

JUMO Ex-i Isolating Switch Amplifier



Safety Manual



70754000T99Z001K000

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1.1 Safety information

General

This manual contains information that must be observed in the interest of your own safety and to avoid material damage. This information is supported by symbols which are used in this manual as indicated.

Please read this manual before starting up the device. Store this manual in a place that is accessible to all users at all times.

If difficulties occur during startup, please do not intervene in any way that could jeopardize your warranty rights!

Warning symbols



WARNING!

This symbol in connection with the signal word indicates that **personal injury** may occur if the respective precautionary measures are not carried out.



CAUTION!

This symbol indicates that **components could be destroyed** by electrostatic discharge (ESD = Electro Static Discharge) if the respective cautionary measures are not taken.

Only use the ESD packages intended for this purpose to return device inserts, assembly groups, or assembly components.

NOTICE!

This note in connection with the signal word indicates that **material damage or data loss** will occur if the respective precautionary measures are not taken.

Note symbols



NOTE!

This symbol refers to **important information** about the product, its handling, or additional benefits.



REFERENCE!

This symbol refers to **additional information** in other sections, chapters, or other manuals.

1 Introduction

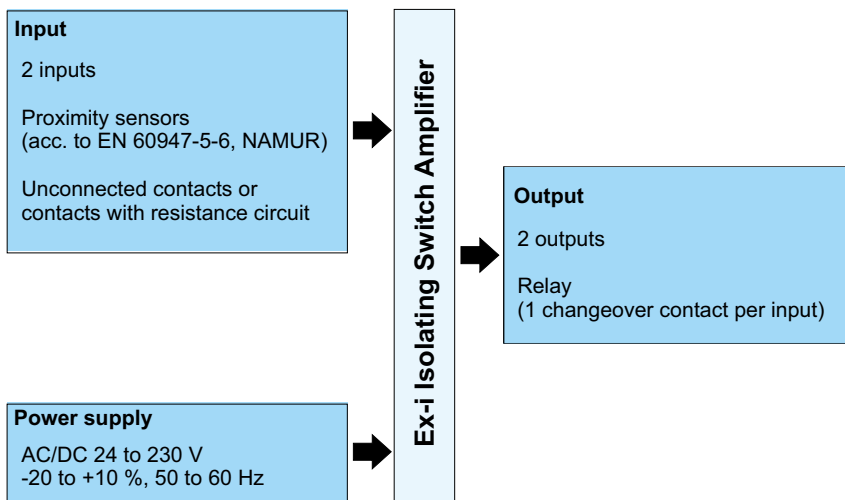
1.2 Description

JUMO Ex-i isolating switch amplifier ensures reliable, galvanic isolation and safe transfer of switch signals in a wide range of applications.

The intrinsically safe isolating switch amplifier is also suitable for use in Ex areas. It can be mounted in Ex zone 2 and used with a sensor in zone 0.

The JUMO Ex-i isolating switching amplifier is ideal for JUMO NESOS float switches with 2 switch contacts and also supports NAMUR proximity sensors. In addition, it features an extended ambient temperature range from -40 to +60 °C. The two-channel version eliminates the need for a second isolating switch amplifier so that it saves costs as well as space in the control cabinet.

1.3 Block diagram



2 Safety requirements and installation instructions

2.1 Installation instructions

- The device is associated equipment with an EPL [Ga], [Da] (category 1) of the ignition protection type "intrinsic safety" and can be installed as a device with the EPL Gc (category 3) in the potentially explosive area of Zone 2. The intrinsically safe electrical circuits can be routed up to Zone 0 / Zone 20. It meets the requirements from the following standards. Precise specifications can be found in the EU declaration of conformity which is supplied; the latest version is also on our website: EN 60079-0, EN 60079-7, EN 60079-11, EN 60079-15
- The installation, operation, and maintenance must be carried out by personnel with electrotechnical qualifications. Follow the described installation instructions.
Adhere to the applicable conditions and safety regulations (including national safety regulations) and the general rules of engineering during set-up and operation.
The safety data can be found in this document and the certificates (EC type examination certificate, if necessary additional approvals).
- Opening or modifying the device is not admissible. Do not repair the device yourself; instead, you should replace it with an equivalent device. Repairs must only be performed by the manufacturer. The manufacturer is not liable for damage resulting from violations of this.
- The protection type IP20 (IEC/EN 60529) of the device is intended for a clean and dry environment. Do not expose the device to any mechanical and/or thermal stresses that exceed the described limits.
- The device complies with the EMC regulations for industrial areas (EMC class A). It may cause EMC problems if used in residential areas.
- The device must be taken out of operation if it is damaged, has been improperly stressed or stored, or malfunctions.
- The products must be installed according to all relevant standards for electrical systems in potentially explosive areas.
- Disconnect the device from all effective energy sources if they are not a SELV or PELV electrical circuits when carrying out installation, repair, or maintenance work.
- Only use copper cables as connecting cables.

2.2 Intrinsic safety

- The device is approved for intrinsically safe (Ex i) electrical circuits up to Zone 0 (gas) and Zone 20 (dust) of the Ex area. The safety values of the intrinsically safe equipment and the connecting lines must be observed during interconnection (IEC/EN 60079-14) and must adhere to the specified values from these installation instructions/the EU type examination certificate.
- During measurements on the intrinsically safe side, make sure to observe the valid conditions relevant to the interconnection of intrinsically safe equipment. Only use the approved measuring devices in intrinsically safe electrical circuits.
- If the device has been used in non-intrinsically safe electrical circuits, using it again in intrinsically safe electrical circuits is prohibited! Clearly mark the device as not intrinsically safe.

2 Safety requirements and installation instructions

2.3 Installation in zone 2

- Adhere to the specified conditions for use in potentially explosive areas. Only use a suitable approved housing of the minimum protection type IP54 that meets the requirements of EN 60079-15 during installation. Also observe the requirements of EN 60079-14.
- Only devices which are suitable for operation in Ex-Zone 2 and the conditions present at the operation location can be connected to electrical circuits in Zone 2.
- Connecting or disconnecting lines and setting the DIP switch is only admissible in a de-energized state in Zone 2.
- The device must be taken out of operation and removed from the Ex area immediately if it is damaged, has been improperly stressed or stored, or malfunctions.
- Temporary malfunctions (transients) must not exceed the value 497 V (355 V x 1.4).

2.4 Areas that are potentially explosive due to dust

- The device is not designed for installation in Zone 22.
- If you nevertheless want to use the device in Zone 22, you have to install it in a housing according to EN 60079-31. In doing so, observe the maximum surface temperatures. Adhere to the requirements of EN 60079-14.
- Only carry out interconnection with the intrinsically safe electrical circuit in areas that are potentially explosive due to dust (Zones 20, 21, or 22) if the equipment connected to this electrical circuit is approved for this zone (e.g. category 1D, 2D, or 3D).

2.5 Safety-related applications (SIL)

When using the device in safety-related applications, observe the instructions in the chapter "Safety-related applications", as the requirements for the safety-related function vary.

⇒ chapter 6 "Safety-related applications", Page 21

2 Safety requirements and installation instructions

2.6 Safety data in accordance with ATEX and IECEx

Intrinsically safe sensor input Max. output voltage U_o Max. output current I_o Max. output power P_o	9.56 V 10.3 mA 25 mW
Group Max. external inductance L_o Max. external capacitance C_o Additional text	IIB/IIIC 1000 mH 26 μ F Simple circuit
Group Max. external inductance L_o Max. external capacitance C_o Additional text	IIB/IIIC 100 mH 5 mH 1 mH 10 μ H 1 μ F 1 μ F 1 μ F 1 μ F Mixed circuit
Group Max. external inductance L_o Max. external capacitance C_o Additional text	IIC 300 mH 3.6 μ F Simple circuit
Group Max. external inductance L_o Max. external capacitance C_o Additional text	IIC 100 mH 50 mH 5 mH 1 mH 10 μ H 510 nF 580 nF 600 nF 600 nF 600 nF Mixed circuit
Max. internal inductance L_i	Negligible
Max. internal capacitance C_i	11 nF
Safety-related maximum voltage U_m Supply terminals Output terminals	253 V AC/DC 250 V AC / 120 V DC

2 Safety requirements and installation instructions

3.1 Connection instructions



WARNING!

Electrical dangers due to improper installation

Observe the following connection information to ensure safe installation according to EN/UL 61010-1:

- In the device installation, separating devices and auxiliary flow circuit protection devices must be provided with suitable AC or DC values.
- The device is intended for installation in a control cabinet or in a comparable housing. The device must only be operated when installed. The control cabinet must correspond to the requirements of a fire protection housing of the safety standard UL/IEC 61010-1 and provide adequate protection against electric shock or burns.
- Provide a switch/power switch close to a device that is marked as the disconnecting device for this device (or the entire control cabinet).
- Provide an **overcurrent protection device** ($I \leq 16 \text{ A}$) in the installation.
- Install the device in an appropriate **housing** with a suitable protection type according to IEC/EN 60529 in order to protect against mechanical or electrical damage.
- Disconnect the device from all effective energy sources if it is not a SELV or PELV electric circuit when carrying out **repair or maintenance work**.
- If the device is not used according to the documentation, the intended protection may be impaired.
- Settings must only be made on the device using the DIP switch when it is in a de-energized state.
- The device has basic insulation of $300 \text{ V}_{\text{eff}}$ to adjacent devices due to its housing. Note this when installing multiple devices next to one another and install additional insulation if necessary. If the adjacent device has basic insulation, no additional insulation is required.
- The voltages present at the input, output, and supply are extra-low voltages (ELV). The switching voltage at the relay output may be a voltage that is dangerous to the touch ($> \text{AC } 30 \text{ V} / > \text{DC } 60 \text{ V}$) depending on the application. In this case, safe, galvanic isolation to the other connections must be available.



WARNING!

Explosion hazard

If you have used the device in non-intrinsically safe electrical circuits, you can then no longer use it in intrinsically safe electrical circuits. Clearly mark the device as not intrinsically safe.

3.2 Electrostatic discharge



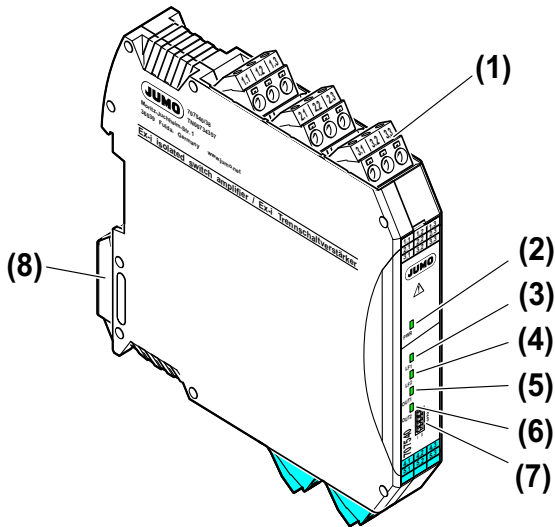
CAUTION!

Electrostatic discharge!

The device contains elements that may be damaged or destroyed by electrostatic discharge. When dealing with the device, observe the necessary safety measures against electrostatic discharge (ESD) according to EN 61340-5-1 and IEC 61340-5-1.

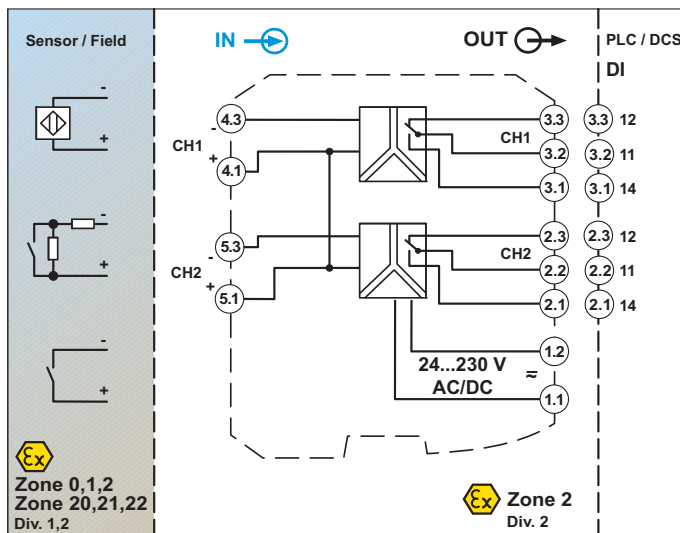
3 Installation

3.3 Structure



- 1 Pluggable screw connection terminal block
- 2 Green "PWR" LED, power supply
- 3 Red "LF1" LED, line fault on sensor line 1
- 4 Red "LF2" LED, line fault on sensor line 2
- 5 Yellow "OUT1" LED, status of relay 1
- 6 Yellow "OUT2" LED, status of relay 2
- 7 Switch DIP 1 to DIP 4
- 8 Snap-on foot for DIN rail mounting

3.4 Schematic diagram



3.5 Inputs (intrinsically safe)

Connection of NAMUR proximity sensors or switching contacts (with resistance circuit)

Channel 1 Terminals 4.1 (+) and 4.3 (-)

Channel 2 Terminals 5.1 (+) and 5.3 (-)

3.6 Outputs

One relay output (changeover contact) per channel

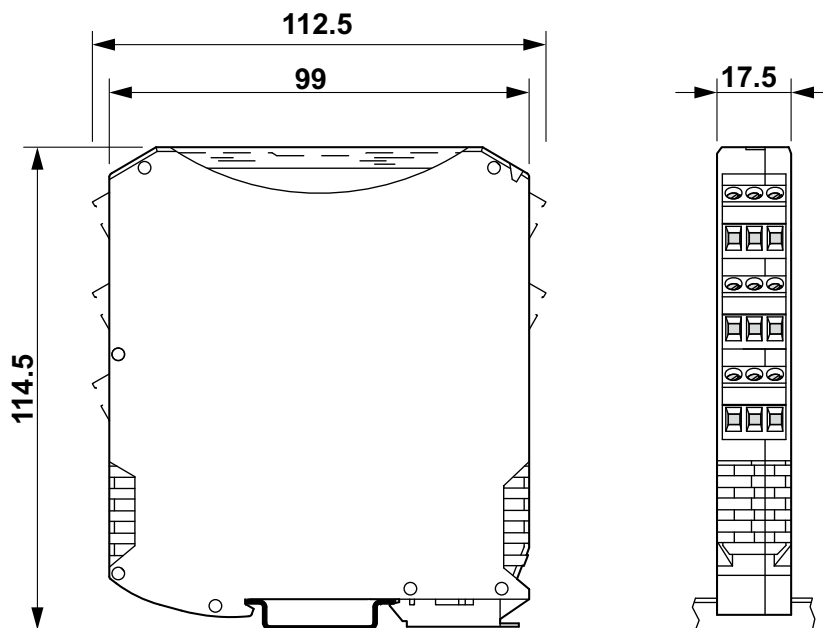
Channel 1 Terminals 3.2 (root/common = 11) and 3.1 (normally open contact = 14)
Terminals 3.2 (root/common = 11) and 3.3 (normally closed contact = 12)

Channel 2 Terminals 2.2 (root/common = 11) and 2.1 (normally open contact = 14)
Terminals 2.2 (root/common = 11) and 2.3 (normally closed contact = 12)

3.7 Voltage supply

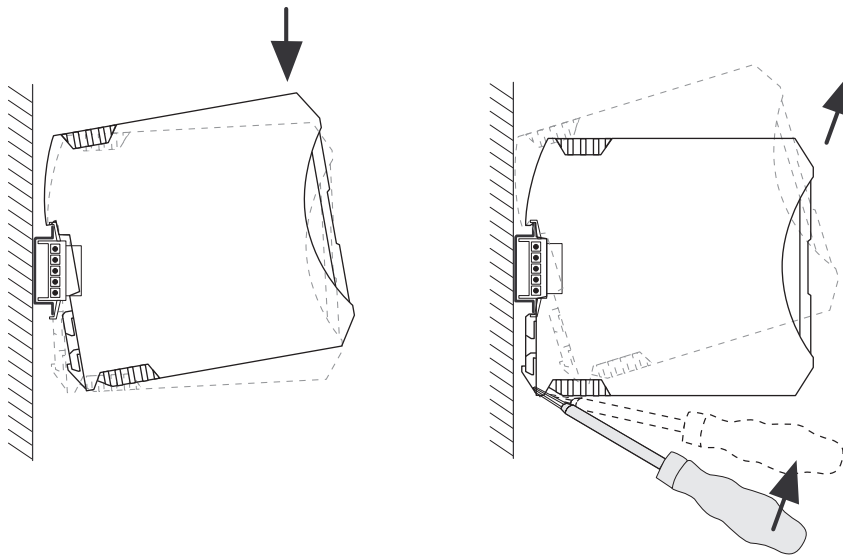
The voltage supply is fed in via the connection terminals 1.1 (+) und 1.2 (-) (DC/AC 24 to 230 V).

3.8 Dimensions



3 Installation

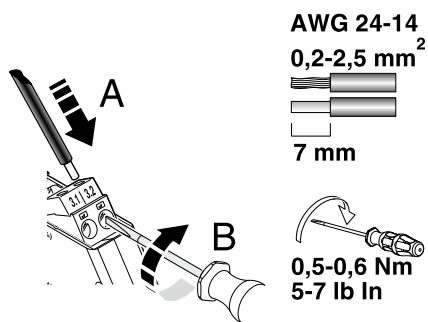
3.9 Mounting



1. Mount the module on a 35 mm mounting rail according to EN 60715.
2. Install the module in a suitable housing in order to meet the requirements for the protection rating.

3.10 Connecting the lines

Screw connection



Admissible conductor cross section: 0.2 mm² to 2.5 mm²

1. Strip 7 mm of the wire and provide it with ferrules.
2. Insert the wire into the relevant connection terminal.
3. Tighten the screw in the opening above the connection terminal using a screwdriver.

Connection torque: 0.6 Nm

NOTICE!

Only switch the DIP switch when the device is de-energized.

By default upon delivery, all DIP switches are in the "I" position.



(7) DIP switch

4.1 Effective direction

Switch DIP 1 = channel 1, DIP 3 = channel 2

The effective direction is set using the DIP switch DIP 1 (for channel 1) and DIP 3 (for channel 3).

Channel 2	Channel 2	
DIP 1	DIP 3	normal phase (I)
DIP 1	DIP 3	inverse phase (II)
Relay output	normal phase (I)	inverse phase (II)
switched if	$I > 2.1 \text{ mA}$	$I < 1.2 \text{ mA}$
in rest position if	$I < 1.2 \text{ mA}$	$I > 2.1 \text{ mA}$

4.2 Line fault detection

Switch DIP 2 = channel 1, DIP 4 = channel 2

The line fault detection is set using the switch DIP 2 (for channel 1) and DIP 4 (for channel 2).

I = Line fault detection disabled.

Not admissible for safety-related applications!

II = Line fault detection enabled.

If line fault detection is enabled, the relay is de-energized when there is an interruption or short-circuit of the line to the sensor, meaning that the output is put into the safe, not-conductive state.

The red LED (LF) flashes (NAMUR NE 44).

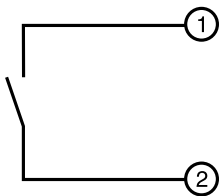
The response range according to EN 60947-5-6 for the line fault report:

Line break	$0.05 \text{ mA} < I_{IN} < 0.35 \text{ mA}$
Short-circuit	$100 \Omega < R_{\text{Sensor}} < 360 \Omega$

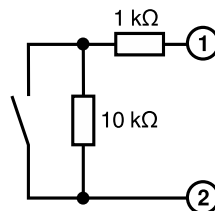
4 Configuration

NOTICE!

For unconnected switching contacts, line fault detection (LF) must be disabled or the corresponding resistance circuit must be provided directly at the switching contact.



Unconnected switching contact



Switching contact with resistance circuit

4.3 Operating mode table



WARNING!

For safety-related applications, only the switch position "DIP 2/DIP 4 = II" is admissible!



WARNING!

For safety-related applications, only switches with resistance circuit are admissible at the input.

Sensor in input		Input circuit		DIP switch		Output		LED	LED	Admissible for safety-related applications		
Switch	Switching contacts with resistance circuit	NAMUR	State	Channel 1	Channel 2	Relay contact		OUT	LF			
				1	2	3	4	Normally open contact	Normally closed contact	Yellow	Red	
Open	Open	Blocking	OK	I	I	I	I	Open	Closed			No
Closed	Closed	Conducting	OK	I	I	I	I	Closed	Open	X		No
Open	Open	Blocking	OK	II	I	II	I	Closed	Open	X		No
Closed	Closed	Conducting	OK	II	I	II	I	Open	Closed			No
	Open	Blocking	OK	I	II	I	II	Open	Closed			Yes
	Closed	Conducting	OK	I	II	I	II	Closed	Open	X		Yes
	Any	Any	Wire break	I	II	I	II	Open	Closed		X	Yes
	Any	Any	Short-circuit	I	II	I	II	Open	Closed		X	Yes
	Open	Blocking	OK	II	II	II	II	Closed	Open	X		Yes
	Closed	Conducting	OK	II	II	II	II	Open	Closed			Yes
	Any	Any	Wire break	II	II	II	II	Open	Closed		X	Yes
	Any	Any	Short-circuit	II	II	II	II	Open	Closed		X	Yes

NAMUR: proximity switch according to EN 60947-5-6 (NAMUR) or switching contact with resistance circuit

X: LED on or flashing

4 Configuration

5 Comparison of the safety data



WARNING!

Explosion hazard

Compare the safety data before you connect a module located in the Ex-i area to the JUMO Ex-i isolating switch amplifier.

Provide proof of intrinsic safety according to the standard IEC/EN 60079-14 and, if necessary, additional national standards and installation regulations.

Safety data of the

Field devices: U_i, I_i, P_i, L_i, C_i
 NAMUR Ex-i isolating switch amplifier U_o, I_o, P_o, L_o, C_o

You can find the values for U_o, I_o, P_o, L_o, C_o in chapter 2.6 "Safety data in accordance with ATEX and IECEx", Page 9.

Example for proof of intrinsic safety (simple electrical circuit):

Data	Conditions
$U_i \geq U_o$	-
$I_i \geq I_o$	-
$P_i \geq P_o$	-
$L_i + L_c \leq L_o$	$L_i < 1 \% \text{ of } L_o \text{ or } C_i < 1 \% \text{ of } C_o$
$C_i + C_c \leq C_o$	
$L_i + L_c \leq 0.5 L_o$	$L_i \geq 1 \% \text{ of } L_o \text{ or } C_i \geq 1 \% \text{ of } C_o$
$C_i + C_c \leq 0.5 C_o$	

L_c and C_c depend on the cables/lines used.

Proof of intrinsic safety (simple intrinsically safe electrical circuit)

In a simple intrinsically safe electrical circuit without external concentrated capacitances (C_i) and without external concentrated inductances (L_i), the full values of C_o and L_o can be used.

⇒ chapter 2.6 "Safety data in accordance with ATEX and IECEx", Page 9

Proof of intrinsic safety (mixed intrinsically safe electrical circuit)

Condition for the mixed intrinsically safe electrical circuit with external concentrated capacitances (C_i) and/or external concentrated inductances (L_i):

- $L_i < 1 \% \text{ of } L_o$ or $C_i < 1 \% \text{ of } C_o$

The full values of C_o and L_o can also be used here.

⇒ chapter 2.6 "Safety data in accordance with ATEX and IECEx", Page 9

- $L_i \geq 1 \% \text{ of } L_o$ and $C_i \geq 1 \% \text{ of } C_o$

The values of C_o and L_o that have been reduced by 50 % must be used here:

- $C_i + C_c \leq 0.5 C_o$
- $L_i + L_c \leq 0.5 L_o$

In order to be able to realize larger line lengths, you can also use certified value pairs alternatively to the values reduced by 50 %.

⇒ chapter 2.6 "Safety data in accordance with ATEX and IECEx", Page 9

5 Comparison of the safety data

6 Safety-related applications

The specifications in this chapter refer to the standard IEC 60508 Edition 2 (2010).

A FMEDA report is available for the JUMO Ex-i isolating switch amplifier; it is available upon request.

⇒ chapter 6.15 "Excerpt from FMEDA report", Page 28

6.1 Safety function/wiring

Input

Admissible for safety-related applications:

- NAMUR sensor (according to EN 60947-5-6)
- Switching contact with resistance circuit (1 kΩ serial und 10 kΩ parallel; tolerance ±10 %)

Remark: the resistance circuit adjusts the behavior of a NAMUR sensor.



WARNING!

Switching contacts without resistance circuit are admissible for safety-related applications.

Output

The output state follows the input status, i.e. the safety-related function at the output is dependent on the position of the switch DIP 1 for channel 1 and DIP 3 for channel 2 (set effective direction).

- | | |
|-----------------------|---|
| I = Normal function | The relay output switches to the state "not conductive" or "open" (normally open contact) and "conductive" or "closed" (normally closed contact) when a 0 signal is present (NAMUR sensor high-resistance, therefore low current in the input circuit). |
| II = Inverse function | The relay output switches to the state "not conductive" or "open" (normally open contact) and "conductive" or "closed" (normally closed contact) when a 1 signal is present at the input. |

6.2 Diagnostic function due to switch DIP 2 (channel 1) and DIP 4 (channel 2)

For safety applications, line fault detection is switched on, i.e. the switches DIP 2/DIP 4 are in the position "II".



WARNING!

The switch position "DIP 2/DIP 4 = I" is admissible for safety-related applications.

The red LED displays faults that occur when line fault detection is switched on. If a line fault is determined, the output is switched off (not conductive). This behavior is independent of the position of the switch DIP1 and DIP3.

6.3 Safe state

The "safe state" of the output is the energy-free state of the relay coil. This means that the normally open contact is open and the normally closed contact is closed.

When the voltage supply fails or is switched off and when line faults occur, the relay output enters the safe state.

⇒ chapter 4.3 "Operating mode table", Page 16

6.4 Reaction times

After a change of state at the input, the output achieves the safe state in ≤ 40 ms.

6 Safety-related applications

6.5 Operating mode

Operating mode according to IEC/EN 61508: "low-demand mode" or "high-demand mode".

6.6 Failure behavior and required reaction

- The safe state is adopted when a line fault is detected or if the voltage supply fails.
- The safe state is achieved by disconnecting the connection terminals.

6.7 Safety/integrity requirements

Safety characteristics

- Type A device (according to IEC/EN 61508-1 and 61508-2)
- Safety integrity level (SIL) 2
- Systematic capability (SC) 2
- HFT 0
- Low-demand mode or high-demand mode
- MTTR = 24 h
- 1-channel: 1001 structure
- Ambient temperature 40 °C
- Mission time 10 years
- Proof test coverage (PTC) 99 %

List of configurations considered

Configuration	Operation	Relay contact	Relay load
C1	Not inverted	Normally closed contact	Load field IV, up to AC 250 V, 2 A or DC 30 V, 2 A resistive or weakly inductive load ($\cos \phi > 0.95$)
C2	Not inverted	Normally closed contact	Load field II, up to AC 120 V, 2 A resistive or weakly inductive load ($\cos \phi > 0.95$)
C3	Inverted	Normally closed contact	Load field IV, up to AC 250 V, 2 A or DC 30 V, 2 A resistive or weakly inductive load ($\cos \phi > 0.95$)
C4	Inverted	Normally closed contact	Load field II, up to AC 120 V, 0.2 A resistive or weakly inductive load ($\cos \phi > 0.95$)
C5	Not inverted	Normally open contact	Load field IV, up to AC 250 V, 2 A or DC 30 V, 2 A resistive or weakly inductive load ($\cos \phi > 0.95$)
C6	Not inverted	Normally open contact	Load field II, up to AC 120 V, 0.2 A resistive or weakly inductive load ($\cos \phi > 0.95$)
C7	Inverted	Normally open contact	Load field IV, up to AC 250 V, 2 A or DC 30 V, 2 A resistive or weakly inductive load ($\cos \phi > 0.95$)
C8	Inverted	Normally open contact	Load field II, up to AC 120 V, 0.2 A resistive or weakly inductive load ($\cos \phi > 0.95$)

6 Safety-related applications

6.8 Failure rates

Non-inverting operation

λ_S	λ_{DD}	λ_{DU}	SFF	DC_{avg}	MTBF	Function
187 FIT	6 FIT	48 FIT	80 %	9 %	227 years	Normally open contact (RNO) C1
252 FIT	6 FIT	83 FIT	76 %	7 %	189 years	Normally open contact (RNO) C2
177 FIT	6 FIT	83 FIT	76 %	9 %	227 years	Normally closed contact (RNC) C5
232 FIT	6 FIT	103 FIT	70 %	6 %	189 years	Normally closed contact (RNC) C6

Inverting operation

λ_S	λ_{DD}	λ_{DU}	SFF	DC_{avg}	MTBF	Function
189 FIT	6 FIT	106 FIT	79.4 %	9 %	227 years	Normally open contact (RNO) C3
254 FIT	56 FIT	86 FIT	75.2 %	5 %	189 years	Normally open contact (RNO) C4
179 FIT	6 FIT	61 FIT	75.3 %	9 %	227 years	Normally closed contact (RNC) C7
234 FIT	6 FIT	106 FIT	69.4 %	5 %	189 years	Normally closed contact (RNC) C8

Low-demand mode

$T_{[PROOF]} =$	1 year	2 years	3 years	4 years	5 years	Function
$PFD_{avg} =$	2.1×10^{-4}	4.2×10^{-4}	6.3×10^{-4}	8.4×10^{-4}	1.05×10^{-3}	Normally open contact (RNO) C1
$PFD_{avg} =$	3.63×10^{-4}	7.26×10^{-4}				Normally open contact (RNO) C2
$PFD_{avg} =$	2.22×10^{-4}	4.44×10^{-4}	6.66×10^{-4}	8.88×10^{-4}	1.11×10^{-3}	Normally open contact (RNO) C3
$PFD_{avg} =$	3.75×10^{-4}	7.5×10^{-4}				Normally open contact (RNO) C4
$PFD_{avg} =$	2.54×10^{-4}	5.08×10^{-4}	7.62×10^{-4}	1.16×10^{-3}		Normally closed contact (RNC) C5
$PFD_{avg} =$	4.51×10^{-4}	9.02×10^{-4}				Normally closed contact (RNC) C6
$PFD_{avg} =$	2.65×10^{-4}	5.3×10^{-4}	7.95×10^{-4}	1.6×10^{-3}		Normally closed contact (RNC) C7
$PFD_{avg} =$	4.64×10^{-4}	9.28×10^{-4}				Normally closed contact (RNC) C8

The PFD_{avg} values for 1, 2, and 3 years are within the permissible range for SIL 2 according to table 2 from IEC/EN 61508-1. They meet the requirement of not covering more than 10 % of the safety circuit or are better than or equal to 1.00×10^{-3} .

The PFD_{avg} values for 4 and 5 years are within the permissible range for SIL 2 according to table 2 from IEC/EN 61508-1. However, they do not meet the requirement of not covering more than 10 % of the safety circuit or are not better than or equal to 1.00×10^{-3} .

6 Safety-related applications

Failure limit value

The operating mode with low-demand mode is taken as the basis. The proportion of the device at PFH/PFD of the entire safety circuit is less than 10 %.

Safety circuit according to IEC/EN 61508-1			
Sensor	Device	Processing	Actuator
25 %	< 10 %	15 %	50 %

High-demand mode

	C1	C2	C3	C4
PFH	4.79×10^{-8}	8.29×10^{-8}	5.06×10^{-8}	8.56×10^{-8}
Cycles/year	1000	100	1000	100

	C5	C6	C7	C8
PFH	5.79×10^{-8}	1.03×10^{-7}	6.06×10^{-8}	1.06×10^{-8}
Cycles/year	1000	100	1000	100

The switching frequency must be taken into account when it comes to the useful life of the relay.

Due to the line inductance, weakly resistive inductive loads are permitted ($\cos \phi > 0.95$).

Exception: switching frequency 1000 cycles/year, admissible switching rate 6/min

6.9 Conditions

The specifications are valid under these conditions:

The failure rates of the components used are constant over the period of use.
The spread of faults through the device in the system is not considered.
The repair time (= replacement) is to be eight hours.
The failure rates of the external power supply are not taken into account.
The line fault detection is enabled.
The average temperature in which the device is to be used is 40 °C. Normal industrial conditions are assumed here.
The specified fault rates refer to an average ambient temperature of 40 °C. For an average ambient temperature of 60 °C, the specified fault rates have to be multiplied by a factor of 2.5. The factor of 2.5 is based on experience.

6.10 Installation and startup

NOTICE!

Installation, operation, and maintenance must be carried out by qualified personnel.

Please note the package leaflet during installation:

Designation
Installation instructions for the electrical installer
EU declaration of conformity

The package leaflet is part of the device's scope of delivery. The documents are available as PDF files and can be downloaded from the manufacturer's website.

- When configuring the device as per the safety requirements according to the operating mode table, observe the switch positions that are not admissible for safety-related applications
- Connect the device according to the installation instructions
- Check the functionality of the device with a connected sensor or switch with resistance circuit for correct function
- Start up the safety circuit and test for correct function
- Avoid inadmissible currents by switching an external 4-A(T) fuse on the contact side of the relay
- Check the external temperature monitoring in an installed state
- Install the device in a control cabinet with a key lock and at least IP54
- Test the used voltage supply in order to be able to compensate for brief interruptions (≤ 20 mA)

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6.11 Notes for operation

In normal operation, the green LED (PWR) lights up continuously.

The yellow LEDs (OUT1/OUT2) display the switching status of the relay output.

The red LEDs (LF1/LF2) display faults that occur when line fault detection is switched on. The safe state is adopted once a line fault is detected or if the voltage supply fails.

6.12 Start and restart

Switching on the device or switching it on again

The output moves into the state without oscillating (as per the operating mode table on page 16). A reset is not provided for.

What happens after a line fault has been determined or what does the user have to do afterwards?

The fault is displayed by the red LED and the output goes into the state "not conductive" independently of the input signal and operating mode (standard operation or inverse operation). The user has to rectify the line fault (short-circuit or break in the sensor line).

The device output is not blocked once fault detection is triggered (no lock or reset). Undefined line states that occur during repair may result in switching the output. The user has to prevent this by switching off the voltage supply or by disconnecting the connection terminals.

Other possibilities that lead to the same result and do not cause any additional hazards are admissible.

The line fault is rectified

The user must ensure a defined state using the operating mode table on page 16. The device is put into operation again as during initial start-up. The device behaves as described under "Switching on the device or switching it on again".

6.13 Regular tests

Regularly test the function of the entire safety loop according to IEC/EN 61508 and EN 61511.

The intervals for the inspection are specified by the intervals for the individual devices in the safety loop.

It is the responsibility of the operator to select the type of inspection and the intervals in the specified period of time.

The test must be carried out so that the correct function of the safety device can be demonstrated in conjunction with all components.

Possible behavior for the recurring tests in order to detect dangerous and undetected device faults

1. Apply a suitable signal at the input of the device in order to obtain the not conductive state at the output.
2. Test whether the output is not conductive.
3. Test the conductive state in the same manner.
4. Establish the full function of the safety circuit.
5. Establish normal operation again.

Using this test, approximately 99 % of the possible "du" ("**d**angerous **u**ndetected") faults in the device are covered.

If the function test is negative, the device has to be taken out of operation and the process maintained in a safe state by other measures.

6.14 Repairs

The devices have a long life cycle, are protected against malfunctions, and are maintenance-free.

If a device fails despite this, send it back to JUMO GmbH & Co. KG. Specify the type of malfunction and the possible reason for the malfunction when doing so.

Use the original package or a suitably secure transport container to send back devices for repair.

Download the "Supplementary sheet for product returns" from our website, please fill it out, and send it together with the faulty device to:

JUMO GmbH & Co. KG
Moritz-Juchheim-Straße 1
36039 Fulda
GERMANY

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6.15 Excerpt from FMEDA report

Normally open configurations C1-C4

Failure category	IEC 61508:2010 Failure rates (in FIT)			
	C1 Normal	C2 Normal	C3 Inverted	C4 Inverted
Safe detected (λ_{SD})	0	0	0	0
Safe undetected (λ_{SU})	187	252	189	254
Dangerous detected (λ_{DD})	6	6	6	6
Dangerous undetected (λ_{DU})	48	83	51	86
No effect	104	104	106	106
Total failure rate (safety function)	241	341	246	346
SFF ^a	80 %	75 %	79 %	75 %
DC	9 %	7 %	9 %	6 %
SIL AC ^b	SIL 2	SIL 2	SIL 2	SIL 2

^a The complete subsystem will need to be evaluated to determine the overall safe failure fraction. The number listed is for reference only.

^b SIL AC (architectural constraints) means that the calculated values are within the range for hardware architectural constraints for the corresponding SIL but does not imply all related IEC 61508 requirements are fulfilled. In addition it must be shown that the device has a suitable systematic capability for the required SIL and that the entire safety function can fulfill the required PFD / PFH values.

Normally closed configurations C5-C8

Failure category	IEC 61508:2010 Failure rates (in FIT)			
	C5 Normal	C6 Normal	C7 Inverted	C8 Inverted
Safe detected (λ_{SD})	0	0	0	0
Safe undetected (λ_{SU})	177	232	179	234
Dangerous detected (λ_{DD})	6	6	6	6
Dangerous undetected (λ_{DU})	58	103	61	106
No effect	104	104	106	106
Total failure rate (safety function)	241	341	246	346
SFF ^a	75 %	69 %	75 %	69 %
DC	9 %	5 %	8 %	5 %
SIL AC ^b	SIL 2	SIL 2	SIL 2	SIL 2

^a The complete subsystem will need to be evaluated to determine the overall safe failure fraction. The number listed is for reference only.

^b SIL AC (architectural constraints) means that the calculated values are within the range for hardware architectural constraints for the corresponding SIL but does not imply all related IEC 61508 requirements are fulfilled. In addition it must be shown that the device has a suitable systematic capability for the required SIL and that the entire safety function can fulfill the required PFD / PFH values.

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6.16 Standards

The devices are developed and approved according to the following standards:

IEC/EN 61508-1:2011	Functional safety of electrical/electronic/programmable electronic safety-related systems, Part 1: General requirements
IEC/EN 61508-2:2011	Functional safety of electrical/electronic/programmable electronic safety-related systems, Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems
IEC/EN 61326-1:2006	Electrical equipment for measurement, control and laboratory use - EMC requirements
IEC/EN 61326-3-2: 2006	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 3-2: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) - Industrial applications with specified electromagnetic environment

6.17 Abbreviations

DC _D	Diagnostic coverage of dangerous failures	Diagnostic coverage of dangerous failures: $DC_D = \lambda_{DD}/(\lambda_{DU} + \lambda_{DD})$
DC _S	Diagnostic coverage of safe failures	Diagnostic coverage of safe failures: $DC_S = \lambda_{SD}/(\lambda_{SU} + \lambda_{SD})$
FIT	Failure in time	1 FIT = 1 failure/10 ⁹ h
HFT	Hardware fault tolerance	Hardware fault tolerance: the ability of a functional unit to continue performing a required function in cases in which fault or deviations exist
λ_D	Rate of dangerous failures	Rate of dangerous failures per hour
λ_{DD}	Rate of dangerous detected failures	Rate of dangerous detected failures per hour
λ_{DU}	Rate of dangerous undetected failures	Rate of dangerous undetected failures per hour
λ_S	Rate of safe failures	Rate of safe failures per hour
λ_{SD}	Rate of safe detectable failures	Rate of safe detectable failures per hour
λ_{SU}	Rate of safe undetectable failures	Rate of safe undetectable failures per hour
MTBF	Mean time between failures	Mean time between two failures
PDF _{avg}	Average probability of failure on demand	Average probability of dangerous failures of a safety function on demand
PFH _D	Probability of a dangerous failure per hour	Probability per hour of a failure for the safety function
SFF	Safe failure fraction	Fraction of safe failures: fraction of failures that do not have the potential of putting the safety-related system into a dangerous or inadmissible functional state
SIL	Safety integrity level	The international IEC 61508 standard defines four discrete safety integrity levels (SIL 1 to SIL 4). Each level corresponds to a probability range for the failure of a safety function. The higher the safety integrity level of the safety-related systems is, the lower the probability of the systems failing to perform the required safety functions is.

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