hotline

Should you have any technical questions, please contact our 24-hour hotline.

Phone: +49 9352 40 5060
E-mail: service-svc@boschrexroth.de

For Your Safety

3 Product Description

3.1 Brief Description of the Safety Module

The R-IB IL 24 PSDI 16-PAC module is an input module, which is designed for use within an Inline station.

The R-IB IL 24 PSDI 16-PAC safety module can be used as part of an Inline station at any point within a PROFIsafe system.

The transmission speed of the Inline local bus can be set to 500 kBaud or 2 Mbaud on the safety module using a switch.

One transmission speed must be used consistently in an Inline station. Please note that operation of the standard Inline modules is only possible with 500 kBaud. In a combined system, you therefore have to set the baud rate of the safety modules to 500 kBaud.

The module has a 10-pos. DIP switch, which is used to set the PROFIsafe address.

The module has eight safe digital inputs for two-channel assignment or sixteen safe digital inputs for single-channel assignment.

The inputs can be parameterized according to the application and enable sensors to be integrated into the PROFIsafe system.

Within a PROFIsafe system, the R-IB IL 24 PSDI 16-PAC safety module can be used to achieve safety functions with the following requirements:

- Up to SIL 3 according to standard EN 61508
- Up to SIL CL 3 according to standard EN 62061
- Up to Cat. 4/PL e according to standard EN ISO 13849-1

3.2 Structure of the Safety Module

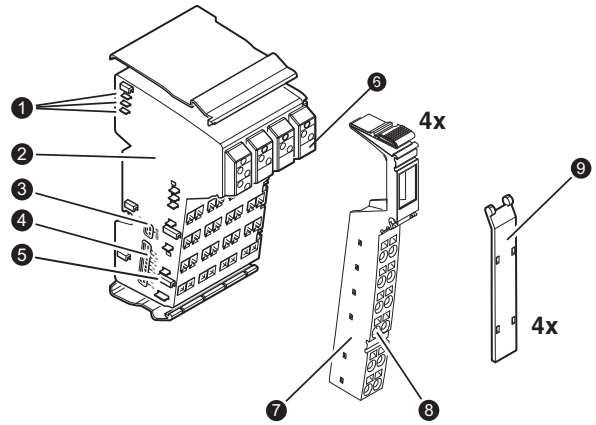


Fig. 3-1 Structure of the safety module

1 Data jumpers (local bus)

2 Electronics base with labeling including hardware/firmware version designation (not shown)

3 Switch for setting the transmission speed and the operating mode

4 Switch for setting the PROFIsafe address

For more detailed information about setting the switches, please refer to Chapter “Setting the DIP Switches” on page 34.

5 Potential jumpers

6 Diagnostics and status indicators; for assignment and meaning see Chapter “Local Diagnostics and Status Indicators” on page 21

7 Inline connector; for assignment see Chapter “Terminal Point Assignment” on page 29

8 Terminal points

9 Labeling field

3.3 Housing Dimensions

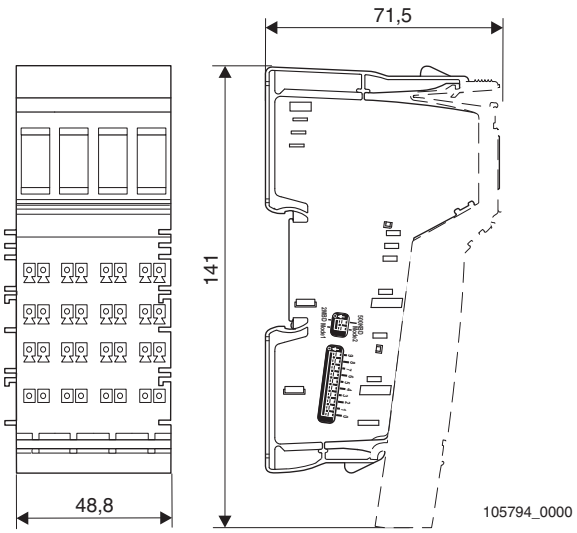


Fig. 3-2 Housing dimensions (in mm)

3.4 Safe Digital Inputs and Clock Outputs UT1 and UT2

3.4.1 Safe Digital Inputs

The safety module has eight safe digital inputs for two-channel assignment or sixteen safe digital inputs for single-channel assignment. The supply voltage for the inputs can be provided externally or via the clock outputs.

Technical data

For the technical data for the safe inputs, please refer to page 88.

Parameterization

The individual safe digital inputs of a safety module can be parameterized differently. This means that the inputs can be adapted to various operating conditions and different safety integrity levels (SIL, SIL CL, Cat., PL) can be implemented.

The safety integrity level (SIL, SIL CL, Cat., PL) and error detection that can be achieved depend on the parameterization, the structure of the sensor, and the cable installation (see “Connection Examples for Safe Inputs” on page 47).

For information on the parameterization of the inputs, please refer to Chapter “Parameterization of the Safe Inputs” on page 40.

Diagnostics

Diagnostics are provided via both the local diagnostics indicators and the diagnostic messages, which are transmitted to the safe controller.

For information about the diagnostic messages of the inputs, please refer to Chapter “Safe Digital Input Errors” on page 77.

⚠ CAUTION **Diagnostic data is not safety-related**

Do not use the diagnostic data to execute safety-related functions or actions.

Product Description

Requirements for controlling devices/sensors

The error detection of the module varies depending on the parameterization. This results in specific requirements for the sensors.

- To acquire input signals, the signal duration must be greater than the parameterized filter time.
- The sensors must be suitable for the application.
  Only use appropriately qualified sensors (suitable for the required category, SIL, SIL CL, PL).
- Use switches with a positive opening contact according to IEC 60947-5-1. Part 5 of this standard includes a description of the specific requirements for control switches with positive opening operation. All positive opening control switches, which meet these specific requirements, are marked with the following symbol:

- Use reliable components. These include, for example:
  - Mechanical position switches with personal protection function with positive opening contact according to EN 60947-5-1
  - Cam-operated switches with positive opening contact
  - Emergency stop buttons/cable-operated switches with positive opening contact according to EN 60947-5-1
- Controlling devices can be evaluated on a single-channel or two-channel connection depending on the application.
- Under certain circumstances, switches (e.g., for position monitoring) must be designed redundantly depending on the risk.
- In order to achieve Cat. 3/Cat. 4, SIL 3/SIL CL 3 or PL d or e, controlling devices must usually be designed redundantly.
- Please observe any special environmental requirements in your application when selecting the controlling devices.
- Please observe the applicable C standards in your application (e.g., EN 1010), in which, for example, the number of controlling devices required to achieve a particular category is specified.

3.4.2 Clock Outputs UT1 and UT2

The module has two independent clock outputs. They provide the supply voltage for the safe inputs. Each of these clock outputs can provide a pulse pattern to detect cross-circuits and short circuits in the external wiring of the inputs.

The clock outputs are also switched on and monitored when not parameterized. If a short circuit occurs at a clock output when it is in this state, the clock output is switched off. This is indicated by the local diagnostics LED.
To exit the error, parameterize the device and acknowledge the error message.

Technical data

For the technical data for the clock outputs, please refer to page 89.

Behavior in the event of an error

In the event of short circuit to GND or overload, the affected clock output is switched off. At the same time, the error is indicated at the UT1 and/or UT2 LEDs and a diagnostic message is generated and transmitted to the safe controller. This error must be acknowledged so that the system can be started up again following error removal.

Error detection

Error detection depends on the parameterization. If cross-circuit detection is activated for an input pair, the relevant inputs are permanently assigned to clock outputs UT1 and UT2.

Diagnostics

Diagnostics are provided via both the local diagnostics indicators and the diagnostic messages, which are transmitted to the safe controller.
For information on the diagnostic messages of the clock outputs, please refer to Chapter “Clock Output UT1 and UT2 Errors” on page 78.

⚠ CAUTION **Diagnostic data is not safety-related**

Do not use the diagnostic data to execute safety-related functions or actions.

Product Description

3.5 Connection Options for Sensors Depending on the Parameterization

Sensors that meet various safety requirements depending on the parameterization can be connected to the inputs. For connection examples, please refer to Chapter 8, “Connection Examples for Safe Inputs”.

The maximum achievable SIL/SIL CL/Cat./PL is specified in the table.
In order to achieve this:

- Observe the information in the connection examples (see Chapter 8, “Connection Examples for Safe Inputs”)
- Observe the requirements of the standards with regard to the external wiring and the sensors to be used to achieve a SIL/SIL CL/Cat./PL (see “Measures Required to Achieve a Specific Safety Integrity Level” on page 48)

	Input							
Connection to the Inline connectors	Single-channel sensor or redundant sensor			Two-channel redundant controlling device/sensor				
Input signal				Equivalent			Non-equivalent	
Cross-circuit monitoring	With	Without		With	Without		With	Without
Sensors that can be connected: – Contact-based	Yes	Yes		Yes	Yes		Yes	Yes
– With OSSD outputs			Yes			Yes		
Achievable SIL/SIL CL/Cat./PL	SIL 2 SIL CL 2 Cat. 3* PL d	SIL 2 SIL CL 2 Cat. 2 PL d	SIL 2 SIL CL 2 Cat. 2 PL d	SIL 3 SIL CL 3 Cat. 4 PL e	SIL 3 SIL CL 3 Cat. 3 PL d	SIL 3 SIL CL 3 Cat. 4** PL e	SIL 3 SIL CL 3 Cat. 4 PL e	SIL 3 SIL CL 3 Cat. 3 PL d
For connection example, see page	Page 51	Page 53	Page 55	Page 59	Page 61	Page 64	Page 68	Page 70

Key:

* Cat. 3 can only be achieved with a redundant sensor.

** The category that can be achieved depends on the sensor used.

Cross-circuit monitoring

The clocking for cross-circuit monitoring is provided when clock outputs UT1 and UT2 are parameterized accordingly. If all inputs are parameterized without cross-circuit monitoring, a DC voltage can be tapped at the clock outputs without clock pulses. As soon as cross-circuit monitoring has been parameterized for at least one input pair, pulses are output at clock outputs UT1 and UT2.

For inputs that are parameterized with cross-circuit monitoring, the assignment is as follows:

Inputs for channel 1 (INx_CH1) are assigned to clock output UT1.

Inputs for channel 2 (INx_CH2) are assigned to clock output UT2.

For information on error detection according to clocking, please refer to Chapter “Clock Outputs UT1 and UT2” on page 19.

Error detection

For information about the special features of error detection, please refer to the connection examples.

3.6 Local Diagnostics and Status Indicators

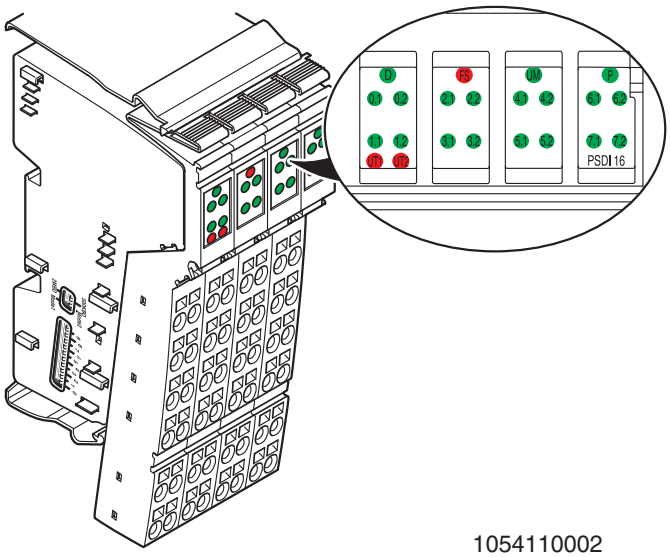


Fig. 3-3 Local diagnostics and status indicators on the R-IB IL 24 PSDI 16-PAC module

D	Green LED	Diagnostics
	OFF:	Communications power not present
	Flashing at 0.5 Hz:	Communications power present, local bus not active
	Flashing at 4 Hz:	Communications power present, error at the interface between previous and flashing terminal (the terminals after the flashing terminal cannot be addressed). (E.g., loose contact at the bus interface, terminal before the flashing terminal has failed, another terminal was snapped on during operation (not permitted))
	Observe the module startup time of approximately 30 s. During this time the D LED flashes at 4 Hz and the bus cannot be started up.	
	ON:	Communications power present, local bus active

Fig. 3-4 Local diagnostics and status indicators

Product Description

FS	Red LED	Failure state
	Flashing at 1 Hz:	Device not parameterized or parameterization was not accepted
	ON:	Hardware fault; communication to safe controller disabled
UM	Green LED	Monitoring the supply voltage U_M
	OFF:	Communications power not present
	Flashing at 1 Hz:	U_M below the permissible voltage range (undervoltage)
	ON:	U_M present
P	Green LED	Status indicator for safe communication
	OFF:	No safe communication
	Flashing at 0.5 Hz:	Safe communication running, the controller requests operator acknowledgment
	ON:	Safe communication running without errors
UT1, UT2	Red LED	Diagnostic message (error) for each clock output
	OFF:	No error
	Flashing at 1 Hz:	Cross-circuit of an input with external signals
	ON:	Short circuit or overload of the clock output
	☞	The clock output is switched off until the acknowledgment is received by the safety module (see also Chapter “Clock Output UT1 and UT2 Errors” on page 78).
IN 0.1 - 7.2	Green LED	Status of each input (see “Terminal Point Assignment” on page 29)
	ON:	Input at logic 1
	OFF:	Input at logic 0
	☞	Even when the module is not parameterized, the physical state at the inputs is indicated. However, substitute value “0” is transmitted to the safe controller.

Fig. 3-4 Local diagnostics and status indicators [...]

3.7 Safe State

The safe state for the module is the transmission of the value equal to “0” in the image of the inputs to the safe controller.

PROFIsafe:
The safe state for the F-Input data is “0”.
The safe state is entered by means of passivation (see “Passivation” on page 94).

The safe state can be entered in the following cases:

1. Operating state
2. Error detection in I/O devices
3. Device errors
4. Parameterization errors

3.7.1 Operating State

In the operating state, the inputs can enter states “1” or “0”. In general, state “0” is the safe state. An exception is a non-equivalent parameterized input. For channel 2 of this input, “1” is the safe state, “0” is represented in the process image of the two-channel input.

Type of input	Operating state equals 1 in input state	Operating state equals 0 (safe state)
Single-channel	High (1)	Low (0)
Two-channel equivalent	High/High (1/1)	High/Low (1/0) Low/High (0/1) Low/Low (0/0)
Two-channel non-equivalent	High/Low (1/0)	Low/High (0/1) Low/Low (0/0) High/High (1/1)

Fig. 3-5 Operating state depending on the state of the inputs

Please observe the state transitions (see “Symmetry/start inhibit” on page 41).

3.7.2 Error Detection in I/O Devices

Inputs If an error is detected at an input, the safe state is set at this input and a “0” is represented in the process image of the input (“0” = safe state).

Depending on the parameterization, the following errors can be detected at inputs:

- Cross-circuits
- Symmetry errors
- Implausible signal change

The relevant diagnostic message is transmitted to the safe controller (see Chapter “Safe Digital Input Errors” on page 77). For information on which errors are detected and when, please refer to Chapter “Connection Examples for Safe Inputs” on page 47.

3.7.3 Device Errors

Device errors can lead to safe communication being set.

Inputs

If a hardware fault in the internal circuit is detected at an input, **all** module inputs enter the safe state and “0” values are represented in the process image of the inputs (“0” = safe state).

The relevant diagnostic message is transmitted to the safe controller (see Chapter “Safe Digital Input Errors” on page 77).

Serious errors

All serious errors that can result in the loss of or adversely affect the safety function cause the entire module to enter the safe state. The FS LED on the safety module is permanently on.

The following errors result in the safe state:

- Serious hardware faults in the internal circuit
- User errors
- Module overload
- Module overheating
- Incorrect supply

The relevant diagnostic message is transmitted to the safe controller (see Chapter “Errors: Messages and Removal” on page 75).

⚠ WARNING **Loss of the safety function due to sequential errors**

In the event of a device error, the following measures should be taken to prevent sequential errors:

Disconnect the module from the power supply and replace it.

3.7.4 Parameterization Errors

The FS LED on the safety module flashes. Parameterization errors are indicated

- as long as the module is not parameterized

or

- in the event of faulty parameterization.

Parameterization errors cause the entire module to enter the safe state.

In the event of faulty parameterization, the relevant diagnostic message is transmitted to the safe controller (see Chapter “Parameterization Errors” on page 78).

3.8 Process Data Words

3.8.1 PROFIsafe (PROFIBUS, PROFINET)

The module occupies four words in the Inline system and four words in the PROFIBUS system. The way in which these words are mapped in the higher-level control system is specific to the controller used and is described in the quick start guide for the controller.

3.9 Programming Data/Configuration Data

3.9.1 Local Bus

	PROFIsafe
Switch address	001_{hex} ... $3FE_{hex}$
Operating mode	Mode 1
ID code	CB_{hex} (203_{dec})
Length code	04_{hex} (04_{dec})
Input address area	Controller-specific
Output address area	Controller-specific
Parameter channel (PCP)	1 word
Register length	4 words

Fig. 3-6 Local bus

The PCP channel is only used internally.

3.9.2 Other Bus Systems (PROFIBUS, PROFINET, etc.)

For the programming data/configuration data of other bus systems, please refer to the corresponding electronic device data sheet (e.g., GSD, GSDML).

Product Description

4 Inline Potential and Data Routing, and Inline Connectors

4.1 Inline Potential and Data Routing

In order to operate the safety module, it must be integrated in an Inline station within the PROFIsafe system.

The bus signals are transmitted via the Inline data jumpers. The required supply voltages are transmitted via the Inline potential jumpers.

For more detailed information on potential and data routing within an Inline station, please refer to the DOK-CONTRL-ILSYSINS***-AW..-EN-P application description.

The segment circuit is looped through the safety module and is available again after the module. The segment circuit is not accessed in the safety module.

4.2 Supply Voltage U_L

Supply the 24 V supply voltage U_{BK}/U_{24V} at a bus coupler or a suitable power terminal (R-IB IL 24 PWR IN/R-PAC). The 7.5 V voltage U_L is generated from this 24 V supply voltage in the bus coupler or power terminal. It is supplied to the safety module via the Inline potential jumper U_L.

⚠ WARNING **Loss of the safety function when using unsuitable power supplies**

Please note for the voltage supply at the bus coupler or power terminal that:
Only power supplies according to EN 50178/VDE 0160 (PELV) may be used.
Make sure that the output voltage of the power supply does not exceed 32 V even in the event of an error.
Please also observe the points in Chapter “Electrical Safety” on page 9.

The supply voltage **U_L** is used to supply the communications power. For the technical data for the supply voltage U_L, please refer to “Supply voltage U_L (logic)” on page 87.

The maximum current carrying capacity for the supply voltage U_L is 2 A.
This current carrying capacity can be reduced if certain terminals are used. Please refer to the information in the terminal-specific data sheets.

4.3 Supply Voltage U_M

Supply the supply voltage at a bus coupler or a power terminal. It is supplied to the safety module via the Inline potential jumper U_M.

⚠ WARNING **Loss of the safety function when using unsuitable power supplies**

Please observe the points in Chapter “Electrical Safety” on page 9.

The supply voltage **U_M** is used to supply the input circuits and the clock outputs. For the technical data for the supply voltage U_M, please refer to “Supply voltage U_M (sensors, clock outputs)” on page 88.

The maximum current carrying capacity for the main circuit U_M is 8 A (total current with the segment circuit that is not used in the safety terminal). This current carry-

ing capacity can be reduced if certain terminals are used. Please refer to the information in the terminal-specific data sheets.

If the limit value of the potential jumpers U_M and U_S is reached (total current of U_S and U_M), a new power terminal must be used.

NOTICE **Module damage due to polarity reversal**

Polarity reversal places a burden on the electronics and, despite protection against polarity reversal, can damage the module. Therefore, polarity reversal must be prevented.

For the behavior of the safety module in the event of an error at the supply voltage U_M, please refer to Chapter “Supply Voltage Errors” on page 78.

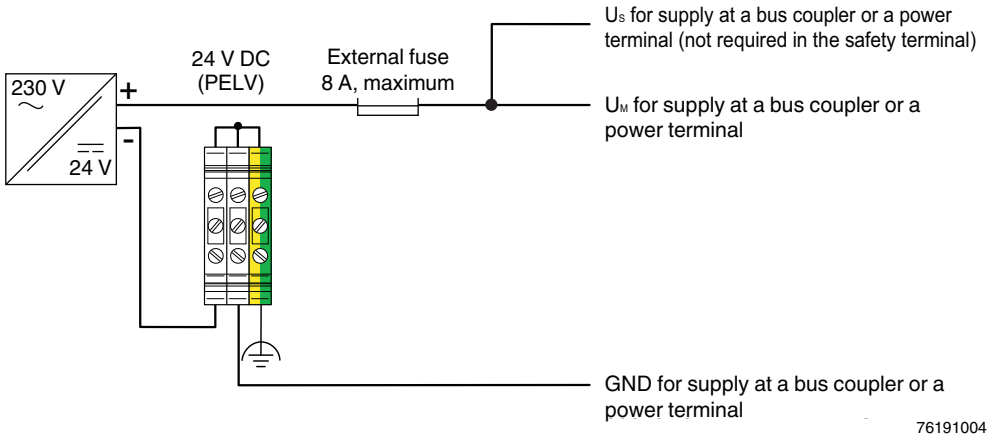


Fig. 4-1 *Supply U_M with connection to functional earth ground according to EN 60204-1*

NOTICE **Damage to module electronics in the event of surge voltage**

Do not use a DC distribution network.

DC distribution network according to IEC 61326-3-1:
A DC distribution network is a DC power supply network which supplies a complete industrial hall with DC voltage and to which any device can be connected. A typical system or machine distribution is not a DC distribution network. For devices that are provided for a typical system or machine distribution, the DC connections are viewed and tested as I/O signals according to IEC 61326-3-1.

4.4 Terminal Point Assignment

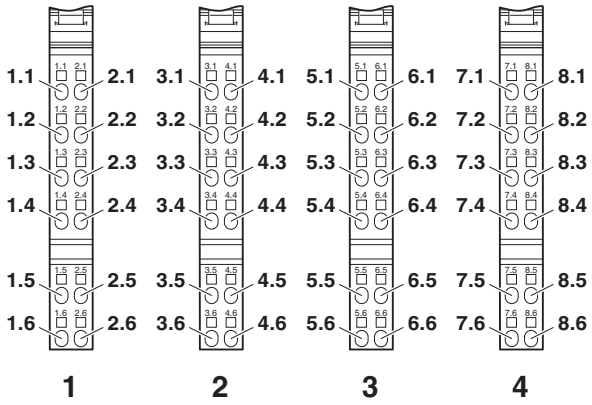


Fig. 4-2 Terminal point assignment

The Inline connectors are supplied with the module. They are coded and marked accordingly for connection to prevent polarity reversal.

Only use the connectors supplied with the module.

The following applies for the tables below:

- All inputs are safe digital inputs.
- 0 V (GND): common ground of inputs and clock outputs
- FE: common functional earth ground

Terminal point	Signal	Channel assignment	LED
1.1	IN0_Ch1	Input 0, channel 1	0.1
2.1	IN0_Ch2	Input 0, channel 2	0.2
1.2	UT1	Clock output 1	UT1
2.2	UT2	Clock output 2	UT2
1.3	0 V (GND)	Channel 1 and channel 2	
2.3	0 V (GND)	Channel 1 and channel 2	
1.4	IN1_Ch1	Input 1, channel 1	1.1
2.4	IN1_Ch2	Input 1, channel 2	1.2
1.5	UT1	Clock output 1	UT1
2.5	UT2	Clock output 2	UT2
1.6	0 V (GND)	Channel 1 and channel 2	
2.6	0 V (GND)	Channel 1 and channel 2	

Fig. 4-3 Terminal point assignment for connector 1

Inline Potential and Data Routing, and Inline Connectors

Terminal point	Signal	Channel assignment	LED
3.1	IN2_Ch1	Input 2, channel 1	2.1
4.1	IN2_Ch2	Input 2, channel 2	2.2
3.2	UT1	Clock output 1	UT1
4.2	UT2	Clock output 2	UT2
3.3	0 V (GND)	Channel 1 and channel 2	
4.3	0 V (GND)	Channel 1 and channel 2	
3.4	IN3_Ch1	Input 3, channel 1	3.1
4.4	IN3_Ch2	Input 3, channel 2	3.2
3.5	UT1	Clock output 1	UT1
4.5	UT2	Clock output 2	UT2
3.6	0 V (GND)	Channel 1 and channel 2	
4.6	0 V (GND)	Channel 1 and channel 2	

Fig. 4-4 Terminal point assignment for connector 2

Terminal point	Signal	Channel assignment	LED
5.1	IN4_Ch1	Input 4, channel 1	4.1
6.1	IN4_Ch2	Input 4, channel 2	4.2
5.2	UT1	Clock output 1	UT1
6.2	UT2	Clock output 2	UT2
5.3	0 V (GND)	Channel 1 and channel 2	
6.3	0 V (GND)	Channel 1 and channel 2	
5.4	IN5_Ch1	Input 5, channel 1	5.1
6.4	IN5_Ch2	Input 5, channel 2	5.2
5.5	UT1	Clock output 1	UT1
6.5	UT2	Clock output 2	UT2
5.6	0 V (GND)	Channel 1 and channel 2	
6.6	0 V (GND)	Channel 1 and channel 2	

Fig. 4-5 Terminal point assignment for connector 3

Terminal point	Signal	Channel assignment	LED
7.1	IN6_Ch1	Input 6, channel 1	6.1
8.1	IN6_Ch2	Input 6, channel 2	6.2
7.2	UT1	Clock output 1	UT1
8.2	UT2	Clock output 2	UT2
7.3	0 V (GND)	Channel 1 and channel 2	
8.3	0 V (GND)	Channel 1 and channel 2	
7.4	IN7_Ch1	Input 7, channel 1	7.1
8.4	IN7_Ch2	Input 7, channel 2	7.2
7.5	UT1	Clock output 1	UT1
8.5	UT2	Clock output 2	UT2
7.6	0 V (GND)	Channel 1 and channel 2	
8.6	0 V (GND)	Channel 1 and channel 2	

Fig. 4-6 Terminal point assignment for connector 4

⚠ WARNING **Loss of functional safety due to parasitic voltages**

For sensors that require a GND, this must be wired to 0 V (GND) on the connector for the input.

Inline Potential and Data Routing, and Inline Connectors

5 Assembly, Removal, and Electrical Installation

5.1 Assembly and Removal

5.1.1 Unpacking the Module

The module is supplied in an ESD box together with a package slip with installation instructions. Please read the complete package slip carefully.
The module may only be installed and removed by qualified personnel.

NOTICE **Electrostatic discharge**

The safety module contains components that can be damaged or destroyed by electrostatic discharge. When handling the safety module, observe the necessary safety precautions against electrostatic discharge (ESD) according to EN 61340-5-1 and EN 61340-5-2.

5.1.2 General

⚠ WARNING **Unintentional machine startup**

Do not assemble or remove the module while the power is connected.

Before assembling or removing the module, disconnect the power to the module and the entire Inline station and ensure that it cannot be switched on again.

Make sure the entire system is reassembled before switching the power back on. Observe the diagnostics indicators and any diagnostic messages.

The system may only be started provided neither the station nor the system poses a hazard.

The R-IB IL 24 PSDI 16-PAC safety terminal is designed for use within an Inline station. Only use the safety terminal in the 24 V DC area of an Inline station.

To ensure reliable operation, install the safety terminal in housing protected from dust and humidity (IP54 or higher). In order to prevent manipulation, secure the housing (control cabinet/control box) against being opened by unauthorized persons.

Mount all Inline terminals on 35 mm DIN rails.

Only connect the cables using the supplied Inline connectors or Inline connectors listed in the ordering data.

Assembly, Removal, and Electrical Installation

5.1.3 Setting the DIP Switches

The module has a 2-pos. and a 10-pos. DIP switch.

The DIP switches are located on the left-hand side of the safety module.

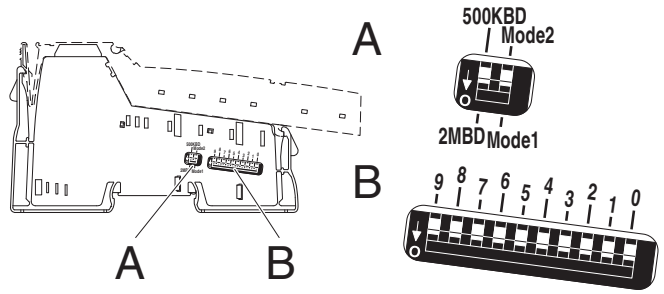


Fig. 5-1 DIP switches

A Switch for setting the transmission speed and the operating mode

B Switch for setting the address

2-pos. DIP switch: The transmission speed and the operating mode are set via the 2-pos. DIP switch.

Left switch: Transmission speed The transmission speed can be set to 500 kBaud or 2 Mbaud.
The transmission speed is set to 500 Mbaud by default.

> Only use devices with a uniform transmission speed within an Inline station (a local bus). It is not possible to operate a mixture of devices with different transmission speeds. Please note that operation of the standard Inline modules is only possible with 500 kBaud. In a combined system, you therefore have to set the baud rate of the safety modules to 500 kBaud.

Right switch: Mode For PROFIsafe, set Mode 1.

10-pos. DIP switch: Address The PROFIsafe address (F-Address) is set via the 10-pos. DIP switch. PROFIsafe addresses 1 to 1022 (1_{hex} to $3FE_{hex}$) are permitted.

Overview of the switch positions

PROFIsafe										
Mode switch	**Address switch**									
	9	8	7	6	5	4	3	2	1	0
Mode 1										
	1_{hex} to $3FE_{hex}$									

Fig. 5-2 Switch position for PROFIsafe

Procedure If you need to modify the DIP switch settings, proceed as follows:

- Use the switch to set the transmission speed to 500 kBaud or 2 Mbaud.
- Set the address.

> Set the DIP switches **before** assembling the module in the Inline station. The switches cannot be accessed when the safety terminal is installed in the Inline station.

> See also: "F_Destination_ Address" on page 95

5.1.4 Assembly and Removal of the Safety Module

For general information on assembling and removing Inline terminals, please refer to the DOK-CONTRL-ILSYSINS***-AW..-EN-P application description.

Assembly

- Set the DIP switches prior to assembly (see Chapter “Setting the DIP Switches” on page 34). The DIP switches cannot be accessed when the safety module is installed in the Inline station.
- Observe a mounting distance of 30 mm above and 40 mm below the safety module. Shorter distances may inhibit proper handling during installation.

– Snap on base

- Disconnect the power to the station.
- Before snapping on the safety module, remove the inserted connectors from the safety terminal and the adjacent connector from the neighboring Inline terminal on the left. This prevents the potential routing knife contacts and the keyway/featherkey connections from being damaged.
- Hold the safety module perpendicular and snap it onto the DIN rail (7.5 mm in height).

Ensure that **all** featherkeys and keyways on adjacent terminals are **securely** interlocked.

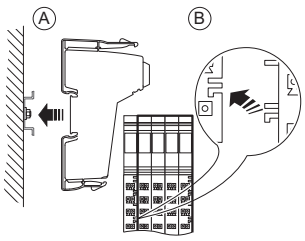


Fig. 5-3 Snapping on the safety module base

– Insert connectors

- Check that all the snap-on mechanisms are securely snapped into place.
- Insert the connectors in the specified order (A, B).

Only use the connectors supplied with the module.

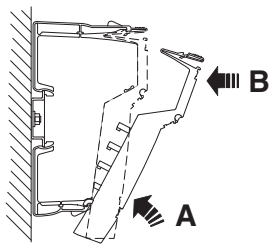


Fig. 5-4 Inserting the connector

Assembly, Removal, and Electrical Installation

Removal

- Disconnect the power to the station.
- Before snapping on the safety module, remove the connectors from the safety module and the adjacent connector from the neighboring Inline terminal on the left.

– Remove connectors

- Remove the connectors by pressing the back shaft latching (A) and levering off the connector (B).

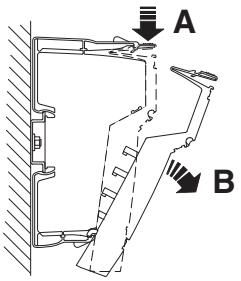


Fig. 5-5 Removing the connector

– Remove base

- Release the base by pressing on the front and back snap-on mechanisms (A) and pull it out perpendicular to the DIN rail (B).

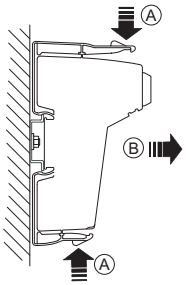


Fig. 5-6 Removing the safety module base

5.2 Electrical Installation

⚠ WARNING **Electric shock/unintentional machine startup**

Prior to electrical installation, disconnect the power to the system and make sure that it cannot be switched on again unintentionally.

Make sure installation has been completed before switching the power back on.

The system may only be started provided the system does not pose a hazard.

5.2.1 Electrical Installation of the Inline Station

Electrical installation of the Inline station includes the following:

- Connecting the bus system to the Inline station
- Connecting the supply voltages for the Inline station

Carry out electrical installation for the Inline station according to the DOK-CONTRL-ILSYSINS***-AW..-EN-P application description. Please also observe the specifications in the documentation for the bus coupler used.

5.2.2 Electrical Installation of the Safety Module

During installation, always observe the instructions in “Electrical Safety” on page 9.
Take measures to prevent the mismatching, polarity reversal, and manipulation of connections.

The supply voltages are supplied at a bus coupler and/or a power terminal and are supplied to the safety module via the potential jumpers. Therefore the electrical installation of the safety module only involves connecting the sensors.

The sensors are connected via Inline connectors.

- Wire the connectors according to your application. For the terminal point assignment, please refer to Chapter “Terminal Point Assignment” on page 29.

For wiring, proceed as follows:

- Strip 8 mm off the cable.

Inline wiring is normally done without ferrules. However, it is possible to use ferrules. If using ferrules, make sure they are properly crimped.

- Push a screwdriver into the actuation shaft of the appropriate terminal point (Fig. 5-7, 1), so that you can insert the wire into the spring opening.
- Insert the wire (Fig. 5-7, 2). Remove the screwdriver from the opening. This clamps the wire.

Assembly, Removal, and Electrical Installation

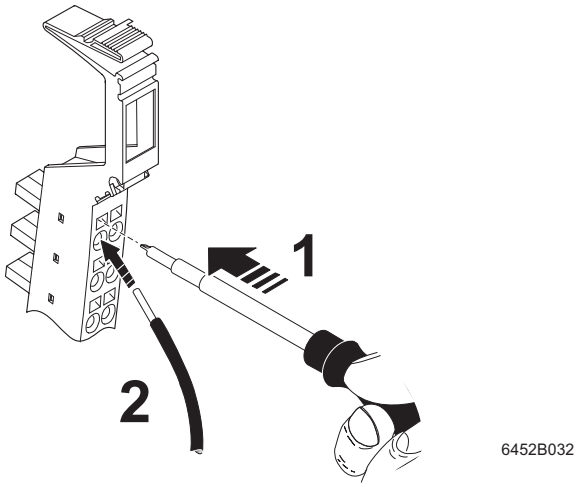


Fig. 5-7 Connecting unshielded cables

- Insert the assembled connectors in the corresponding module slot (see Chapter “Terminal Point Assignment” on page 29).
- Mark all connections to prevent connections to the Inline connectors being mixed up (see DOK-CONTRL-ILSYSINS***-AW..-EN-P application description).

6 Parameterization of the Safety Module

6.1 Parameterization in a PROFIsafe System

Parameterization includes the following:

- Assigning the PROFIsafe address via the configuration software of the control system manufacturer
- Parameterizing the inputs
- Assigning the parameterizable F-Parameters and iParameters

PROFIsafe address

The PROFIsafe address is a unique ID for the safety module in the PROFIsafe structure. It is assigned in the configuration software. Set this address via the DIP switches prior to assembling the safety module (see “Setting the DIP Switches” on page 34).

Parameterization of inputs

The parameterization of the safe inputs determines the behavior of the module and therefore has a considerable effect on the safety integrity level that can be achieved.

To parameterize the module, the parameterization of the safe controller created in the parameterization tool is automatically written to the module on every power up or reset.

The following conditions must be met:

- The supply voltage is present.
- The local bus is in the RUN state.
- The communication connection has been established between the controller and safety module.

The module cannot be operated if it is not parameterized.
In this case, the FS LED flashes.

The module is ready to operate if the parameters for all inputs are valid and transmitted without errors. Valid input data is only read in this state. In every other state, the safe state is transmitted for each input (“0” in the process image of the inputs).

If errors are detected during parameterization, the parameterization data is not transmitted. The FS LED on the module flashes to indicate that the parameterization is invalid.
In addition, the error is reported to the safe controller. In this case, check and correct the settings. For information about error messages and instructions for their removal, please refer to Chapter “Errors: Messages and Removal” on page 75.

F-Parameters and iParameters

Assign the parameterizable F-Parameters and iParameters. For an overview of the module parameters and possible settings, please refer to “F-Parameters and iParameters” on page 95.

6.2 Parameterization of the Safe Inputs

Each input pair of a safety module can be parameterized differently and can therefore achieve different safety integrity levels (SIL, SIL CL, Cat., PL).

Two-channel

If the inputs are operated via two channels, the following fixed assignment applies:

- IN0_Ch1 to IN0_Ch2
- IN1_Ch1 to IN1_Ch2
- IN2_Ch1 to IN2_Ch2
- IN3_Ch1 to IN3_Ch2
- IN4_Ch1 to IN4_Ch2
- IN5_Ch1 to IN5_Ch2
- IN6_Ch1 to IN6_Ch2
- IN7_Ch1 to IN7_Ch2

For two-channel assignment, the inputs have a fixed assignment to one another. The input information of both inputs is mapped to one bit. The unused bits are always set to “0”.

Single-channel

If two-channel operation in the external wiring of the inputs is not required, the inputs can be parameterized in such a way that they operate independently of one another (single-channel).

Position of the data in the process data word

(Word.bit) view	Byte	Byte 0							
	Bit	7	6	5	4	3	2	1	0
Module	Input (single-channel)	IN3 _Ch2	IN3 _Ch1	IN2 _Ch2	IN2 _Ch1	IN1 _Ch2	IN1 _Ch1	IN0 _Ch2	IN0 _Ch1
	Input (two-channel)	0	IN3 _Ch 1&2	0	IN2 _Ch 1&2	0	IN1 _Ch 1&2	0	IN0 _Ch 1&2

(Word.bit) view	Byte	Byte 1							
	Bit	15	14	13	12	11	10	9	8
Module	Input (single-channel)	IN7 _Ch2	IN7 _Ch1	IN6 _Ch2	IN6 _Ch1	IN5 _Ch2	IN5 _Ch1	IN4 _Ch2	IN4 _Ch1
	Input (two-channel)	0	IN7 _Ch 1&2	0	IN6 _Ch 1&2	0	IN5 _Ch 1&2	0	IN4 _Ch 1&2

Parameterization

Parameterize all safe input pairs in pairs. The parameterization options are described in Fig. 6-1.

Parameterization	Value range	Remark
Assignment	**Not used** Used, both single-channel Two-channel equivalent Two-channel non-equivalent	Parameterization is always for one input pair. For unused inputs, the data is filled with 0. For “two-channel”, the assignment of the inputs to one another is specified and cannot be modified.
Filter time (t_{Filter})	**3 ms** 5 ms 15 ms	The filter time is used to suppress interference for the input signals. Select the filter time so that the duration of the input signal is greater than the filter time.
	NOTICE The filter time directly affects the response time of the safety function.	
Symmetry	**Disabled** 100 ms 1 s 5 s	Parameterization is only active if the input is parameterized for two-channel operation. Select the same value for both channels. See also “Symmetry/start inhibit” on page 41.
Start inhibit due to symmetry violation	**Disabled** Enabled	Disabled (default setting): Only a diagnostic message is generated in the event of symmetry violation. Enabled: A diagnostic message is generated in the event of symmetry violation. In addition, the affected input is set to the safe state.
Cross-circuit detection	No cross-circuit monitoring **Cross-circuit monitoring** INx_CH1 -> UT1 INx_CH2 -> UT2	As soon as cross-circuit monitoring is enabled for an assigned input pair, clock outputs UT1 and UT2 are clocked. Otherwise they are enabled without clocking.

Fig. 6-1 Parameterization of inputs

The default values are shown in bold.

Symmetry/start inhibit

Symmetry monitoring can be used to monitor the contact wear of the switch. Symmetry monitoring checks the extent to which the related (filtered) inputs enter another state simultaneously. Symmetry is violated if the inputs indicate different states for a time greater than the value parameterized for “symmetry”. This applies for positive and negative edges.

The safe controller is informed of a symmetry violation by a diagnostic message. If “Start inhibit due to symmetry violation” is enabled, symmetry violation locks the affected input.

Key for the following diagrams:

S	Symmetry monitoring
Diag	Diagnostics
Q	Acknowledgment of the diagnostic message. After acknowledging the diagnostic message, the current state is read.

For non-equivalent parameterization, a negated signal is present at input IN0_Ch2 shown in the diagrams.

Parameterization of the Safety Module

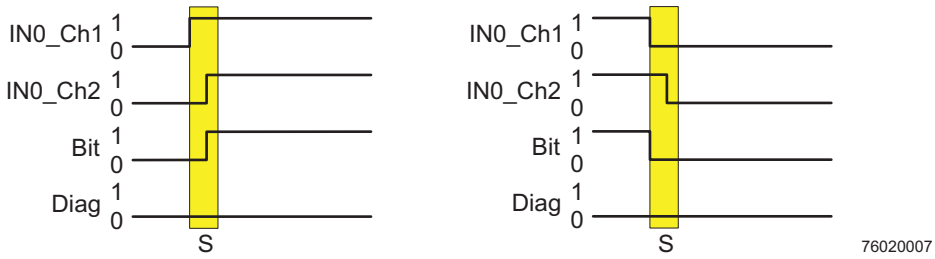


Fig. 6-2 Example for a signal change within the parameterized time for symmetry monitoring

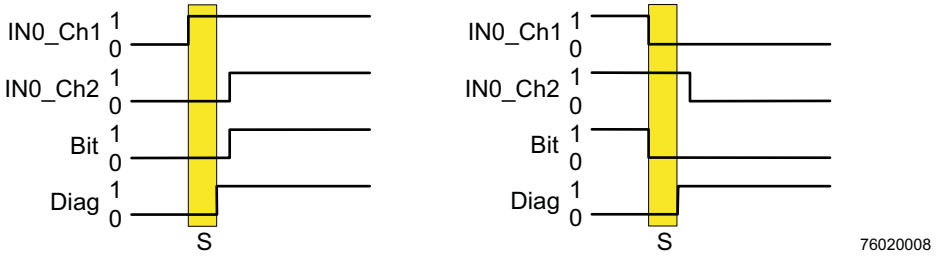


Fig. 6-3 Example for a signal change outside the parameterized time for symmetry monitoring; start inhibit due to symmetry violation is disabled

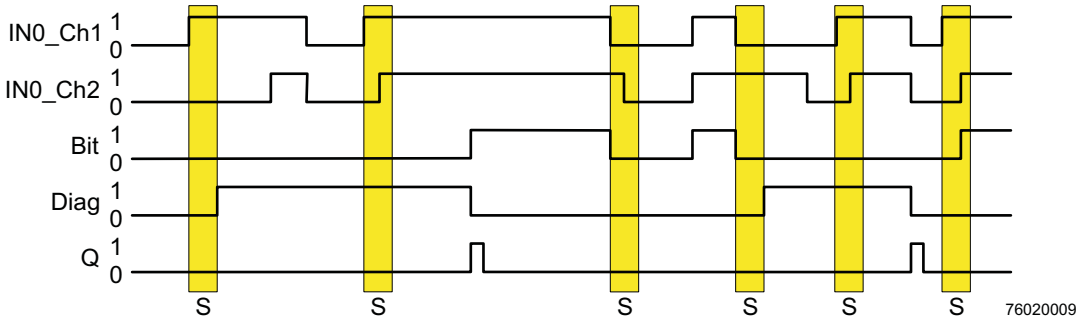


Fig. 6-4 Example for a signal change outside the parameterized time for symmetry monitoring; start inhibit due to symmetry violation is enabled

After acknowledging the diagnostic message (see Chapter “Error Acknowledgment” on page 81), the current state at the input is immediately transmitted to the safe controller. If a startup inhibit is required following error acknowledgment, this must be implemented by the user in the application program.

A symmetry violation can also be triggered by a cross-circuit (see Chapter “Connection Examples for Safe Inputs” on page 47).

Processing time of input t_{IN} in the event of a safety demand

The processing time of input t_{IN} in the event of a safety demand consists of the parameterized filter time t_{Filter} and the firmware runtime t_{FW}: It is calculated for the R-IB IL 24 PSDI 16-PAC module according to the following formula:

$$t_{IN} = t_{Filter} + t_{FW}$$

Where:

t_{IN}	Processing time of the input
t_{Filter}	Parameterized filter time
t_{FW}	Firmware runtime: 250 µs

6.3 Parameterization of Clock Outputs UT1 and UT2

As long as the module is not parameterized:

- The clock outputs are enabled if no errors are present.
- Short-circuit detection is activated.

The clock output settings are specified by the parameterization of the safe inputs. If all safe inputs are parameterized without cross-circuit monitoring, an unclocked DC voltage is output at both clock outputs.

If cross-circuit detection is activated for at least one safe input, low pulses with a maximum pulse width of 1 ms and a maximum period length of 40 ms are output at the clock outputs.
The time offset between the clocks of the clock outputs is approximately 50% of the period length.

If clock outputs are parameterized without clock pulses, no cross-circuits or short circuits can be detected between the channels.

If clocking is enabled, the clock output is operated with a maximum pulse width of 1 ms and a maximum period length of 40 ms.
The time offset between the clocks of the clock outputs is approximately 50% of the period length.

Typical pulse pattern

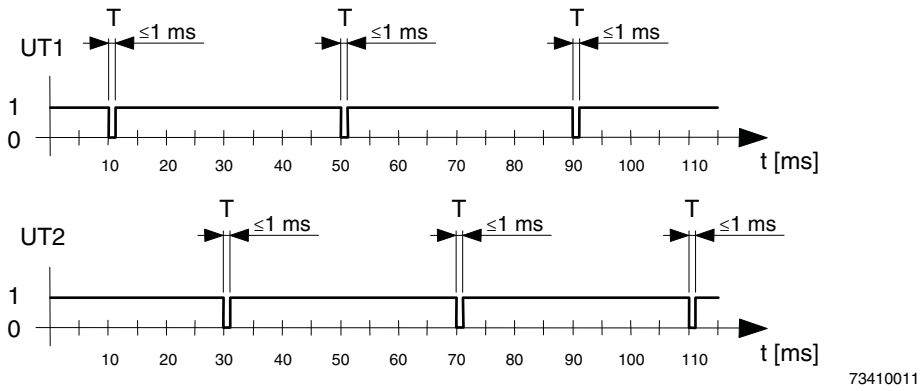


Fig. 6-5 Typical pulse pattern

Key:

T	Test pulse
	Pulse width ≤ 1 ms
	Period length ≤ 40 ms

Parameterization of the Safety Module

7 Duration of a Safety Demand

The duration of a safety demand must be greater than the processing time of the corresponding input (t_{IN}, see also “Processing time of input t_{IN} in the event of a safety demand” on page 42).

PROFIsafe

If the safety module detects a safety demand (safe “0”) after the processing time of the input t_{IN} has elapsed, when using PROFIsafe this time is extended by the module until the consecutive number has changed twice.

⚠ WARNING **Loss of functional safety**

Observe the behavior of the controller when processing the safe inputs.

In addition to the processing time of input t_{IN}, please observe the system-specific PROFIsafe behavior (e.g., watchdog time, duration of demand, processing time of the safe controller).

Duration of a Safety Demand

8 Connection Examples for Safe Inputs

8.1 Explanation of the Examples

Depending on the type of wiring, the inputs of a module can achieve different safety integrity levels (SIL, SIL CL, Cat., PL) simultaneously (as long as the settings do not contradict one another).

The following examples only describe the options for the electrical connection of sensors to the safe inputs.
Should you have any questions regarding applications to be implemented, please contact the Bosch Rexroth safety hotline (see “Safety Hotline” on page 13).

The following data is specified for each example:

- **Basic specifications**
  The main data for the example is specified in the table.
- **Device diagnostics and behavior of the module in the event of an error**
  Diagnostics capability depends on the parameterization.
  If a message is transmitted to the safe controller in the event of an error, the message is specified in the tables. For information on the relevant error code, possible solutions, and information as to whether acknowledgment is required, please refer to Chapter “Errors: Messages and Removal” on page 75.
  The symmetry violation diagnostic message is only displayed if it was not disabled during parameterization of the affected input.
- **Typical parameterization**
  The table illustrates an example of all the parameters for the specified assignment.

Key for all figures and tables in this chapter:

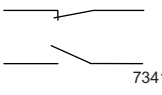
Representation	Meaning
 73410009	Floating switch (mechanical or electrical)

Fig. 8-1 Figures

Representation	Meaning
SF	Safety function
UTx	UT1 or UT2 LED; diagnostic message for each clock output
Clocked	Clocking enabled

Fig. 8-2 “Device diagnostics and behavior of the module in the event of an error” tables

Representation	Meaning
Bold	Mandatory setting
Normal	Typical setting, another setting is possible depending on the application
–	Not evaluated

Fig. 8-3 Parameterization tables

Errors (cross-circuits, short circuits), which can be prevented by correct installation (e.g., protected cable installation, isolated cable installation, double insulation, use of ferrules) are not described in the following tables.

Therefore, for example, only errors between inputs, which are on the same connector, are described. For example, in the event of correct installation, cross-circuits with inputs/outputs of other connectors cannot occur.

For all examples, please also observe the measures specified in the individual tables, which must be taken to achieve the specified SIL/SIL CL/Cat./PL and all measures according to standards EN 61508, EN 62061, and EN ISO 13849-1 to achieve the specified SIL/SIL CL/Cat./PL.

The assignment of the input signals to the clock outputs is parameterized as required.

8.2 Measures Required to Achieve a Specific Safety Integrity Level

The safety integrity level (SIL, SIL CL, performance level, and category) that can be achieved is specified for each connection example.

SIL/SIL CL

In order to determine the probability of failure according to EN 61508 (SIL), use this standard.
In order to determine the probability of failure according to EN 62061 (SIL CL), use this standard.

When the SIL/SIL CL is specified, the module takes up 1% of the specified SIL/SIL CL.

	PFD	PFH
SIL 2/SIL CL 2	1% of 10^{-2}	1% of 10^{-6}
SIL 3/SIL CL 3	1% of 10^{-3}	1% of 10^{-7}

Fig. 8-4 PFD and PFH depending on the SIL/SIL CL

Performance level

Use standard EN ISO 13849-1 to determine the performance level.

Category

In order to actually achieve the specified category, the required measures listed below must be implemented.

Cat. 2

- Use proven and basic safety principles according to EN ISO 13849-2.
- Use appropriately qualified sensors (see Chapter “Requirements for controlling devices/sensors” on page 18).
- Please note that mechanical failure of the switching device can result in the loss of the safety function.
- Take appropriate measures (e.g., fuse protection, redundancy, positive opening operation, etc.) to ensure that the contacts can be opened (e.g., following welding or mechanical failure) when a switch is actuated.
- Please note that **a single** error can result in the loss of the safety function between tests.
- Ensure that the external wiring is tested by the machine control system on machine startup and at suitable intervals. This test must detect the loss of the safety function.

Cat. 3

- Use proven and basic safety principles according to EN ISO 13849-2.
- Use appropriately qualified sensors (see Chapter “Requirements for controlling devices/sensors” on page 18).
- Please note that mechanical failure of the switching device can result in the loss of the safety function.
- Take appropriate measures (e.g., fuse protection, redundancy, positive opening operation, etc.) to ensure that the contacts can be opened (e.g., following welding or mechanical failure) when a switch is actuated.
- Please take into consideration errors with a common cause.
- All errors that cannot be detected can result in the loss of the safety function. Take appropriate measures to prevent such errors. Suitable measures include, for example, protected cable installation or double insulation. Please note the information in the following tables.
- Ensure that **a single** error does not result in the loss of the safety function.
- If single-channel sensors are not available for this category, use two-channel sensors.

Cat. 4

- Use proven and basic safety principles according to EN ISO 13849-2.
- Use appropriately qualified sensors (see Chapter “Requirements for controlling devices/sensors” on page 18).
- Please note that mechanical failure of the switching device can result in the loss of the safety function.
- All errors that cannot be detected can result in the loss of the safety function. Take appropriate measures to prevent such errors. Suitable measures include, for example, protected cable installation or double insulation. Please note the information in the following tables.
- An accumulation of errors must not result in the loss of the safety function. Following the third error, evaluation can be aborted if the probability of further errors occurring is low.
- Please take into consideration errors with a common cause.

8.3 Single-Channel Assignment of Safe Inputs

For the single-channel assignment of safe inputs, the inputs operate independently of one another. The assignment of each input signal to the clock output cannot be freely selected.

For the following examples, please note the resulting behavior in the event of an error:

Note about cross-circuits

- Please note that cross-circuits with other inputs can only be detected if cross-circuit monitoring is enabled.
- The **cross-circuit** error results in the transmission of the safe state in the process data image of the affected inputs.
  Remove the error and then acknowledge the message.
- Please observe the maximum failure detection time of 64 ms.

If a “1” signal is present at the input and an error occurs, a maximum of 64 ms elapses until the error is detected. Within this time, another “1” can also be transmitted, even in the event of an error.
Within the failure detection time (64 ms, maximum), the error can cause the state to change unexpectedly from “0” to “1”.
Ensure that such a change in state cannot restart the system unintentionally.
Please note that the processing time for the input t_{IN} increases by up to 64 ms in the event of an error.

For supply for single-channel assignment, use the relevant clock output or an external supply (external +24 V or OSSD).

State evaluation

The module evaluates the states of the inputs and transmits the result to the safe controller.

In the process data image of a safe input:

- A “0” is transmitted if a “0” signal is present at the input **or** an error has been detected.
- A “1” is transmitted if a “1” signal is present at the input **and** no error has been detected.

8.3.1 Single-Channel with Cross-Circuit Monitoring

If an input pair is parameterized as single-channel with cross-circuit monitoring, the following fixed assignment applies:

- INx_Ch1 is permanently assigned to clock output UT1.
- INx_Ch2 is permanently assigned to clock output UT2.

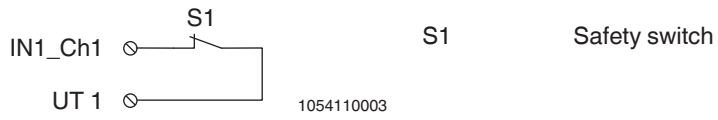


Fig. 8-5 Single-channel assignment of inputs

Basic specifications

Sensor	Single-channel
Sensor supply	Internally through clock output UT1 (clocked) or UT2 (clocked)
Achievable SIL/SIL CL/Cat./PL	SIL 2/SIL CL 2/Cat. 3/PL d

⚠ WARNING Loss of electrical and functional safety

- To achieve the specified category, please refer to Chapter “Measures Required to Achieve a Specific Safety Integrity Level” on page 48.
- Please note that in order to achieve the specified PL, the sensor must have a medium level of diagnostic coverage (90% to 99%) and medium MTTFd. A high level of diagnostic coverage (> 99%) is recommended for the application according to PL d.
- Use sensors that can achieve the required safety integrity level.

Device diagnostics and behavior of the module in the event of an error

Error type	Detection	Diagnostics	Loss of SF	Remark
Error in the sensor				
A contact will not open.	**No**	None	**Yes**	The error cannot be detected and results in the loss of the safety function.
A contact will not close.	**No**	None	No	The error cannot be detected.
Other errors (depending on the sensor)				**Please take into consideration possible errors that can occur in the sensor.**
Wiring error				
Interrupt				
Input (cable interrupt between clock output and sensor or between sensor and input)	Yes	None	No	**– Behavior when the input is in state “1”:** The error is detected as a change in state from “1” to “0”. An unexpected change from “0” to “1” is possible (e.g., due to a loose contact). **Ensure that such a change in state cannot restart the system unintentionally.** **– Behavior when the input is in state “0”: Please note that if this error causes the safety switch to be switched on again, this can result in delayed transmission of state “1” in the process data image of the inputs (e.g., due to a loose contact).**

Fig. 8-6 Single-channel: supply through UT1 (clocked) or UT2 (clocked)

Connection Examples for Safe Inputs

Error type	Detection	Diagnostics	Loss of SF	Remark
Cross-circuit				
Input to input	**No**	None	**Yes**	The error cannot be detected and results in the loss of the safety function, as the safety switch is bypassed. If the inputs are assigned different clock outputs, this error is detected as a cross-circuit after 64 ms.
Input to assigned clock output	**No**	None	**Yes**	The error cannot be detected and results in the loss of the safety function, as the safety switch is bypassed.
Input to non-assigned clock output	Yes	Cross-circuit	No	See “Note about cross-circuits” on page 50.
Clock output to clock output	Yes	Cross-circuit	No	The error is only detected in state “1” of the input.
Short circuit				
Input to ground	Yes	None	No	The error is only detected as a change in state from “1” to “0” in state “1” of the input. An unexpected change from “0” to “1” is possible (e.g., due to a loose contact). **Ensure that such a change in state cannot restart the system unintentionally.**
Clock output to ground	Yes	Short circuit UTx ON	No	The affected clock output is disabled.

Fig. 8-6 Single-channel: supply through UT1 (clocked) or UT2 (clocked) [...]

Typical parameterization

Parameterization	Parameterized as/value range	Remark
Input xx channel 1/channel 2		
Assignment	**Both single-channel**	
Filter time (t_{Filter})	3 ms	Application-specific
Symmetry	Disabled	
Start inhibit due to symmetry violation	Disabled	
Cross-circuit monitoring	Cross-circuit monitoring	

8.3.2 Single-Channel: Supply through UT1 without Cross-Circuit Monitoring

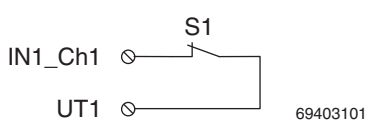


Fig. 8-7 Single-channel assignment of inputs: supply through UT1

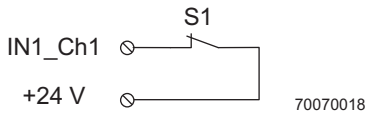


Fig. 8-8 Single-channel assignment of inputs: external supply

Basic specifications

Sensor	Single-channel switch
Sensor supply	• Internally through clock output UT1 or UT2; cross-circuit monitoring disabled • External (24 V)
Achievable SIL/SIL CL/Cat./PL	SIL 2/SIL CL 2/Cat. 2/PL d

⚠ WARNING Loss of electrical and functional safety

- To achieve the specified category, please refer to Chapter “Measures Required to Achieve a Specific Safety Integrity Level” on page 48.
- Please note that in order to achieve the specified PL, cross-circuits must be avoided.
- Please note that in order to achieve the specified PL, the sensor must have a medium level of diagnostic coverage (90% to 99%) and high MTTFd. A high level of diagnostic coverage (> 99%) is recommended for the application according to PL d.
- Use sensors that can achieve the required safety integrity level.

Connection Examples for Safe Inputs

Device diagnostics and behavior of the module in the event of an error

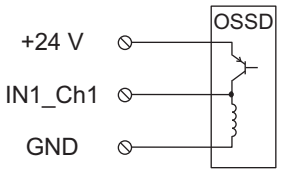
Error type	Detection	Diagnostics	Loss of SF	Remark
Error in the sensor				
A contact will not open.	**No**	None	**Yes**	The error cannot be detected and results in the loss of the safety function.
A contact will not close.	**No**	None	No	The error cannot be detected.
Other errors (depending on the sensor)				**Please take into consideration possible errors that can occur in the sensor.**
Wiring error				
Interrupt				
Input (cable interrupt between clock output or external 24 V and sensor or between sensor and input)	Yes	None	No	**– Behavior when the input is in state “1”:** The error is detected as a change in state from “1” to “0”. An unexpected change from “0” to “1” is possible (e.g., due to a loose contact). **Ensure that such a change in state cannot restart the system unintentionally.** **– Behavior when the input is in state “0”: Please note that if this error causes the safety switch to be switched on again, this can result in delayed transmission of state “1” in the process data image of the inputs (e.g., due to a loose contact).**
Cross-circuit				
Input to input	**No**	None	**Yes**	The error cannot be detected and results in the loss of the safety function, as the safety switch is bypassed.
Input to clock output	**No**	None	**Yes**	The error cannot be detected and results in the loss of the safety function, as the safety switch is bypassed.
Short circuit				
Input to external 24 V	**No**	None	**Yes**	The error cannot be detected and results in the loss of the safety function, as the safety switch is bypassed.
Input to ground	Yes	None	No	The error is only detected as a change in state from “1” to “0” in state “1” of the input. An unexpected change from “0” to “1” is possible (e.g., due to a loose contact). **Ensure that such a change in state cannot restart the system unintentionally.**
Clock output to external 24 V	**No**	None	No	The error cannot be detected as clocking is disabled.
Clock output to ground	Yes	Short circuit UTx ON	No	The affected clock output is disabled.
External 24 V to ground	Yes	None	No	The error is only detected as a change in state from “1” to “0” in state “1” of the input. An unexpected change from “0” to “1” is possible (e.g., due to a loose contact). Ensure that such a change in state cannot restart the system unintentionally.

Fig. 8-9 Single-channel without cross-circuit monitoring: supply through UT1/UT2, external supply

Typical parameterization

Parameterization	Parameterized as/value range	Remark
Input xx channel 1/channel 2		
Assignment	**Both single-channel**	
Filter time (t_{Filter})	3 ms	Application-specific
Symmetry	Disabled	
Start inhibit due to symmetry violation	Disabled	
Cross-circuit monitoring	No cross-circuit monitoring	

8.3.3 Single-Channel: Supply through OSSD



+24 V
Supply through external 24 V

Fig. 8-10 Single-channel assignment of inputs: external supply (OSSD)

⚠ WARNING **Loss of functional safety due to parasitic voltages**

Connect the sensor ground directly to terminal point GND of the safety module. An external ground may not be used.

Basic specifications

Sensor	Single-channel OSSD output (with internal testing)
Sensor supply	External (OSSD sensor)
Achievable SIL/SIL CL/Cat./PL	SIL 2/SIL CL 2/Cat. 2/PL d

⚠ WARNING **Loss of electrical and functional safety**

- To achieve the specified category, please refer to Chapter “Measures Required to Achieve a Specific Safety Integrity Level” on page 48.
- Please note that in order to achieve the specified PL, cross-circuits must be avoided.
- Please note that in order to achieve the specified PL, the sensor must have a medium level of diagnostic coverage (90% to 99%) and high MTTFd. A high level of diagnostic coverage (> 99%) is recommended for the application according to PL d.
- Use sensors that can achieve the required safety integrity level.

Device diagnostics and behavior of the module in the event of an error

Error type	Detection	Diagnostics	Loss of SF	Remark
Error in the sensor				
(depending on the sensor)				**Please take into consideration possible errors that can occur in the sensor.**
Wiring error				
Interrupt				
Input (cable interrupt between external 24 V and sensor or between sensor and input)	Yes	None	No	**– Behavior when the input is in state “1”:** The error is detected as a change in state from “1” to “0”. An unexpected change from “0” to “1” is possible (e.g., due to a loose contact). **Ensure that such a change in state cannot restart the system unintentionally.** **– Behavior when the input is in state “0”:** **Please note that if this error causes the safety switch to be switched on again, this can result in delayed transmission of state “1” in the process data image of the inputs (e.g., due to a loose contact).**
Input (cable interrupt between sensor and GND)	No	None	No	The error must be detected by the sensor. **The sensor must ensure that the safe state is entered in the event of an error.**

Fig. 8-11 Single-channel: supply through OSSD

Connection Examples for Safe Inputs

Error type	Detection	Diagnostics	Loss of SF	Remark
Cross-circuit				
Input to input	**No**	None	**Yes**	The error cannot be detected and results in the loss of the safety function, as the safety switch is bypassed.
Input to clock output	**No**	None	**Yes**	The error cannot be detected and results in the loss of the safety function, as the safety switch is bypassed.
Short circuit				
Input to external 24 V	**No**	None	**Yes**	The error cannot be detected and results in the loss of the safety function, as the safety switch is bypassed.
Input to ground	Yes	None	No	The error is only detected as a change in state from “1” to “0” in state “1” of the input. An unexpected change from “0” to “1” is possible (e.g., due to a loose contact). **Ensure that such a change in state cannot restart the system unintentionally.**
Clock output to external 24 V	**No**	None	No	The error cannot be detected as clocking is disabled.
Clock output to ground	Yes	Short circuit UTx ON	No	The affected clock output is disabled.
External 24 V to ground	Yes	None	No	The error is only detected as a change in state from “1” to “0” in state “1” of the input. An unexpected change from “0” to “1” is possible (e.g., due to a loose contact). Ensure that such a change in state cannot restart the system unintentionally.

Fig. 8-11 Single-channel: supply through OSSD [...]

Typical parameterization

Parameterization	Parameterized as/value range	Remark
Input xx channel 1/channel 2		
Assignment	**Both single-channel**	
Filter time (t_{Filter})	3 ms	Application-specific
Symmetry	Disabled	
Start inhibit due to symmetry violation	Disabled	
Cross-circuit monitoring	No cross-circuit monitoring	

Set the filter time for the input to a value greater than the width of the test pulse for the OSSD sensor. The input must be parameterized without cross-circuit monitoring.

8.4 Two-Channel Equivalent Assignment of Safe Inputs

For two-channel assignment of the inputs, two adjacent inputs are always used. This assignment is fixed and cannot be parameterized (see “Two-channel” on page 40).

For two-channel equivalent assignment, the state changes from “0” to “1” only when both inputs change state from “0” to “1”. If symmetry monitoring is enabled and the state at both inputs does not change within the parameterized time, a diagnostic message is generated.

An input is active when the state of the signal is equal to “1”.

☞	Cross-circuits between different inputs can only be detected if the input signals are supplied by different clock outputs.
☞	Please note that if a delayed change in state at one of the two inputs causes the safety switch to be switched on again, this can result in delayed transmission of state “1” in the process data image of the inputs (e.g., due to a loose contact).

Example of correct and incorrect signal change

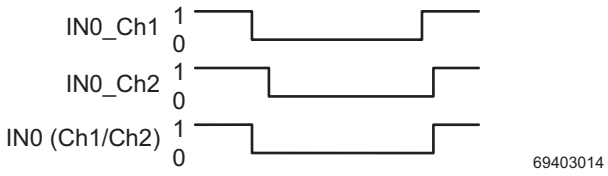


Fig. 8-12 Correct signal change

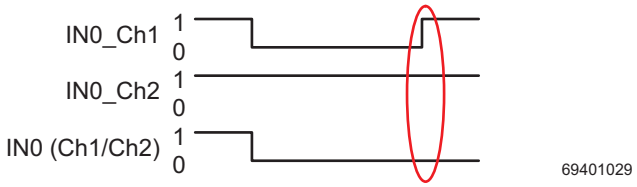


Fig. 8-13 Error during signal change

In Fig. 8-13, the condition that both signals must be in state “0” before the change in state from “0” to “1” is not met. In this case, diagnostic message 018x$_{hex}$ is generated.

Key for Fig. 8-12 and Fig. 8-13

IN0_Ch1	Signal sequence at input 0 channel 1
IN0_Ch2	Signal sequence at input 0 channel 2
IN0 (Ch1/Ch2)	Safety-related signal for two-channel input 0 channel 1 and channel 2 at the safe controller

State evaluation

The module evaluates the states of the inputs and transmits the result to the safe controller.

In the process data image of the safe inputs:

- A “0” is transmitted if a “0” signal is present at at least one of the two inputs **or** an error has been detected.
- A “1” is transmitted if a “1” signal is present at both inputs **and** no error has been detected and the conditions are met for a change in state according to Fig. 8-13.

8.4.1 Notes about Errors for Two-Channel Equivalent Assignment of Safe Inputs

For the following examples, please note the resulting behavior in the event of an error:

Note about cross-circuits

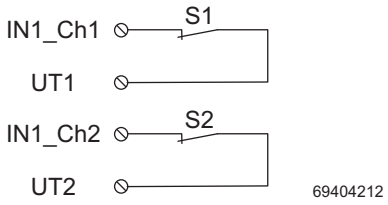
- The **cross-circuit** error results in the transmission of the safe state in the process data image of the affected inputs.
  Remove the error and then acknowledge the message.
  Acknowledging the diagnostic message deletes the message and activates the input. The states at the input are detected immediately. **In your safe application program, ensure that the system cannot be restarted unintentionally following acknowledgment of the diagnostic message.**
- Please observe the maximum failure detection time of 64 ms.
  Exceptions in the failure detection time are indicated in the tables.
  If a “1” signal is present at the input and an error occurs, a maximum of 64 ms elapses until the error is detected. Within this time, another “1” can also be transmitted, even in the event of an error.
  Within the failure detection time (64 ms, maximum), the error can cause the state to change unexpectedly from “0” to “1”.
  Ensure that such a change in state cannot restart the system unintentionally.

Note about symmetry violation

- The symmetry violation diagnostic message is only displayed if it was not disabled during parameterization of the affected input.
- **Start inhibit due to symmetry violation disabled:**
  The symmetry violation message does **not** result in the transmission of the safe state (see also “Symmetry/start inhibit” on page 41).
  The message must be acknowledged. However, the current status of the inputs is displayed in the process data image of the inputs.
- **Start inhibit due to symmetry violation enabled:**
  The symmetry violation message results in the transmission of the safe state (see also “Symmetry/start inhibit” on page 41).
  The message must be acknowledged. The current status of the inputs is displayed in the process data image of the inputs following acknowledgment.
- The message can be used to monitor the wear of the safety switch.

8.4.2 Two-Channel Equivalent Cross-Circuit Monitoring Enabled: Supply through UT1 and UT2

Possible wiring versions:



S1, S2
Two switching elements

Fig. 8-14 Two-channel equivalent assignment of inputs, supply through UT1 and UT2 (both clocked)

Basic specifications

Sensor	Two-channel equivalent with cross-circuit monitoring
Sensor supply	Internally through clock output UT1 **and** UT2 (both clocked)
Achievable SIL/SIL CL/Cat./PL	SIL 3/SIL CL 3/Cat. 4/PL e

⚠ WARNING **Loss of electrical and functional safety**

- To achieve the specified category, please refer to Chapter “Measures Required to Achieve a Specific Safety Integrity Level” on page 48.
- Please note that in order to achieve the specified PL, the sensor must have a high level of diagnostic coverage (> 99%) and high MTTFd.
- Use sensors that can achieve the required safety integrity level.

Device diagnostics and behavior of the module in the event of an error

To understand the change in state, please refer to "Example of correct and incorrect signal change" on page 57.

Error type	Detection	Diagnostics	Loss of SF	Remark
Error in the sensor				
A contact will not open.	Yes	Symmetry violation *)	No	The error is detected on a change in state, as the state only changes in one channel. – **Change in state from "1" to "0":** The faulty input remains at "1". A "0" is transmitted in the process data image of the affected inputs. – **Change in state from "0" to "1":** A "0" is transmitted in the process data image of the affected inputs, as the faulty input was not previously set to state "0".
A contact will not close.	Yes	Symmetry violation *)	No	On a change in state from "0" to "1", a "0" is transmitted in the process data image of the affected inputs, as only one channel reports this change in state.
Other errors (depending on the sensor)				**Please take into consideration all possible errors that can occur in the sensor.**
Wiring error				
Interrupt				
Input (cable interrupt between clock output and sensor or between sensor and input)	Yes	Symmetry violation *)	No	The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel.
Cross-circuit				
Input to input	Yes	Cross-circuit	No	The error is detected in state "1".
Input to assigned clock output	Yes	Symmetry violation *)	No	The error is detected on a change in state, as the state only changes in one channel. – **Change in state from "1" to "0":** The faulty input remains at "1". A "0" is transmitted in the process data image of the affected inputs. – **Change in state from "0" to "1":** A "0" is transmitted in the process data image of the inputs, if the faulty input was not previously set to state "0".
Input to non-assigned clock output	Yes	Cross-circuit	No	See "Note about cross-circuits" on page 58.
Clock output to clock output	Yes	Cross-circuit	No	The error is detected for inputs, which are assigned to different clock outputs.
Short circuit				
Input to ground	Yes	Symmetry violation *)	No	The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel.
Clock output to ground	Yes	Short circuit UTx ON	No	The error is detected in state "1" or on a change in state from "0" to "1", as the state only changes in one channel. The error is also detected as a short circuit of the clock output. The affected clock output is disabled.

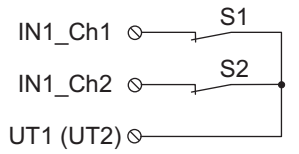
Fig. 8-15 Two-channel equivalent with cross-circuit monitoring: supply through UT1 and UT2

*) Only applies when symmetry monitoring is active

Typical parameterization

Parameterization	Parameterized as/value range	Remark
Input xx channel 1/channel 2		
Assignment	**Two-channel equivalent**	
Filter time (t_{Filter})	3 ms	Application-specific
Symmetry	100 ms	Application-specific
Start inhibit due to symmetry violation	Enabled	Application-specific
Cross-circuit monitoring	Cross-circuit monitoring	

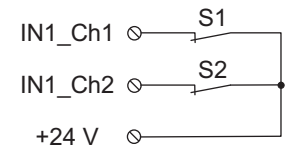
8.4.3 Two-Channel Equivalent Cross-Circuit Monitoring Disabled: Supply through a Clock Output or External Supply



S1, S2
Two switching elements

UT1 (UT2)
Supply through UT1 **or** UT2

Fig. 8-16 Two-channel equivalent assignment of inputs, supply through UT1 (or UT2), cross-circuit monitoring disabled



S1, S2
Two switching elements

+24 V
External supply

Fig. 8-17 Two-channel equivalent assignment of inputs, external supply, cross-circuit monitoring disabled

Basic specifications

Sensor	Two-channel equivalent
Sensor supply	Internally through clock output UT1 (or UT2) **or** externally
Achievable SIL/SIL CL/Cat./PL	SIL 3/SIL CL 3/Cat. 3/PL d

⚠ WARNING **Loss of electrical and functional safety**

- To achieve the specified category, please refer to Chapter “Measures Required to Achieve a Specific Safety Integrity Level” on page 48.
- Please note that in order to achieve the specified PL, the sensor must have a medium level of diagnostic coverage (90% to 99%) and medium MTTFd. A high level of diagnostic coverage (> 99%) is recommended for the application according to PL d.
- Use sensors that can achieve the required safety integrity level.

To understand the change in state, please refer to “Example of correct and incorrect signal change” on page 57.

Connection Examples for Safe Inputs

Device diagnostics and behavior of the module in the event of an error

Error type	Detection	Diagnostics	Loss of SF	Remark
Error in the sensor				
A contact will not open.	Yes	Symmetry violation *)	No	The error is detected on a change in state, as the state only changes in one channel. **– Change in state from “1” to “0”:** The faulty input remains at “1”. A “0” is transmitted in the process data image of the affected inputs. **– Change in state from “0” to “1”:** A “0” is transmitted in the process data image of the affected inputs, as the faulty input was not previously set to state “0”.
A contact will not close.	Yes	Symmetry violation *)	No	On a change in state from “0” to “1”, a “0” is transmitted in the process data image of the affected inputs, as only one channel reports this change in state.
Other errors (depending on the sensor)				**Please take into consideration all possible errors that can occur in the sensor.**
Wiring error				
Interrupt				
Cable interrupt between clock output or external supply and sensor	Yes	None	No	**– Behavior when the input is in state “1”:** The error is detected as a change in state from “1” to “0”. An unexpected change from “0” to “1” is possible (e.g., due to a loose contact). **Ensure that such a change in state cannot restart the system unintentionally.**
Cable interrupt between sensor and input	Yes	Symmetry violation *)	No	The error is detected in state “1” or on a change in state from “0” to “1”, as the state only changes in one channel.
Cross-circuit				
Input to input	**No**	None	No	**An accumulation of errors can result in the loss of the safety function.**
Input to clock output	Yes	Symmetry violation *)	No	The error is detected on a change in state, as the state only changes in one channel. **– Change in state from “1” to “0”:** The faulty input remains at “1”. A “0” is transmitted in the process data image of the affected inputs. **– Change in state from “0” to “1”:** A “0” is transmitted in the process data image of the inputs, if the faulty input was not previously set to “0”.
Clock output to clock output	**No**	None	No	The error is not detected.
Short circuit				
Input to external 24 V	Yes	Symmetry violation *)	No	The error is detected on a change in state, as the state only changes in one channel. **– Change in state from “1” to “0”:** The faulty input remains at “1”. A “0” is transmitted in the process data image of the affected inputs. **– Change in state from “0” to “1”:** A “0” is transmitted in the process data image of the inputs, as the faulty input was not previously set to “0”.
Input to ground	Yes	None	No	The error is detected in state “1” or on a change in state from “0” to “1”, as the state only changes in one channel.
Clock output that is not clocked to external 24 V	**No**	None	No	The error is not detected.
Clock output to ground	Yes	Short circuit UTx ON	No	The error is detected as a change in state from “1” to “0”. An unexpected change from “0” to “1” is possible (e.g., due to a loose contact). **Ensure that such a change in state cannot restart the system unintentionally.** The error is also detected as a short circuit of the clock output. The affected clock output is disabled.

Fig. 8-18 Two-channel equivalent cross-circuit monitoring disabled: supply through a clock output or external supply

Error type	Detection	Diagnostics	Loss of SF	Remark
External 24 V to ground	Yes	None	No	The error is detected as a change in state from “1” to “0”. An unexpected change from “0” to “1” is possible (e.g., due to a loose contact). **Ensure that such a change in state cannot restart the system unintentionally.**

Fig. 8-18 Two-channel equivalent cross-circuit monitoring disabled: supply through a clock output or external supply [...]

*) Only applies when symmetry monitoring is active

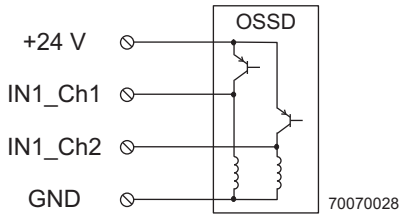
For all inputs that are parameterized without cross-circuit monitoring, cross-circuits and short circuits are not detected by the device diagnostics, but only on a change in state of the input signals, as the state only changes in one channel. Early error detection, e.g., by testing the safety function at regular intervals, is required, as an accumulation of errors may result in the loss of the safety function.

Typical parameterization

Parameterization	Parameterized as	Remark
Input xx channel 1/channel 2		
Assignment	**Two-channel equivalent**	
Filter time (t_{Filter})	3 ms	Application-specific
Symmetry	100 ms	Application-specific
Start inhibit due to symmetry violation	Disabled	Application-specific
Cross-circuit monitoring	**No cross-circuit monitoring**	

Connection Examples for Safe Inputs

8.4.4 Two-Channel Equivalent: External Supply (OSSD)



+24 V
Supply through external 24 V

Fig. 8-19 Two-channel equivalent assignment of inputs, external supply (OSSD)

⚠ WARNING **Loss of functional safety due to parasitic voltages**

Connect the sensor ground directly to terminal point GND of the safety module. An external ground may not be used.

Basic specifications

Sensor	Two-channel OSSD output (with internal testing)
Sensor supply	External (OSSD sensor)
Achievable SIL/SIL CL/Cat./PL	SIL 3/SIL CL 3/Cat. 4/PL e

⚠ WARNING **Loss of electrical and functional safety**

- To achieve the specified category, please refer to Chapter “Measures Required to Achieve a Specific Safety Integrity Level” on page 48.
- Please note that in order to achieve the specified PL, the sensor must have a high level of diagnostic coverage (> 99%) and high MTTFd.
- Use sensors that can achieve the required safety integrity level.

Device diagnostics and behavior of the module in the event of an error

To understand the change in state, please refer to “Example of correct and incorrect signal change” on page 57.

Error type	Detection	Diagnostics	Loss of SF	Remark
Error in the sensor				
Channel failure	Yes	Symmetry violation *)	No	The error is detected on a change in state, as the state only changes in one channel. – **Change in state from “1” to “0”:** The faulty input remains at “1”. A “0” is transmitted in the process data image of the affected inputs. – **Change in state from “0” to “1”:** A “0” is transmitted in the process data image of the affected inputs, as the faulty input was not previously set to state “0”.
Other errors (depending on the sensor)				**Please take into consideration all possible errors that can occur in the sensor.**

Fig. 8-20 Two-channel equivalent: external supply (OSSD)

Error type	Detection	Diagnostics	Loss of SF	Remark
Wiring error				
Interrupt				
Input (cable interrupt between sensor and input)	Yes	Symmetry violation *)	No	The error is detected in state “1” or on a change in state from “0” to “1”, as the state only changes in one channel.
Input (cable interrupt between sensor and GND)	No	None	No	The error must be detected by the sensor. **The sensor must ensure that the safe state is entered in the event of an error.**
Cross-circuit				
Input to input	No	None	**Yes**	The error must be detected by the sensor. **The sensor must ensure that the safe state is entered in the event of an error.**
Input to clock output	Yes	Symmetry violation *)	No	The error is detected on a change in state if the clock output is set to “1”, as the state only changes in one channel.
Short circuit				
Input to 24 V	Yes	Symmetry violation *)	No	The error is detected on a change in state, as the state only changes in one channel.
Input to ground	Yes	Symmetry violation *)	No	The error is detected in state “1” or on a change in state from “0” to “1”, as the state only changes in one channel.

Fig. 8-20 Two-channel equivalent: external supply (OSSD) [...]

*) Only applies when symmetry monitoring is active

Typical parameterization

Parameterization	Parameterized as	Remark
Input xx channel 1/channel 2		
Assignment	**Two-channel equivalent**	
Filter time (t_{Filter})	3 ms	Application-specific
Symmetry	100 ms	Application-specific
Start inhibit due to symmetry violation	Disabled	Application-specific
Cross-circuit monitoring	**No cross-circuit monitoring**	

Set the filter time for the input to a value greater than the width of the test pulse for the OSSD sensor.
Cross-circuit detection must be disabled.

8.5 Two-Channel Non-Equivalent Assignment of Safe Inputs

For two-channel assignment of the safe inputs, two adjacent inputs are always used. This assignment is fixed and cannot be parameterized (see “Two-channel” on page 40).

For two-channel non-equivalent assignment, the state changes from “0” to “1” only when input INx_Ch1 changes state from “0” to “1” and input INx_Ch2 changes state from “1” to “0”. If symmetry monitoring is enabled and the state at both inputs does not change within the parameterized time, a diagnostic message is generated.

The state is active when the state of the signal at channel 1 is equal to “1” and the signal at channel 2 is equal to “0”.

Cross-circuits between different inputs can only be detected if the input signals are supplied by different clock outputs.

Please note that if a delayed change in state at one of the two inputs causes the safety switch to be switched on again, this can result in delayed transmission of state “1” in the process data image of the inputs (e.g., due to a loose contact).

Example of correct and incorrect signal change

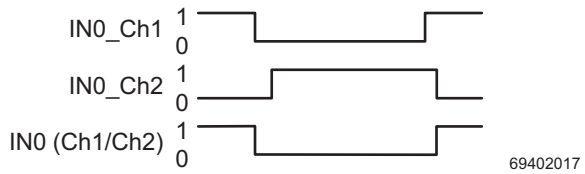


Fig. 8-21 Correct signal change

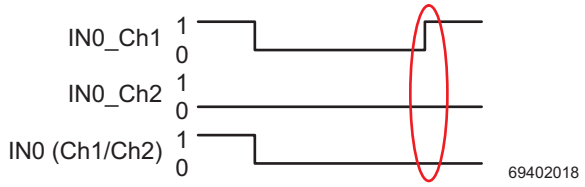


Fig. 8-22 Error during signal change

In Fig. 8-22, the condition that both signals must be in the opposite state before the change in state is not met. In this case, diagnostic message $018x_{hex}$ is generated.

Key for Fig. 8-12 and Fig. 8-13

IN0_Ch1	Signal sequence at input 0 channel 1
IN0_Ch2	Signal sequence at input 0 channel 2
IN0 (Ch1/Ch2)	Safety-related signal for two-channel input 0 channel 1 and channel 2 to the safe controller

State evaluation

The module evaluates the states of the inputs and transmits the result to the safe controller.

In the process data image of the safe inputs:

- A “1” is transmitted if a “1” signal is present at channel 1 of the input and a “0” signal is present at channel 2 of the input **and** no error has been detected and the conditions are met for a change in state according to Fig. 8-22.
- A “0” is transmitted in all other cases.

8.5.1 Notes about Errors for Two-Channel Non-Equivalent Assignment of Safe Inputs

For the following examples, please note the resulting behavior in the event of an error:

Note about cross-circuits

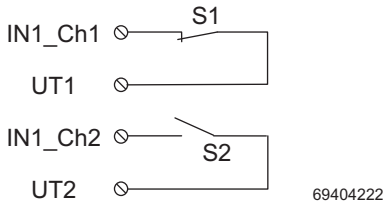
- The **cross-circuit** error results in the transmission of the safe state in the process data image of the affected inputs.
  Remove the error and then acknowledge the message.
  Acknowledging the diagnostic message deletes the message and activates the input. The states at the input are detected immediately. **In your safe application program, ensure that the system cannot be restarted unintentionally following acknowledgment of the diagnostic message.**
- Please observe the maximum failure detection time of 64 ms.
  Exceptions in the failure detection time are indicated in the tables.
  If a “1” signal is present at the input and an error occurs, a maximum of 64 ms elapses until the error is detected. Within this time, another “1” can also be transmitted, even in the event of an error.
  Within the failure detection time (64 ms, maximum), the error can cause the state to change unexpectedly from “0” to “1”.
  Ensure that such a change in state cannot restart the system unintentionally.

Note about symmetry violation

- The symmetry violation diagnostic message is only displayed if it was not disabled during parameterization of the affected input.
- **Start inhibit due to symmetry violation disabled:**
  The symmetry violation message does **not** result in the transmission of the safe state (see also “Symmetry/start inhibit” on page 41).
  The message must be acknowledged. However, the current status of the inputs is displayed in the process data image of the inputs.
- **Start inhibit due to symmetry violation enabled:**
  The symmetry violation message results in the transmission of the safe state (see also “Symmetry/start inhibit” on page 41).
  The message must be acknowledged. The current status of the inputs is displayed in the process data image of the inputs following acknowledgment.
- The message can be used to monitor the wear of the safety switch.

Connection Examples for Safe Inputs

8.5.2 Two-Channel Non-Equivalent with Cross-Circuit Monitoring: Supply through UT1 and UT2



S1, S2
Two switching elements

Fig. 8-23 Two-channel non-equivalent assignment of inputs, supply through UT1 and UT2, cross-circuit monitoring enabled

Basic specifications

Sensor	Two-channel non-equivalent
Sensor supply	Internally through clock output UT1 **and** UT2; cross-circuit monitoring enabled
Achievable SIL/SIL CL/Cat./PL	SIL 3/SIL CL 3/Cat. 4/PL e

⚠ WARNING **Loss of electrical and functional safety**

- To achieve the specified category, please refer to Chapter “Measures Required to Achieve a Specific Safety Integrity Level” on page 48.
- Please note that in order to achieve the specified PL, the sensor must have a high level of diagnostic coverage (> 99%) and high MTTFd.
- Use sensors that can achieve the required safety integrity level.

To understand the change in state, please refer to “Example of correct and incorrect signal change” on page 66.

Device diagnostics and behavior of the module in the event of an error

Error type	Detection	Diagnostics	Loss of SF	Remark
Error in the sensor				
A contact will not open. A contact will not close.	Yes	Symmetry violation *)	No	The error is detected, as the state only changes in one channel.
Other errors (depending on the sensor)				**Please take into consideration all possible errors that can occur in the sensor.**
Wiring error				
Interrupt				
Input (cable interrupt between clock output and sensor or between sensor and input)	Yes	Symmetry violation *)	No	The error is detected on a change in state at the latest, as the state only changes in one channel.
Cross-circuit				
Input to input	Yes	Cross-circuit	No	The error is detected if the other input is set to “1”.
Input to assigned clock output	Yes	Symmetry violation *)	No	The error is detected on a change in state, as the state only changes in one channel.
Input to non-assigned clock output	Yes	Cross-circuit	No	See “Note about cross-circuits” on page 67.
Clock output to clock output	Yes	Cross-circuit	No	The error is detected for inputs, which are assigned to different clock outputs.
Short circuit				
Input to ground	Yes	None	No	The error is detected on a change in state at the latest, as the state only changes in one channel.
Clock output to ground	Yes	Short circuit UTx ON	No	The error is detected on a change in state at the latest, as the state only changes in one channel. The error is also detected as a short circuit of the clock output. The affected clock output is disabled.

Fig. 8-24 Two-channel non-equivalent with cross-circuit monitoring: supply through UT1 and UT2

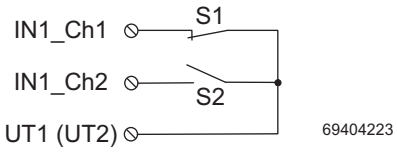
*) Only applies when symmetry monitoring is active

An error in input circuit INx_Ch2 can only be detected in the event of a requested safety function. Early error detection, e.g., by testing the safety function at regular intervals, is required, as an accumulation of errors may result in the loss of the safety function.

Typical parameterization

Parameterization	Parameterized as/value range	Remark
Input xx channel 1/channel 2		
Assignment	Two-channel non-equivalent	
Filter time (t_{Filter})	3 ms	Application-specific
Symmetry	Disabled	Application-specific
Start inhibit due to symmetry violation	Disabled	Application-specific
Cross-circuit monitoring	**Cross-circuit monitoring**	

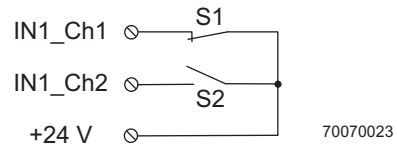
8.5.3 Two-Channel Non-Equivalent Cross-Circuit Monitoring Disabled: Supply through a Clock Output or External Supply



S1, S2
Two switching elements

UT1 (UT2)
Supply through UT1 **or** UT2

Fig. 8-25 Two-channel non-equivalent assignment of inputs, supply through UT1 (or UT2), cross-circuit monitoring disabled



S1, S2
Two switching elements

+24 V
Supply through external 24 V

Fig. 8-26 Two-channel non-equivalent assignment of inputs, external supply

Basic specifications

Sensor	Two-channel non-equivalent
Sensor supply	Internally through clock output UT1 (or UT2) (clocking disabled) **or** externally
Achievable SIL/SIL CL/Cat./PL	SIL 3/SIL CL 3/Cat. 3/PL d

⚠ WARNING **Loss of electrical and functional safety**

- To achieve the specified category, please refer to Chapter “Measures Required to Achieve a Specific Safety Integrity Level” on page 48.
- Please note that in order to achieve the specified PL, the sensor must have a medium level of diagnostic coverage (90% to 99%) and medium MTTFd. A high level of diagnostic coverage (> 99%) is recommended for the application according to PL d.
- Use sensors that can achieve the required safety integrity level.

To understand the change in state, please refer to “Example of correct and incorrect signal change” on page 66.

Device diagnostics and behavior of the module in the event of an error

Error type	Detection	Diagnostics	Loss of SF	Remark
Error in the sensor				
A contact will not open. A contact will not close.	Yes	Symmetry violation *)	No	The error is detected, as the state only changes in one channel.
Other errors (depending on the sensor)				**Please take into consideration all possible errors that can occur in the sensor.**
Wiring error				
Interrupt				
Input (cable interrupt between clock output and sensor or between sensor and input)	Yes	Symmetry violation *)	No	The error is detected on a change in state at the latest, as the state only changes in one channel.
Cross-circuit				
Input to input	Yes	Symmetry violation *)	No	The error is detected, as the state only changes in one channel.
Input to clock output	Yes	Symmetry violation *)	No	The error is detected, as the state only changes in one channel. **– Change in state from “1” to “0”:** The faulty input remains at “1”. A “0” is transmitted in the process data image of the affected inputs.
Clock output to clock output	**No**	None	No	The error is not detected.
Short circuit				
Input to external 24 V	Yes	Symmetry violation *)	No	The error is detected on a change in state at the latest, as the state only changes in one channel.
Input to ground	Yes	Symmetry violation *)	No	The error is detected in state “1” or on a change in state from “0” to “1”, as the state only changes in one channel.
Clock output to external 24 V	**No**	None	No	The error is not detected.
Clock output to ground	Yes	Short circuit UTx ON	No	The error is detected as a change in state from “1” to “0”. The error is also detected as a short circuit of the clock output. The affected clock output is disabled.
External 24 V to ground	Yes	Symmetry violation *)	No	The error is detected in state “1” or on a change in state from “0” to “1”, as the state only changes in one channel.

Fig. 8-27 Two-channel non-equivalent without cross-circuit monitoring: supply through a clock output or external supply

*) Only applies when symmetry monitoring is active

Early error detection, e.g., by testing the safety function at regular intervals, is required, as an accumulation of errors may result in the loss of the safety function.

Typical parameterization

Parameterization	Parameterized as/value range	Remark
Input xx channel 1/channel 2		
Assignment	**Two-channel non-equivalent**	
Filter time (t_{Filter})	3 ms	Application-specific
Symmetry	100 ms	Application-specific
Start inhibit due to symmetry violation	Enabled	Application-specific
Cross-circuit monitoring	**No cross-circuit monitoring**	

Connection Examples for Safe Inputs

9 Startup and Validation

9.1 Initial Startup

To start up, proceed as described in Fig. 9-1.

Step	Relevant section and literature
Set the transmission speed and the mode.	Chapter “Setting the DIP Switches” on page 34
Set the address.	Chapter “Setting the DIP Switches” on page 34
Install the safety module within the Inline station.	Chapter “Assembly, Removal, and Electrical Installation” on page 33
Connect the bus system and supply voltage cables to the Inline station.	DOK-CONTRL-ILSYSINS***-AW..-EN-P application description or documentation for the bus coupler
Wire the inputs according to your application.	Chapter “Assembly, Removal, and Electrical Installation” on page 33 Chapter “Inline Potential and Data Routing, and Inline Connectors” on page 27 Application descriptions for the function blocks used
Before applying the operating voltage: • Make sure that there are no wiring errors (e.g., cross-circuit or short circuit) or grounding errors by testing with a multimeter. • Check whether the ground connection is safe.	
Connect the required voltages to the Inline station.	DOK-CONTRL-ILSYSINS***-AW..-EN-P application description or documentation for the bus coupler
Once the operating voltage has been applied: • If possible, measure the waveform of the voltages to make sure that there are no deviations. • Measure the input voltages on the module to make sure that they are in the permissible range. • Use the LEDs on the module to check that the module starts up without any errors.	
Check the assembly and installation.	Checklist “Assembly and Electrical Installation” on page 101
Carry out the necessary parameterization.	Chapter “Parameterization of the Safety Module” on page 39 Documentation for the controller used
Program the safety function.	Application descriptions for the function blocks used Documentation for the controller used
When verifying the safety function, check whether the F_iPar_CRC parameter is greater than 0 for all devices. If not, modify the settings.	Checklist “Validation” on page 103
Perform a function test and validation. Check whether the safety function responds as planned during programming and parameterization.	Checklist “Validation” on page 103

Fig. 9-1 Steps for startup

When connecting the supply voltages, use the diagnostics and status indicators to check whether the module has started up correctly or whether any errors are indicated. For instructions on how to proceed in the event of an error, please refer to Chapter “Errors: Messages and Removal” on page 75.

9.2 Restart after Replacing a Safety Module

9.2.1 Replacing a Safety Module

⚠ WARNING: Unintentional machine startup

Do not assemble or remove the module while the power is connected.

Before assembling or removing the module, disconnect the power to the module and the entire Inline station and ensure that it cannot be switched on again.

Make sure the entire system is reassembled before switching the power back on. Observe the diagnostics indicators and any diagnostic messages.

The system may only be started provided neither the station nor the system poses a hazard.

If replacing a module, proceed as described for assembly and removal (see Chapter “Assembly, Removal, and Electrical Installation” on page 33).

Ensure that the new safety module is mounted at the correct position in the local bus. The new module must meet the following requirements:

- Same device type
- Same or later version

9.2.2 Restart

Once the safety module has been replaced, proceed as described for initial startup (see Chapter “Initial Startup” on page 73).

The parameterization of the previous module remains the same and is transmitted to the new module when the system is started.

Plug the Inline connectors into the correct connections.

Perform a function test after replacing the module.

9.3 Validation

Carry out a safety validation every time you make a safety-related modification to the PROFIsafe system.

When validating your individual EUC, check the assignment of the sensor connections.

Determine whether:

- The correct safe sensors are connected to the safety module.
- The safety module has been parameterized correctly.
- The variables used in your application program have been linked to the safe sensors correctly.

Perform a function test and error simulation.

Please observe the checklist “Validation” on page 103 during validation.

10 Errors: Messages and Removal

Depending on the error type, errors that are diagnosed are displayed via the local diagnostics indicators and/or transmitted to the safe controller as diagnostic messages.

The tables below provide an overview of the diagnosed errors, their causes, effects, and possible measures for error removal.

For every error that occurs, the cause of the error must first be removed. If necessary, the error is then acknowledged. Errors that must be acknowledged are indicated in the “Acknowledgment” column in the tables below.

If error codes are indicated by the system, which do not appear in the tables below, please contact Bosch Rexroth.

Error removal

To remove the cause of an error, please proceed as described in the “Solution” column in the tables below.

Error acknowledgement

Instructions on how to acknowledge an error can be found in Chapter “Error Acknowledgment” on page 81.

Module replacement following an error

If in the event of failure the safety module is replaced, please proceed as described in Chapter 5, “Assembly, Removal, and Electrical Installation” and Chapter “Restart after Replacing a Safety Module” on page 74.

Notes on the tables below

The error code of a diagnostic message consists of the code for the error cause and the code for the error location.

Structure of the error code

	Error code	
	Code for error cause	Code for error location
E.g.,	012	x

Error code The error code is specified in Fig. 10-2 and onwards.

Error location In the error code specified, “x” specifies the location of the error. The value range for “x” is specified in the relevant row of the table.
For some errors a single channel is specified as the error location (e.g., IN0_Ch1).
Some errors only occur for inputs/outputs parameterized for two-channel operation. Here, the channel pair is specified as the error location (e.g., IN0_Ch1&2).

Example: Safe input errors (Fig. 10-2)

Error cause	Error code (hex)
Cross-circuit	012x
x = 0 ... 7: IN0_Ch1 ... IN7_Ch1; x = 8 ... F: IN0_Ch2 ... IN7_Ch2	

Fig. 10-1

012x	Cross-circuit
012**x**	Error location
This means, for example:	
0122	Cross-circuit at IN2_Ch1 (input 2 channel 1)
012A	Cross-circuit at IN2_Ch2 (input 2 channel 2)

LED The “LED” column specifies which local diagnostics LEDs indicate the error.

Acknowledgment Errors that must be acknowledged are indicated with “Yes” in the “Acknowledgment” column. Special conditions for re-enabling an input or the module are specified in brackets [e.g., Yes (1)] in the “Acknowledgment” column and explained below the relevant table.

10.1 Safe Digital Input Errors

Error cause	Error code (hex)	LED	Remark	Effect	Solution	Acknowledgment
Cross-circuit x = 0 ... 7: IN0_Ch1 ... IN7_Ch1; x = 8 ... F: IN0_Ch2 ... IN7_Ch2	**012x**	–	Cross-circuit with another input or with a clock output	Affected input is in the safe state.	Check sensor. Check clock outputs. Check connector and cabling.	Yes (2)
Symmetry violation x = 0 ... 7: IN0 Ch1&2 ... IN7_Ch1&2	**013x**	–	Not safety-related. Only for inputs parameterized for two-channel operation; used to evaluate the contacts of connected switches. State change in both channels takes longer than the value parameterized for symmetry. This message can also be triggered by a cross-circuit/short circuit.	"Start inhibit due to symmetry violation" is disabled: inputs continue to be detected and their states transmitted to the safe controller. "Start inhibit due to symmetry violation" is enabled: affected input is in the safe state.	Check whether the message was triggered by a short circuit/cross-circuit. If not: Check value for symmetry. Check switches. Replace switches during next maintenance. Activate connected I/O devices once (e.g., activate and unlock emergency stop).	Yes (4)
Hardware fault x = 0 ... 7: IN0_Ch1 ... IN7_Ch1; x = 8 ... F: IN0_Ch2 ... IN7_Ch2	**014x**	–		All module inputs are in the safe state.	Power up with error-free selftest Replacement	Yes (3)
Hardware fault	**0170**	–		All module inputs are in the safe state.	Power up with error-free selftest Replacement	Yes (3)
Error during signal change x = 0 ... 7: IN0 Ch1&2 ... IN7_Ch1&2	**018x**	–	Only for inputs parameterized for two-channel operation; implausible signal change at indicated input pair	Affected inputs in the safe state	Set both inputs to the safe state.	Yes (1)

Fig. 10-2 Safe digital input errors

Acknowledgment: yes (1) Acknowledging the diagnostic message deletes the message.

Acknowledgment: yes (2) Acknowledging the diagnostic message deletes the message and activates the input. The states at the input are detected immediately. In your safe application program, ensure that the system cannot be restarted unintentionally following acknowledgment of the diagnostic message.

Acknowledgment: yes (3) Acknowledging the diagnostic message deletes the message. The module can only be restarted following power up and error-free selftest.

Acknowledgment: yes (4) "Start inhibit due to symmetry violation" is disabled: Acknowledging the diagnostic message deletes the message. "Start inhibit due to symmetry violation" is enabled: Acknowledging the diagnostic message deletes the message and activates the disabled inputs again.

10.2 Clock Output UT1 and UT2 Errors

Error cause	Error code (hex)	LED	Remark	Effect	Solution	Acknowledgment
Short circuit or overload x = 0: Clock output UT1; x = 8: Clock output UT2	**01Ex**	UT1 or UT2 ON		Affected clock output is disabled. Assigned inputs are set to “0”.	Check connector and cabling (acknowledge error at all inputs, if necessary).	Yes (1)

Fig. 10-3 Clock output errors

Acknowledgment: yes (1) Acknowledging the diagnostic message deletes the message and re-enables the clock output and the assigned inputs. In your safe application program, ensure that the system cannot be restarted unintentionally following acknowledgment of the diagnostic message.

The clock outputs are also switched on and monitored when not parameterized. If a short circuit occurs at a clock output when it is in this state, the clock output is switched off.
To exit the error, parameterize the device and acknowledge the error message.

10.3 Supply Voltage Errors

Error cause	Error code (hex)	LED	Remark	Effect	Solution	Acknowledgment
Undervoltage U_M	**01F0**	U_M flashing	U_M below the permissible voltage range	All module inputs are in the safe state.	Check supply voltage level and correct. Check supply line length and load.	Yes (1)

Fig. 10-4 Supply voltage U_M errors

Acknowledgment: yes (1) Acknowledging the diagnostic message deletes the message and activates the inputs.

Undervoltage at U_M: Supply voltage U_M is measured. If U_M < 17 V, a diagnostic message is generated.

10.4 Parameterization Errors

Error cause	Error code (hex)	LED	Remark	Effect	Solution	Acknowledgment
Incorrect parameterization	See Fig. 10-6	FS (flashing)	Each input and clock output is parameterized individually.	Module is in the safe state.	Check and correct parameterization.	–

Fig. 10-5 Parameterization errors

In order to determine what type of parameterization error has occurred, use the corresponding software to access the safe controller online and read the error.

Error code		**Short description**	**Solution**
(hex)	**(dec)**		
034x x = 0 ... 7: IN0_Ch1&2 ... IN7_Ch1&2	**832**: IN0_Ch1&2 : **839**: IN7_Ch1&2	Symmetry monitoring has been parameterized, even though single-channel operation is used for the input pair.	Disable symmetry monitoring or parameterize two-channel operation. Resend parameter data to the module.
035x x = 0 ... 7: IN0_Ch1&2 ... IN7_Ch1&2	**848**: IN0_Ch1&2 : **855**: IN7_Ch1&2;	Start inhibit due to symmetry violation has been parameterized and single-channel operation is used for the input pair and/or symmetry monitoring is not activated.	For one-channel assignment: Disable start inhibit due to symmetry violation. For two-channel assignment: Activate symmetry monitoring. Resend parameter data to the module.

Fig. 10-6 Parameterization errors

10.5 General Errors

Error cause	Error code (hex)	LED	Remark	Effect	Solution	Acknowledgment
Device temperature at critical value	**01F2**			Immediate shutdown. Further temperature increase causes the module to switch to the safe state.	Check and adapt: • Ambient conditions • Derating • Switching frequency	Yes (1)
Error due to receipt of an unexpected message	**01F3**		Error due to receipt of an unexpected message while acknowledging a diagnostic message. The device firmware handles this diagnostic message with the highest priority. Only when this message has been acknowledged correctly are other errors indicated (if present).	The acknowledgment process, during which an unexpected message was received, is aborted. The corresponding error remains in the error memory. Diagnostic message 01F3 is indicated.	Check and adapt the assignment of the diagnostic and confirmation variables at the corresponding function block (see documentation for the controller used). Acknowledge diagnostic message 01F3 so that the next message from the error memory can be indicated.	Yes (1)
Hardware fault		FS ON	Error in the logic area	Module is in the safe state.	Replacement	

Fig. 10-7 General errors

Acknowledgment: yes (1) Acknowledging the diagnostic message deletes the message.

10.6 PROFIsafe Errors

In addition to the module errors specified, the following errors can occur:

- PROFIsafe system errors: These messages can be found in Chapter “Diagnostic Messages for Parameter Errors” on page 97.
- PROFIBUS or PROFINET system errors: For information about these errors, please refer to the documentation for the system used.

10.7 Error Acknowledgment

- Remove the cause of the error.
- Then acknowledge the diagnostic message.

For instructions on error acknowledgment, please refer to the documentation for the controller used.

⚠ WARNING: Acknowledgment may result in a hazardous system state

With the exception of a few special cases, the acknowledgment of an error immediately returns the safe input to the operating state. Before acknowledging an error you must, therefore, make sure that the acknowledgment will not cause the machine to switch to a dangerous state.

When planning the machine or system, make sure that acknowledgment is only possible if the danger zone is visible.

If in the event of failure the safety module is replaced, please proceed as described in Chapter 5, “Assembly, Removal, and Electrical Installation” and Chapter 9.2, “Restart after Replacing a Safety Module”.

Errors: Messages and Removal

11 Maintenance, Repair, Decommissioning, and Disposal

11.1 Maintenance

The device is designed in such a way that maintenance work is not required during the duration of use. However, depending on the application and connected I/O devices it may be necessary to test the function of the I/O devices and the safety chain at regular intervals.

The duration of use of the module is 20 years.

Repeat testing within this time is not required.

Carry out maintenance of connected I/O devices (e.g., light grid) according to the relevant manufacturer specifications.

11.2 Repair

It is prohibited for the user to carry out repair work or make modifications to the module. The housing must not be opened. If the housing is opened, correct operation can no longer be ensured.

In the event of an error, send the module to Bosch Rexroth or contact Bosch Rexroth immediately and engage a service engineer.

11.3 Decommissioning and Disposal

The machine or system manufacturer specifies the procedure for decommissioning.
Decommissioning may only take place according to these specified procedures.

When decommissioning a PROFIsafe system or parts thereof, ensure that the safety modules used:

- Are correctly reused in another system.
  In this case, please observe the storage and transport requirements according to the technical data (see “R-IB IL 24 PSDI 16-PAC” on page 85).
  Or
- Are disposed of according to the applicable environmental regulations, and in this case can never be reused.

Maintenance, Repair, Decommissioning, and Disposal

12 Technical Data and Ordering Data

12.1 System Data

12.1.1 Rexroth Inline

For the system data for the Rexroth Inline system, please refer to the DOK-CONTRL-ILSYSINS***-AW..-EN-P application description.

12.1.2 PROFIsafe

PROFIsafe	
PROFIsafe profile	2.4
DAT	2 ms

For the system data for your system, please refer to the corresponding documentation for the controller used.

12.2 R-IB IL 24 PSDI 16-PAC

General data	
Housing dimensions (width x height x depth)	48.8 mm x 141 mm x 71.5 mm
Weight (with connectors)	225 g
Operating mode	
PROFIsafe	Process data mode with 4 words and 1 word PCP (internal use)
Transmission speed (local bus)	500 kBaud or 2 Mbaud
Ambient temperature	
Operation	-25°C ... +55°C
Storage/transport	-25°C ... +70°C
Humidity	
Operation	75% on average, 85% occasionally (non-condensing)

In the range from -25°C ... +55°C appropriate measures against increased humidity must be taken.

Storage/transport	75% on average; 85% occasionally (non-condensing)

For a short period, slight condensation may appear on the outside of the housing.

Air pressure	
Operation	80 kPa ... 108 kPa (up to 2000 m above sea level)
Storage/transport	66 kPa ... 108 kPa (up to 3500 m above sea level)
Degree of protection	IP20
Housing material	Plastic PBT, self-extinguishing (V0)
Air and creepage distances	According to IEC 60664-1
Protection class	III (PELV)

Technical Data and Ordering Data

General data [...]	
Gases that may endanger functions according to DIN 40046-36, DIN 40046-37	
Sulfur dioxide (SO_2)	Concentration 10 ± 0.3 ppm Ambient conditions – Temperature 25°C ± 2 K – Humidity 75% ± 5% – Test duration 10 days
Hydrogen sulfide (H_2S)	Concentration 1 ± 0.3 ppm Ambient conditions – Temperature 25°C ± 2 K – Humidity 75% ± 5% – Test duration 4 days
Resistance of housing material to termites	Resistant
Resistance of housing material to fungal decay	Resistant
Ambient compatibility	Not resistant to chloroform
Connection data for Inline connectors	
Connection method	Spring-cage terminal blocks
Conductor cross section	0.2 mm^2 ... 1.5 mm^2 (solid or stranded), 24 - 16 AWG

Mechanical requirements	
Vibration according to IEC 60068-2-6	Operation: 2g, Criterion A
Shock according to IEC 60068-2-27	15g over 11 ms, Criterion A

Safety characteristics according to IEC 61508/EN 61508	
Achievable SIL	SIL 2 (single-channel) SIL 3 (two-channel) Depends on the parameterization and wiring (see Chapter "Connection Options for Sensors Depending on the Parameterization" on page 20 and Chapter "Connection Examples for Safe Inputs" on page 47)
Probability of a dangerous failure on demand by the safety function (PFD)	SIL 2: 1% of 10^{-2}, maximum (corresponds to 1 x 10^{-4}) SIL 3: 1% of 10^{-3}, maximum (corresponds to 1 x 10^{-5})
Probability of a dangerous failure per hour for the entire module (PFH)	SIL 2: 1% of 10^{-6}, maximum (corresponds to 1 x 10^{-8}) SIL 3: 1% of 10^{-7}, maximum (corresponds to 1 x 10^{-9}) Depends on the parameterization (see Fig. 8-4 on page 8-48)
Hardware fault tolerance (HFT) of the module	1
Permissible duration of use	20 years

Safety characteristics according to DIN EN 62061	
Achievable SIL claim limit	SIL CL = SIL 2 (single-channel) SIL CL = SIL 3 (two-channel) Depends on the parameterization and wiring (see Chapter "Connection Options for Sensors Depending on the Parameterization" on page 20 and Chapter "Connection Examples for Safe Inputs" on page 47)
Safe failure fraction (SFF)	99%
Probability of a dangerous failure per hour for the entire module (PFH)	SIL 2: 1% of 10^{-6}, maximum (corresponds to 1 x 10^{-8}) SIL 3: 1% of 10^{-7}, maximum (corresponds to 1 x 10^{-9}) Depends on the parameterization (see Fig. 8-4 on page 8-48)
Hardware fault tolerance (HFT) of the module	1
Permissible duration of use	20 years

Safety characteristics according to EN ISO 13849-1	
Achievable performance level	PL e (two-channel) PL d (single-channel) Depends on the parameterization and wiring (see Chapter “Connection Options for Sensors Depending on the Parameterization” on page 20 and Chapter “Connection Examples for Safe Inputs” on page 47)
Diagnostic coverage (DC)	99%
Mean time to dangerous failure (MTTFd)	For single-channel assignment: 76 years For two-channel assignment: 100 years

Supply voltage U_L (logic)	

The safety terminal is supplied with communications power via the bus coupler or a designated power terminal in the station. Potential routing is used for the communications power in the Inline station. For the technical data, please refer to the data sheet for the bus coupler or power terminal used.

Current consumption	190 mA, maximum

Technical Data and Ordering Data

Supply voltage U_M (sensors, clock outputs)	

The safety terminal is supplied with main voltage U_M via the bus coupler or a power terminal in the station. Potential routing is used for the main voltage in the Inline station. For the technical data, please refer to the data sheet for the bus coupler or power terminal used.

⚠ WARNING **Loss of the safety function when using unsuitable power supplies**

Only use power supplies according to EN 50178/VDE 0160 (PELV).

Nominal voltage	24 V DC according to EN 61131-2 and EN 60204
Tolerance	-15%/+20% including an entire AC voltage component with peak value of 5%
Ripple	3.6 V_{PP}
Permissible voltage range	19.2 V DC ... 30.0 V DC, ripple included
Current consumption	10 mA, typical (**plus** current consumption of the inputs when supplied through the clock outputs **plus** current consumption of the connected initiators when supplied through the clock outputs)
Permissible interrupt time	10 ms (output voltage of the clock outputs can fail)
Surge protection	Yes (in the bus coupler/power terminal)
Protection against polarity reversal	Yes (in the bus coupler/power terminal)

NOTICE **Module damage due to polarity reversal**

Polarity reversal places a burden on the electronics and, despite protection against polarity reversal, can damage the module. Therefore, polarity reversal must be prevented.

Undervoltage detection	Yes, at 17 V, approximately
Diagnostics indicators	Green U_M LED (see “Local Diagnostics and Status Indicators” on page 21)
External protection	8 A slow-blow, maximum

NOTICE **Module damaged when overloaded**

Polarity reversal places a burden on the electronics and, despite protection against polarity reversal, can damage the module. Therefore, polarity reversal must be prevented.

Safe digital inputs	
Number	8 two-channel or 16 single-channel
Input design	According to the requirements of EN 61131-2 Type 3
Supply	Via clock outputs UT1 and UT2 or external supply
Input current	Approximately 2.7 mA at 24 V, typical
Maximum permissible current for “0”	1.5 mA
Minimum permissible current for “1”	2.0 mA
Permissible input voltage range	-3 V ... +30 V

Safe digital inputs [...]	
Voltage range for “0”	-3 V ... +5 V
Voltage range for “1”	11 V ... 30 V
Maximum switching frequency	10 Hz
Filter time t_{Filter}	Can be parameterized; see Chapter “Parameterization of the Safe Inputs” on page 40
Minimum filter time	3 ms, accuracy +0 ms, -0.5 ms
Processing time of the input	$t_{IN} = t_{Filter} + t_{FW}$ (see “Processing time of input t_{IN} in the event of a safety demand” on page 42)
Simultaneity	100%
Symmetry evaluation	Yes, can be parameterized, accuracy ±25%
Derating	No
Permissible cable lengths	500 m from the clock output to the safe input (total based on forward and return path)
Status indicators	One green LED per input (see “Local Diagnostics and Status Indicators” on page 21)

The switching state of the inputs is constantly monitored. In the event of an error, e.g., if a component fails, the error is reported to the safe controller.

Clock outputs	
Number	2
Supply	From U_M
Maximum switching current	0.2 A short-circuit and overload protection
Saturation voltage	U_M –1 V
Simultaneity	100%
Derating	No
Permissible cable lengths	The total length of the connected cables must not exceed 500 m per clock output
Status indicators	None
Diagnostics indicators	One red LED for each (UT1, UT2) (see “Local Diagnostics and Status Indicators” on page 21)

Power dissipation	
If U_M = 24 V, no input is set, without load at clock outputs UT1 and UT2	1200 mW
If U_M = 24 V, 16 inputs are set, load at clock outputs UT1 and UT2 is 100 mA each	2600 mW

Technical Data and Ordering Data

Electrical isolation/isolation of the voltage areas

To provide electrical isolation between the logic level and the I/O area, it is necessary to supply the bus coupler and this safety module from separate power supply units. Interconnection of the power supply units in the 24 V area is not permitted. (See also application description.)

Separate potentials in the system consisting of bus coupler/power terminal and safety module	
– Test distance	**- Test voltage**
5 V supply incoming remote bus/7.5 V supply (bus logic)	500 V AC, 50 Hz, 1 min.
5 V supply outgoing remote bus/7.5 V supply (bus logic)	500 V AC, 50 Hz, 1 min.
7.5 V supply (bus logic)/24 V supply U_M, FE	500 V AC, 50 Hz, 1 min.

The isolating distance between U_M and FE is covered by a varistor.

Approvals

For the latest approvals, please visit www.boschrexroth.com/electrics.

12.3 Conformance with EMC Directive

Conformance with EMC Directive 2014/30/EU		
Noise immunity test according to DIN EN 61000-6-2		
Electrostatic discharge (ESD)	EN 61000-4-2 (IEC 61000-4-2)	Criterion B 6 kV contact discharge, 8 kV air discharge
Electromagnetic fields	EN 61000-4-3 (IEC 61000-4-3)	Criterion A, field strength 10 V/m
Fast transients (burst)	EN 61000-4-4 (IEC 61000-4-4)	Criterion B, test voltage 2 kV
Surge voltage	EN 61000-4-5 (IEC 61000-4-5)	Test intensity 2, Criterion B DC supply lines: 0.5 kV/0.5 kV (symmetrical/asymmetrical) Signal lines: 1.0 kV/2.0 kV (symmetrical/asymmetrical)
Conducted interference	EN 61000-4-6 (IEC 61000-4-6)	Criterion A, test voltage 10 V
Noise emission test according to DIN EN 61000-6-4		
Emission	EN 55011	Class A, industrial applications

12.4 Ordering Data

12.4.1 Ordering Data: Safety Module

Description	Type	MNR	Pcs. / Pkt.
Rexroth Inline module with safe digital inputs	R-IB IL 24 PSDI 16-PAC	R911173314	1

12.4.2 Ordering Data: Documentation

Description	Type	MNR	Pcs. / Pkt.
Inline			
Application description Automation Terminals of the Rexroth Inline Product Range	DOK-CONTRL-ILSYSINS***-AW..-EN-P	R911317021	1
PROFIsafe			
Specification PROFIsafe - Profile for Safety Technology on PROFIBUS DP and PROFINET IO, Version 2.4, February 2007	See http://www.profisafe.net		

Make sure you always use the latest documentation. It can be downloaded at www.boschrexroth.com/electrics.

Documentation for PROFIsafe, PROFIBUS, and PROFINET is available on the Internet at www.profibus.com/pall/meta/downloads.

Technical Data and Ordering Data

13 PROFIsafe Terms Used in the Application Description

Some of the terms that are used in connection with PROFIsafe in this application description are described below.

A definition of PROFIsafe terms is also provided in the PROFIsafe profile.

CRC Cyclic Redundancy Check

A cyclic redundancy check (check value) is used to verify the validity of the process data contained in the safety telegram, check whether the assigned address relationships are correct, and verify the safety-related parameters. This value is part of the safety telegram.

Consecutive number Method for ensuring that the safe data is transmitted completely and in the correct order.

F-Parameter (According to PROFIsafe system description, Version 09, November 2007)

F-Parameters contain information for adapting the PROFIsafe layer to specific customer specifications and for checking the parameterization by means of a separate method (diverse). The main F-Parameters are:

F_S/D_Address (F-Address for short)	A unique address for F-Devices within a PROFIsafe island. The technology part of the F-Device compares the value with the address switch locally or with an assigned F-Address in order to check the authenticity of the connection.
F_WD_Time	Specifies the millisecond value for the watchdog timer. The timer monitors the time that elapses until the next valid PROFIsafe message is received.
F_SIL	Indicates the SIL that the user can expect from the relevant F-Device. It is compared with the manufacturer's specification that is stored locally.
F_iPar_CRC	A checksum that is calculated from all iParameters of the technology-specific part of the F-Device.
F_Par_CRC	A CRC signature, which is created via all F-Parameters and ensures error-free transmission of the F-Parameters.

F-CPU Failsafe controller, safe controller

F_Destination_Address F-Parameter; PROFIsafe destination address; address of the safe device (see also “F-Parameter”)

F-I/O device Failsafe I/O device; safe input and/or output modules

Modules with integrated safety functions, which are approved for safety-related operation.

F-Slave Failsafe slave

F_Source_Address F-Parameter; PROFIsafe source address; address of the safe controller (see also “F-Parameter”)

PROFIsafe Terms Used in the Application Description

F-System Failsafe system

A failsafe system is a system that remains in the safe state or immediately enters a safe state when specific failures occur.

iParameter Individual safety parameters of a device

Passivation If the safety module (F-I/O device) detects an error, it switches the affected channel or all channels of the module to the safe state; the channels are then passivated. The detected errors are reported to the safe controller.

For a safe input module when the F-System is passivated, instead of the process values present at the safe inputs, substitute values (0) are provided for the safety program.

For a safe output module when the F-System is passivated, instead of the output values provided by the safety program, substitute values (0) are transferred to the safe outputs.

PROFIsafe Safety-related bus profile based on PROFIBUS DP or PROFINET. It defines the communication between a safety program and the safe I/O device (F-I/O device) in a safe system (F-System).

PROFIsafe address Each safe module has a PROFIsafe address. This address must be set on the safety module (F-I/O device) via DIP switches and then configured in the configuration tool for the safe controller used.

PROFIsafe monitoring time Monitoring time for safety-related communication between the safe controller (F-CPU) and safe I/O device (F-I/O device).

This time is parameterized in the F_WD_Time F-Parameter.

14 F-Parameters and iParameters

14.1 F-Parameters

The values indicated in italics in Table 14-1 are preset by the system and cannot be modified manually.

F-Parameter	Default value	Description
F_Source_ Address	-	The parameter uniquely identifies the PROFIsafe source address (controller address). The address is assigned manually.
F_Destination_ Address	-	PROFIsafe destination address (address of the safe device) The address is assigned manually and the value can be modified. Make sure that the value set under F_Destination_Address and the value that you have set via the 10-pos. DIP switch are the same. Value range: 1 ... 1022
F_WD_Time	150	Monitoring time in the safety module A valid current safety telegram must arrive from the safe controller during the monitoring time. Otherwise, the safety module enters the safe state. The selected monitoring time must be sufficiently high for telegram delays to be tolerated by the communication, but still ensure a sufficiently fast error response in the event of an error (e.g., interruption in communication). Value range: 1 ... 65534, in steps of 1 ms Unit: ms
F_SIL	*SIL 3*	Safety integrity (SIL according to IEC 61508) of the safety module
		⚠ WARNING Safety functions up to SIL 3 can be achieved with the safety module. The safety integrity level that can actually be achieved depends on the parameterization, the structure of the sensor, and the cable installation (see “Connection Examples for Safe Inputs” on page 47).
F_CRC_Length	*3-byte CRC*	This parameter transmits the length of the CRC2 code to be expected in the safety telegram to the safe controller.
F_Block_ID	*1*	Parameter block type identification 1: the parameter block of the F-Parameters contains the F_iPar_CRC parameter.
F_Par_Version	*1*	Version number of the F-Parameter block 1: valid for V2 mode
F_iPar_CRC	0	CRC checksum via the iParameters The value must be greater than 0. When verifying the safety function, check whether the F_iPar_CRC parameter is greater than 0 for all devices. If not, check the iParameters and the CRC checksum in the iParameter and F-Parameter.

Table 14-1 Overview of the F-Parameters for the module

14.2 iParameters

The iParameters are individual device parameters. These include:

- Device parameters (see “Parameterization of the Safe Inputs” and “Parameterization of Clock Outputs UT1 and UT2”)
- PST_Device_ID (70_{hex} for R-IB IL 24 PSDI 16-PAC)
- F_Destination_Address (not included in the checksum calculation)

iPar_CRC The device parameters are verified with a checksum: iPar_CRC.

F_Destination_Address This address is the PROFIsafe address of the module. Make sure that it matches the switch position of the 10-pos. DIP switch.

14.3 Diagnostic Messages for Parameter Errors

Error code		Error cause	Solution
dec	hex		
64	40	The parameterized F_Destination_Address does not match the PROFIsafe address set on the safety module (F-Module).	Make sure that the PROFIsafe address of the safety module and the value in F_Destination_Address are the same.
65	41	Invalid parameterization of F_Destination_Address. Addresses 0000_{hex} and $FFFF_{hex}$ are not permitted.	Correct value.
66	42	Invalid parameterization of F_Source_Address. Addresses 0000_{hex} and $FFFF_{hex}$ are not permitted.	Correct value.
67	43	Invalid parameterization of F_WD_Time. A monitoring time of 0 ms is not permitted.	Correct value.
68	44	Invalid parameterization of F_SIL. The safety module (F-Module) cannot support the required SIL.	Use a device with the required SIL. The safety module achieves SIL 3, maximum.
69	45	Invalid parameterization of F_CRC_Length. The CRC length generated by the safety module (F-Module) does not match the required length.	Check device description.
70	46	Invalid F-Parameter record version. The safety module (F-Module) version does not match the required version.	Check device description. Only V2 mode permitted.
71	47	The checksum determined by the safety module (F-Module) via the PROFIsafe parameters (CRC1) does not match the CRC1 transmitted in the parameter telegram.	Check F-Parameters, repeat calculation.
255	4F	During active process data communication, a new F-Parameter block was received, which differs from the F-Parameter block currently used. Incorrect type ID for the F-Parameter block (F_Block_ID).	Only send modified parameter data when process data communication is not active. Check device description.

Table 14-2 F-Parameter parameter errors

Error code (hex)	Error cause	Solution
03F2	iPar_CRC is incorrect.	Check iParameters, repeat calculation.
03FA	iPar_CRC is not equal to F_iPar_CRC.	Apply correct value.
03FB	PST_Device_ID is incorrect.	Check device type. Correct value (70_{hex} for R-IB IL 24 PSDI 16-PAC).
03FC	F_Destination_Address in the iParameters is incorrect.	Correct value. Make sure that the value set under F_Destination_Address and the value that you have set via the 10-pos. DIP switch are the same.

Table 14-3 iParameter parameter errors

Diagnostic Messages for Parameter Errors

15 Checklists

The checklists listed in this chapter provide support during the planning, assembly and electrical installation, startup, parameterization, and validation of the R-IB IL 24 PSDI 16-PAC module.

These checklists may be used as planning documentation and/or as verification to ensure the steps in the specified phases are carried out carefully.

Archive the completed checklists to use as reference for recurring tests.

The checklists do not replace the validation, initial startup, and regular testing performed by qualified personnel.

The following section of a checklist shows an example of a completed checklist.

Checklist . . .				
Device type/equipment identification		R-IB IL 24 PSDI 16-PAC/BK20NA10		
Version: HW/FW	00/202	**Date**	2013-01-17	
Test engineer 1	John Smith	**Test engineer 2**	Jane Brown	
Remark	System XXX has been checked for engine hood production			
No.	**Requirement (mandatory)**	**Yes**		**Remark**
X	. . .	☐		
No.	**Requirement (optional)**	**Yes**	**No**	**Remark**
Y	. . .	☐	☐	

Key:

Equipment identification	Enter the device type and/or the equipment identification for the relevant device.
Version: HW/FW	Enter the hardware and firmware version of the device (see Chapter “Structure of the Safety Module” on page 16).
Date	Enter the date on which you began to fill in this checklist.
Test engineer 1/2	Enter the names of the test engineers.
Remark	Enter a remark, if required.
Requirement (mandatory)	These requirements must be met for a safety application, in order to complete the relevant phase using the checklist.
Requirement (optional)	These requirements are optional. For points that are not met, please enter an appropriate remark in the relevant field.

Checklists

15.1 Planning

Checklist for planning the use of the safety module			
Device type/equipment identification			
Version: HW/FW		**Date**	
Test engineer 1		**Test engineer 2**	
Remark			

No.	Requirement (mandatory)	Yes	Remark
1	Has the current module application description been used as the basis for planning?	☐	Revision:
2	Are the sensors approved for connection to the module (according to the technical data and parameterization options)?	☐	
3	Has the voltage supply been planned according to the specifications for the protective extra-low voltage in accordance with PELV?	☐	
4	Is external protection of the module planned (according to the specifications in this application description for supply voltage U_M)?	☐	
5	Are measures planned to prevent simple manipulation?	☐	
6	Are measures planned to prevent connectors being mixed up?	☐	
7	Are requirements for the sensors and cable installation observed according to the SIL/SIL CL/Cat./PL to be achieved and is the corresponding implementation planned?	☐	
8	Are the specifications for the parameterization for each channel specified?	☐	
9	Has it been ensured that any person intentionally starting hazardous movements can only do so with a direct view of the danger zone?	☐	
10	Does the planned use correspond to the intended use?	☐	
11	Are the ambient conditions observed according to the technical data?	☐	
12	Have test intervals been defined?	☐	

No.	Requirement (optional)	Yes	No	Remark
13	Have the accessories to be used been planned according to the ordering data in this application description (cables, connectors)?	☐	☐	
14	Have specifications for assembly and electrical installation been defined (e.g., EPLAN) and communicated to the relevant personnel?	☐	☐	
15	Have specifications for startup been defined and communicated to the relevant personnel?	☐	☐	

Date	Signature (test engineer 1)
Date	Signature (test engineer 2)

15.2 Assembly and Electrical Installation

Checklist for assembly and electrical installation of the safety module			
Device type/equipment identification			
Version: HW/FW		**Date**	
Test engineer 1		**Test engineer 2**	
Remark			

No.	Requirement (mandatory)	Yes	Remark
1	Was assembly completed according to the specifications (specifications from the planning phase or according to the application description)?	☐	
2	Was the safety module installed in the control cabinet (IP54)?	☐	
3	Do the cable cross sections correspond to the specifications?	☐	

No.	Requirement (optional)	Yes	No	Remark
4	Is the transmission speed and the operating mode set correctly according to the specifications?	☐	☐	
5	Is the address set correctly according to the specifications?	☐	☐	

Date	Signature (test engineer 1)
Date	Signature (test engineer 2)

Checklists

15.3 Startup and Parameterization

Checklist for startup and parameterization of the safety module			
Device type/equipment identification			
Version: HW/FW		**Date**	
Test engineer 1		**Test engineer 2**	
Remark			

No.	Requirement (mandatory)	Yes	Remark
1	Was startup completed according to the specifications (specifications from the planning phase or according to the application description)?	☐	
2	During startup, is it ensured that any person starting hazardous movements intentionally can only do so with a direct view of the danger zone?	☐	
3	Are all parameters parameterized for the inputs?	☐	
4	For inputs that are parameterized for two-channel operation, are both channels parameterized correctly for each other?	☐	
5	Is the assignment to the clock outputs parameterized for the inputs?	☐	
6	Are the clock outputs parameterized?	☐	

No.	Requirement (optional)	Yes	No	Remark
7	Have safety distances that must be observed been calculated according to the response and delay times implemented?	☐	☐	

Date	Signature (test engineer 1)
Date	Signature (test engineer 2)

15.4 Validation

Checklist for validating the safety module			
Device type/equipment identification			
Version: HW/FW		**Date**	
Test engineer 1		**Test engineer 2**	
Remark			

No.	Requirement (mandatory)	Yes	Remark
1	Have all the mandatory requirements for the "Planning" checklist been met?	☐	
2	Have all the mandatory requirements for the "Assembly and Electrical Installation" checklist been met?	☐	
3	Have all the mandatory requirements for the "Startup and Parameterization" checklist been met?	☐	
4	Does the parameterization of the safe inputs and clock outputs correspond to the version and the actual connection of the controlling devices?	☐	
5	Has the assignment of the sensors to the inputs and the variables of the safe application program been tested (also as online status in the software)?	☐	
6	Has a function test been performed to check all safety functions, in which the module is involved?	☐	
7	Have measures been taken to achieve a specific Cat.?	☐	
8	Do all cables correspond to the specifications?	☐	
9	Does the voltage supply correspond to the specifications for the protective extra-low voltage in accordance with PELV?	☐	
10	Is external protection of the module implemented (according to the specifications in this application description for supply voltage U_M)?	☐	
11	Have measures been taken to prevent simple manipulation?	☐	
12	Have measures been taken to prevent connectors being mixed up?	☐	
13	Are the requirements for the sensors and cable installation observed according to the SIL/SIL CL/Cat./PL to be achieved?	☐	
14	Are the specifications for the parameterization for each channel implemented?	☐	
15	Is the F_iPar_CRC parameter greater than 0 for all devices?	☐	
16	Has it been ensured that any person intentionally starting hazardous movements can only do so with a direct view of the danger zone?	☐	
		Date	Signature (test engineer 1)
		Date	Signature (test engineer 2)

Checklists

16 Conditions for Use at Altitudes greater than 2000 m above Sea Level

This section describes the conditions for using safe Inline I/O modules at altitudes greater than 2000 m above sea level to a maximum of 4500 m above sea level.

Observe the relevant data (technical data, derating, etc.) that is specific to the module being used.

16.1 Conditions

Use of the module at altitudes **greater 2000 m above sea level to a maximum of 4,500 m above sea level** is possible under the following conditions:

1. Determine the maximum ambient temperature for operation with the corresponding factor in accordance with the table below.
2. If derating is specified, offset all the derating points by the corresponding factor in accordance with the table below.

Altitude above sea level	Temperature derating factor
2000 m	1
2500 m	0.953
3000 m	0.906
3500 m	0.859
4000 m	0.813
4500 m	0.766

For relay outputs:

3. Limit the maximum switching voltage for relay outputs in accordance with the table below. Observe the technical data for the module.

Max. switching voltage according to the technical data for the module	Max. switching voltage when used at altitudes greater than 2000 m above sea level
< 150 V AC/DC	Max. switching voltage according to the technical data for the module still valid
> 150 V AC/DC	Limited to max. 150 V AC/DC

Conditions for Use at Altitudes greater than 2000 m above Sea Level

16.2 Example Calculation

The following calculation is an example for using a safe Inline I/O module at an altitude of 3000 m above sea level.

Perform the actual calculation for the module used according to the technical data from the user documentation for the module.

Data in the “Technical data and ordering data” section (example):

Derating	Up to 50 °C, total current of all outputs 6 A, maximum Up to 55 °C, total current of all outputs 4 A, maximum

Calculation:

50 °C • 0.906 ≈ 45 °C
55 °C • 0.906 ≈ 50 °C

Reduced derating:

Derating at 3,000 m above sea level	Up to **45 °C**, total current of all outputs 6 A, maximum Up to **50 °C**, total current of all outputs 4 A, maximum

17 Disposal

17.1 General Information

Dispose the products according to the respective valid national standard.

17.2 Return

For disposal, our products can be returned free of charge. However, the products must be free of remains like oil and grease or other impurities.

Furthermore, the products returned for disposal must not contain any undue foreign substances or components.

Send the products free of charge to the following address:

Bosch Rexroth AG
Electric Drives and Controls
Bürgermeister-Dr.-Nebel-Straße 2
D-97816 Lohr am Main, Germany

17.3 Packaging

The packaging material consists of cardboard, plastics, wood or styrofoam. Packaging material can be recycled anywhere.

For ecological reasons, please do not return empty packages.

17.4 Batteries and Accumulators

Batteries and accumulators can be labelled with this symbol.

The symbol indicating "separate collection" for all batteries and accumulators is the crossed-out wheeled bin.

The end user within the EU is legally obligated to return used batteries. Outside the validity of the EU Directive 2006/66/EC keep the stipulated directives.

Used batteries can contain hazardous substances, which can harm the environment or the health of the individual when they are stored incorrectly or disposed of.

After use, the batteries or accumulators contained in Rexroth products have to be disposed of according to the country-specific collection system.

Disposal

18 Service and Support

Our worldwide service network provides an optimized and efficient support. Our experts offer you advice and assistance should you have any queries.
You can contact us **24/7**.

Service Germany

Our technology-oriented Competence Center in Lohr, Germany, is responsible for all your service-related queries for electric drive and controls.

Contact the **Service Hotline** and **Service Helpdesk** under:

Phone:	**+49 9352 40 5060**
Fax:	**+49 9352 18 4941**
E-mail:	service.svc@boschrexroth.de
Internet:	http://www.boschrexroth.com

Additional information on service, repair (e.g. delivery addresses) and training can be found on our internet sites.

Service worldwide

Outside Germany, please contact your local service office first. For hotline numbers, refer to the sales office addresses on the internet.

Preparing information

To be able to help you more quickly and efficiently, please have the following information ready:

- Detailed description of malfunction and circumstances
- Type plate specifications of the affected products, in particular type codes and serial numbers
- Your contact data (phone and fax number as well as your e-mail address)

Service and Support

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Notes

The Drive & Control Company

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