MACX MCR-EX-SL-NAM-R(-SP)



Isolation switch amplifier

Data sheet
103463_en_09

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1 Description

Isolation amplifier are used for transfer of binary switching signals from the Ex area.

The signal conditioner is designed for the intrinsically safe operation of proximity sensors (in accordance with EN 60947-5-6 (NAMUR)) and open-circuit and resistance-circuit mechanical contacts installed in the Ex area.

The input circuit is monitored for line faults (breakage and short circuit (LFD)) (can be switched on/off).

Errors are indicated by a red flashing LED (as per NE 44) and the output switches to a high-impedance state. Error messages can also be transmitted to the supply and error evaluation module via the DIN rail connector.

A changeover contact relay is available on the output side, which can be operated as a signal output.

The DIP switches can be used to set the direction of action (open or closed circuit current behavior).

The relay status is indicated via a yellow LED.

The device is approved for safety-related applications up to SIL 2 (1oo1)/SIL 3 (1oo2) in accordance with IEC/EN 61508.

Features

- 1-channel
- Intrinsically safe input for NAMUR proximity sensors or switch contacts [Ex ia]
- Output: one changeover contact relay
- Direction of operation can be selected
- Line fault detection (LFD) can be enabled/disabled
- Up to SIL 2 (1oo1) / SIL 3 (1oo2) in accordance with IEC/EN 61508
- Safe 3-way electrical isolation
- Energy supply and error indication possible via DIN rail connector
- Installation in Ex zone 2 permitted
- Plug-in connection terminal blocks, either screw or spring-cage connection technology (Push-in Technology)
- Housing width of 12.5 mm

Make sure you always use the latest documentation.
It can be downloaded from the product at phoenixcontact.com/products.

This document is valid for the products listed in the “Ordering data” chapter.

You can use the Signal Conditioner app to call-up DIP switch setting help and comprehensive module information via the integrated QR code reader.

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3 Ordering data

Description	Type	Item no.	Pcs./Pkt.
Ex i NAMUR isolation amplifier. For operating proximity sensors and switches in a potentially explosive area. The signals are transmitted by a relay output (changeover contact) to a safe area. Line fault detection (LFD), 3-way isolation, SIL 2.	MACX MCR-EX-SL-NAM-R	2865434	1
Ex i NAMUR isolation amplifier. For operating proximity sensors and switches in a potentially explosive area. The signals are transmitted by a relay output (changeover contact) to a safe area. Line fault detection (LFD), 3-way isolation, SIL 2.	MACX MCR-EX-SL-NAM-R-SP	2924045	1

Accessories	Type	Item no.	Pcs./Pkt.
DIN rail bus connector (TBUS), 5-pos., for bridging the supply voltage, can be snapped onto NS 35/... DIN rail in accordance with EN 60715	ME 6,2 TBUS-2 1,5/5-ST-3,81 GY	2695439	10
Power rail adapter (ME 6,2 TBUS-PR-ADAPTER), 2-pos., enables MINI and MACX Analog modules to be adapted for supply via universal power rail UPR-03 and UPR-05.	ME 6,2 TBUS-PR-ADAPTER	1136500	10
The partition plate is used to maintain Ex i isolating distances when Ex i and non-Ex i devices are mounted side by side on a DIN rail.	MCR-DP	1430594	1
Universal termination carrier for connecting 16 MACX Analog Ex i signal conditioners to digital or analog I/O cards, via D-SUB connector, 37-pos. (1:1 connection)	TC-D37SUB-ADIO16-EX-P-UNI	2924854	1
Cover for screw shafts of the MSTB connector ranges with a pitch of 5.0 mm and 5.08 mm. These can be aligned and shortened for use with different numbers of positions.	EA-MSTB 2,5/ 5	1831016	50
Insulating sleeve, color: white	MPS-IH WH	0201663	10
Insulating sleeve, color: red	MPS-IH RD	0201676	10
Insulating sleeve, color: blue	MPS-IH BU	0201689	10
Insulating sleeve, color: yellow	MPS-IH YE	0201692	10
Insulating sleeve, color: green	MPS-IH GN	0201702	10
Insulating sleeve, color: gray	MPS-IH GY	0201728	10
Insulating sleeve, color: black	MPS-IH BK	0201731	10
Test plug, with solder connection up to 1 mm² conductor cross-section, number of positions: 1, color: gray	MPS-MT	0201744	10
Plastic label, Sheet, white, unmarked, can be labeled with: BLUEMARK E.CARD, BLUEMARK ID COLOR, BLUEMARK ID, BLUEMARK CLED, PLOTMARK, CMS-P1-PLOTTER, mounting type: adhesive, Number of individual labels: 10, text field height: 9 mm, text field width: 11 mm	UC-EMLP (11X9)	0819291	10
Plastic label, Sheet, yellow, unmarked, can be labeled with: BLUEMARK E.CARD, BLUEMARK ID COLOR, BLUEMARK ID, BLUEMARK CLED, PLOTMARK, CMS-P1-PLOTTER, mounting type: adhesive, Number of individual labels: 10, text field height: 9 mm, text field width: 11 mm	UC-EMLP (11X9) YE	0822602	10

Accessories	Type	Item no.	Pcs./Pkt.
Plastic label, can be ordered: by sheet, white, labeled according to customer specifications, mounting type: adhesive, text field height: 9 mm, text field width: 11 mm	UC-EMLP (11X9) CUS	0824547	1
Plastic label, can be ordered: by sheet, yellow, labeled according to customer specifications, mounting type: adhesive, text field height: 9 mm, text field width: 11 mm	UC-EMLP (11X9) YE CUS	0824548	1
Plastic label, Sheet, silver, unmarked, can be labeled with: BLUEMARK E.CARD, BLUEMARK ID COLOR, BLUEMARK ID, BLUEMARK CLED, PLOTMARK, CMS-P1-PLOTTER, mounting type: adhesive, Number of individual labels: 10, text field height: 9 mm, text field width: 11 mm	UC-EMLP (11X9) SR	0828094	10
Plastic label, can be ordered: by sheet, silver, labeled according to customer specifications, mounting type: adhesive, Number of individual labels: 10, text field height: 9 mm, text field width: 11 mm	UC-EMLP (11X9) SR CUS	0828098	1
Plastic label, Card, white, unmarked, can be labeled with: BLUEMARK ID COLOR, BLUEMARK ID, THERMOMARK PRIME, THERMOMARK CARD 2.0, THERMOMARK CARD, THERMOMARK PRIME 2.0, mounting type: adhesive, Number of individual labels: 135, text field height: 9 mm, text field width: 11 mm	US-EMLP (11X9)	0828789	10
Plastic label, Card, yellow, unmarked, can be labeled with: BLUEMARK ID COLOR, BLUEMARK ID, THERMOMARK PRIME, THERMOMARK CARD 2.0, THERMOMARK CARD, THERMOMARK PRIME 2.0, mounting type: adhesive, Number of individual labels: 135, text field height: 9 mm, text field width: 11 mm	US-EMLP (11X9) YE	0828871	10
Plastic label, Card, silver, unmarked, can be labeled with: BLUEMARK ID COLOR, BLUEMARK ID, THERMOMARK PRIME, THERMOMARK CARD 2.0, THERMOMARK CARD, THERMOMARK PRIME 2.0, mounting type: adhesive, Number of individual labels: 135, text field height: 9 mm, text field width: 11 mm	US-EMLP (11X9) SR	0828872	10
Device marker, Sheet, white, unmarked, can be labeled with: TOPMARK NEO, TOPMARK LASER, mounting type: adhesive, Number of individual labels: 255, text field height: 9 mm, text field width: 11 mm	LS-EMLP (11X9) WH	0831678	10
Device marker, Sheet, silver, unmarked, can be labeled with: TOPMARK NEO, TOPMARK LASER, mounting type: adhesive, Number of individual labels: 255, text field height: 9 mm, text field width: 11 mm	LS-EMLP (11X9) SR	0831705	10
Device marker, Sheet, yellow, unmarked, can be labeled with: TOPMARK NEO, TOPMARK LASER, mounting type: adhesive, Number of individual labels: 255, text field height: 9 mm, text field width: 11 mm	LS-EMLP (11X9) YE	0831732	10
Power and fault signaling module with screw connection, including corresponding ME 17,5 TBUS 1,5/ 5-ST-3,81 GY DIN rail connector	MACX MCR-PTB	2865625	1

Accessories	Type	Item no.	Pcs./Pkt.
Power and fault signaling module with Push-in connection, including corresponding ME 17,5 TBUS 1,5/ 5-ST-3,81 GY DIN rail connector	MACX MCR-PTB-SP	2924184	1
Primary-switched power supply, QUINT POWER, screw connection, DIN rail mounting, supply of devices possible via the TBUS DIN rail connector, protective coating, input: single-phase, output: 24 V DC/2.5 A	QUINT4-SYS-PS/1AC/24DC/2.5/SC	2904614	1
End cover, depth: 52 mm, width: 2.5 mm, height: 56 mm, color: gray	D-UKK 3/5	2770024	50
End cover, depth: 62 mm, width: 2.5 mm, height: 56 mm, color: blue	D-UKK 3/5 BU	2770105	50
Component terminal block, connection method: Screw connection, 1st and 2nd level, Rated cross section: 4 mm², cross section: 0.2 mm² - 4 mm², mounting type: NS 35/7,5, NS 35/15, NS 32, color: gray	UKK 5-2R/NAMUR	2941662	50
Actuation tool, for ST terminal blocks, insulated, also suitable for use as a bladed screwdriver, size: 0.6 x 3.5 x 100 mm, 2-component grip, with non-slip grip	SZS 0,6X3,5	1205053	10
TVFKC plug set for MACX Ex i devices with 2-pos. plugs	MACX EX-SET-TVFKC 2-POLE	1584378	1
Resistor network 22 kΩ parallel, 680 Ω in series for monitoring floating contacts and proximity switches. Line fault monitoring via isolation amplifiers or digital inputs in accordance with NAMUR IEC/EN 60947-5-6.	FA MCR-FMR-22K-680-IP20-PT	1642714	1
Resistor network 10 kΩ parallel, 1 kΩ in series for monitoring floating contacts and proximity switches. Line fault monitoring via isolation amplifiers or digital inputs in accordance with NAMUR IEC/EN 60947-5-6.	FA MCR-FMR-10K-1K-IP20-PT	1642715	1
Resistor network 10 kΩ parallel, 1.5 kΩ in series for monitoring floating contacts and proximity switches. Line fault monitoring via isolation amplifiers or digital inputs in accordance with NAMUR IEC/EN 60947-5-6.	FA MCR-FMR-10K-1.5K-IP20-PT	1642716	1
Resistor network 22 kΩ parallel, 620 Ω in series for monitoring floating contacts and proximity switches. Line fault monitoring via isolation amplifiers or digital inputs in accordance with NAMUR IEC/EN 60947-5-6.	FA MCR-FMR-22K-620-IP20-PT	1642820	1

4 Technical data

Hardware/firmware version	
Hardware/firmware version (2865434)	17 / -
Hardware/firmware version (2924045)	17 / -

The technical data and safety characteristics are valid as of the specified HW/FW version.

Input data NAMUR	
Description of the input	intrinsically safe
Input signals	NAMUR proximity sensors (IEC/EN 60947-5-6) floating switch contacts Switch contacts with resistance circuit
Switching threshold "0" signal current	< 1.2 mA (blocking)
Switching threshold "1" signal, current	> 2.1 mA (conductive)
Short-circuit current	8 mA
Switching hysteresis	< 0.2 mA
Line fault detection	< 0.05 mA ... 0.35 mA (Line break) < 100 Ω ... 360 Ω (Short circuit) Activated /deactivated via DIP switch
Open-circuit voltage	8 V DC

Output data Relay output	
Number	1
Contact switching type	1 changeover contact
Contact material	$AgSnO_2$, hard gold-plated
Switching behavior	can be inverted using DIP switch
Maximum switching voltage	250 V AC (2 A) 120 V DC (0.2 A) 30 V DC (2 A)
Switching frequency	≤ 20 Hz (without load)
Mechanical service life	10^7 cycles

General data	
Nominal supply voltage	24 V DC -20 % ... +25 %
Supply voltage range	19.2 V DC ... 30 V DC
Max. current consumption	21 mA (24 V DC)
Power dissipation	< 1 W
Power consumption	< 1 W
Degree of protection	IP20 (not assessed by UL)
Flammability rating according to UL 94	V0 (Housing)
Status display	Green LED (supply voltage) LED yellow (switching state) Red LED (line errors)
Dimensions W/H/D	12.5 mm / 112.5 mm / 113.7 mm (MACX MCR-EX-SL-NAM-R) 12.5 mm / 107.9 mm / 113.7 mm (MACX MCR-EX-SL-NAM-R-SP)
Depth (Snapped onto DIN rail NS 35/7,5 in accordance with EN 60715)	114.5 mm
Type of housing	PA 6.6-FR

Ambient conditions	
Ambient temperature (operation)	-40 °C ... 60 °C (Any mounting position)
Ambient temperature (operation)	-40 °C ... 70 °C (Derating)
Ambient temperature (storage/transport)	-40 °C ... 85 °C
Permissible humidity (operation)	10 % ... 95 % (non-condensing)
Altitude Ambient temperature (operation) Ambient temperature (operation) Rated insulation voltage	≤ 2000 m -40 °C ... 60 °C -40 °C ... 70 °C (Derating) 253 V AC (Power supply, input / output) 125 V DC (Power supply, input / output)
Height range Ambient temperature (operation) Ambient temperature (operation) Rated insulation voltage	> 2000 m ... 3000 m -40 °C ... 54 °C -40 °C ... 63 °C (Derating) 190 V AC (Power supply, input / output) 110 V DC (Power supply, input / output)
Height range Ambient temperature (operation) Ambient temperature (operation) Rated insulation voltage	> 3000 m ... 4000 m -40 °C ... 48 °C -40 °C ... 56 °C (Derating) 60 V AC/DC (Power supply, input / output)
Height range Ambient temperature (operation) Ambient temperature (operation) Rated insulation voltage	> 4000 m ... 5000 m -40 °C ... 42 °C -40 °C ... 49 °C (Derating) 60 V AC/DC (Power supply, input / output)

Electrical isolation (≤ 2000 m above mean sea level)	
Electrical isolation	3-way isolation
Test voltage	2.5 kV AC (50 Hz, 60 s)
Input/output	
Standards/regulations	IEC/EN 60079-11
Rated insulation voltage	375 V_{PP}
Overvoltage category	II
Pollution degree	2
Input/output/supply, DIN rail connector	
Standards/regulations	IEC/EN 61010-1
Rated insulation voltage	300 V_{rms}
Overvoltage category	II
Pollution degree	2
Insulation	Safe isolation
Output/input, supply, TBUS	
Standards/regulations	IEC/EN 61010-1
Rated insulation voltage	300 V_{rms}
Overvoltage category	III
Pollution degree	2
Insulation	Safe isolation
Input/supply, DIN rail connector	
Standards/regulations	IEC/EN 60079-11
Rated insulation voltage	375 V_{PP}
Overvoltage category	II
Pollution degree	2

Safety data in accordance with ATEX and IECEx (≤ 2000 m above mean sea level)	
Max. output voltage U_o	9.6 V
Max. output current I_o	10 mA
Max. output power P_o	25 mW
Max. external inductivity L_o / Max. external capacitance C_o simple circuit	IIA/I : 1000 mH / 210 µF
Max. external inductivity L_o / Max. external capacitance C_o simple circuit	IIB/IIIC : 1000 mH / 26 µF
Max. external inductivity L_o / Max. external capacitance C_o simple circuit	IIC : 300 mH / 3.6 µF
Max. external inductivity L_o / Max. external capacitance C_o mixed circuit	IIC : 100 mH / 500 nF ; 50 mH / 570 nF ; 5 mH / 590 nF
Max. external inductivity L_o / Max. external capacitance C_o mixed circuit	I/IIB/IIA/IIIC : 100 mH / 1 µF
Max. internal inductance L_i	negligible
Max. internal capacitance C_i	11 nF
Safety-related maximum voltage U_m	253 V AC
Safety-related maximum voltage U_m	125 V DC

Connection data	Screw connection	Push-in connection
Conductor cross-section, rigid	0.2 mm² ... 2.5 mm²	0.2 mm² ... 2.5 mm²
Conductor cross-section, flexible	0.2 mm² ... 2.5 mm²	0.2 mm² ... 2.5 mm²
Conductor cross-section flexible (2 conductors with same cross section)		0.25 mm² ... 0.34 mm² (TWIN ferrule without plastic sleeve) 0.5 mm² ... 1.5 mm² (TWIN ferrule with plastic sleeve)
Conductor cross-section AWG	24 ... 14	24 ... 14 24 ... 22 (TWIN ferrule without plastic sleeve) 20 ... 16 (TWIN ferrule with plastic sleeve)
Stripping length	7 mm	10 mm
Tightening torque	0.5 Nm ... 0.6 Nm	
Diameter Test socket in the connector	2 mm	

Conformance with EMC directive
Noise immunity according to EN 61000-6-2
Noise emission according to EN 61000-6-4

Conformance/approvals	
CE CE-compliant and EN 61326	
ATEX IBExU 07 ATEX 1069 X	Ⓔx II (1) G [Ex ia Ga] IIC Ⓔx II (1) D [Ex ia Da] IIIC Ⓔx II 3 (1) G Ex ec [ia Ga] nC IIC T4 Gc Ⓔx I (M1) [Ex ia Ma] I
IECEx IECEx IBE 08.0001X	[Ex ia Ga] IIC [Ex ia Da] IIIC Ex ec [ia Ga] nC IIC T4 Gc [Ex ia Ma] I
CCC / China-Ex 2022122316115975	[Ex ia Ga] IIC [Ex ia Da] IIIC Ex ec nC [ia Ga] IIC T4 Gc
UL, USA/Canada c Ⓤ us, C.D.-No 83104549	UL 61010 Listed Class I, Div. 2, Groups A, B, C, D T4 Class I, Div. 2, Groups IIC, IIB, IIA T4 Associated apparatus for use in Class I, Division 1, Groups A,B,C,D Associated apparatus for use in Class II, Div.1 Groups E,F,G Associated apparatus for use in Class III, Division 1 Associated apparatus for use in Class I, Zone 0,1,2, Groups IIC,IIB,IIA
KC-s 17-KA4BO-0408X	[Ex ia] IIC/IIB
Shipbuilding approval DNV GL TAA00000AG Temperature Humidity Vibration EMC Enclosure	 B B A B Required protection according to the Rules shall be provided upon installation on board
Safety Integrity Level (SIL, IEC 61508) IN-AT-AS-MRL-24-00163	2
Systematic Capability	3
INMETRO DNV 18.0114 X	[Ex ia Ga] IIC [Ex ia Da] IIIC Ex ec nC [ia Ga] IIC T4 Gc [Ex ia Ma] I

5 Safety regulations and installation notes

5.1 Installation notes

- The device is an item of associated equipment with an EPL [Ga], [Da] (category 1) with “intrinsic safety” type of protection and can be installed in zone 2 potentially explosive areas as an EPL Gc (category 3) device. Intrinsically safe circuits can be led up to zone 0 / zone 20. It satisfies the requirements of the following standards.
  IEC/EN 60079-0, IEC/EN 60079-7, IEC/EN 60079-11, and IEC/EN 60079-15
  ABNT NBR IEC 60079-0, ABNT NBR IEC 60079-7, ABNT NBR IEC 60079-11, ABNT NBR IEC 60079-15
  GB/T 3836.1, GB/T 3836.3, GB/T 3836.4, GB/T 3836.8
  For detailed information, please refer to the declarations of conformity.
- Installation, operation, and maintenance may only be carried out by qualified electricians. Follow the installation instructions as described.
- When installing and operating the device, observe the applicable regulations and safety directives (including national safety directives), as well as the generally recognized technical regulations.
- Observe the safety information, conditions, and limits of use specified in the product documentation. Comply with them.
- The device must not be opened or modified. Do not repair the device yourself, replace it with an equivalent device. Repairs may only be carried out by the manufacturer. The manufacturer is not liable for damage resulting from violation.
- The IP20 degree of protection (IEC/EN 60529) specifies that the device is intended for use in a clean and dry environment. Do not subject the device to mechanical and/or thermal stress that exceeds the specified limits.
- The device complies with the EMC regulations for industrial areas (EMC class A). When using the device in residential areas, it may cause radio interference.
- The device must be stopped if it is damaged, has been subjected to an impermissible load, stored incorrectly, or if it malfunctions.
- The products must be installed in accordance with all applicable standards for electrical systems in potentially explosive areas.
- A SELV/PELV power supply unit with a nominal voltage of 24 V DC (max. 30 V DC) is needed for the external power supply of the device.
- Only use copper connecting cables.

5.2 Intrinsic safety

- The device is approved for intrinsically safe (Ex i) circuits up to zone 0 (gas) and zone 20 (dust) in the Ex area. The safety technology values for intrinsically safe equipment and the connecting lines must be observed for the hook-up process (IEC/EC 60079-14) and the values specified in this installation note and/or the EU examination certificate must be observed.
- When carrying out measurements on the intrinsically safe side, observe the relevant regulations regarding the connection of intrinsically safe equipment. Use only these approved measuring devices in intrinsically safe circuits.
- If the device was used in circuits which are not intrinsically safe, it is forbidden to use it again in intrinsically safe circuits. Label the device clearly as being not intrinsically safe.

5.3 Installation in the Ex area (zone 2)

- Observe the specified conditions for use in potentially explosive areas! Install the device in a suitable approved housing with a minimum degree of protection of IP54 that meets the requirements of IEC/EN 60079-7 or another degree of protection in accordance with ABNT NBR IEC 60079-0, Section 1 or GB/T 3836.1 and GB/T 3836.3. Also observe the requirements of IEC/EN 60079-14.
- Only devices which are designed for operation in Ex zone 2 and are suitable for the conditions at the installation location may be connected to the circuits in the Ex zone.
- In potentially explosive areas, connecting and disconnecting cables and plugs in non-intrinsically safe circuits, the latching of devices onto and unlatching devices from the DIN rail connector, and the actuation of DIP switches is only permitted in a de-energized state or when the atmosphere is not potentially explosive.
- The device must be stopped and immediately removed from the Ex area if it is damaged, was subject to an impermissible load, stored incorrectly or if it malfunctions.
- Temporary malfunctions (transients) must not exceed the value of 497 V (355 V x 1.4).
- The specified ambient temperature range of $-40°C \leq T_{amb} \leq +60°C$ (+70°C with derating) refers to the temperature inside the installation housing.

5.4 Installation in areas with a danger of dust explosions (zone 22)

- The device is not suitable for installation in zone 22.
- If, however, you wish to use the device in zone 22, you must install it in housing that complies with IEC/EN 60079-31. When doing so, observe the maximum surface temperatures. Observe the requirements of IEC/EN 60079-14.
- Connection to the intrinsically safe circuit in areas with a danger of dust explosions (zone 20, 21 or 22) is only permitted if the equipment connected to this circuit is approved for this zone (e.g., category 1D, 2D or 3D).

5.5 Safety-related applications (SIL)

When using the device in safety-related applications, observe the instructions in “Safety-related applications”, as the requirements differ for safety-related functions.

5.6 UL note

The safety specifications, which are based on UL approval, can be found in the “Control Drawing”. The “Control Drawing” is part of the package slip.

6 Installation

6.1 Connection notes

WARNING: Electrical danger due to improper installation

Observe the connection notes for safe installation in accordance with EN/UL 61010-1:

- Disconnecting devices and branch circuit protection with suitable AC or DC rating shall be provided in the building installation.
- The device is intended for installation in a control cabinet or in a comparable enclosure. The device may only be operated when it has been installed. The control cabinet must meet the requirements of UL/IEC 61010-1 in terms of protection against spread of fire and protection against electric shock or burn.
- Provide a switch/circuit breaker close to the device that is labeled as the disconnect device for this device (or the entire control cabinet).
- Provide overcurrent protection (I ≤ 16 A) within the installation.
- To protect the device against mechanical or electrical damage, install it in suitable housing with an appropriate degree of protection according to IEC/EN 60529.
- During installation, servicing, and maintenance work, disconnect the device from all effective power sources, provided you are not dealing with SELV or PELV circuits.
- If the device is not used as described in the documentation, the intended protection can be negatively affected.
- Thanks to its housing, the device has basic insulation to the neighboring devices, for 300 V_{eff}. If several devices are installed next to each other, this has to be taken into account, and additional insulation has to be installed if necessary! If the neighboring device is equipped with basic insulation, no additional insulation is necessary.
- The voltages applied at the input, output, and power supply are extra-low voltages (ELV). Depending on the application, the switching voltage at the relay output may be a hazardous contact voltage (> 30 V AC/> 60 V DC). Safe electrical isolation from other connections exists for such cases.
- Use of the device within an ambient temperature range from >+60°C ... ≤+70°C is described in Section “Derating”.

WARNING: Explosion hazard

If the device has been used in non-intrinsically safe circuits, it must not be used again in intrinsically safe circuits.

The device must be clearly marked as non-intrinsically safe.

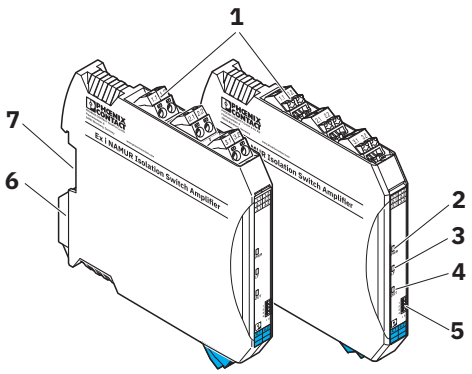
6.2 Electrostatic discharge

NOTE: Electrostatic discharge

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

6.3 Structure

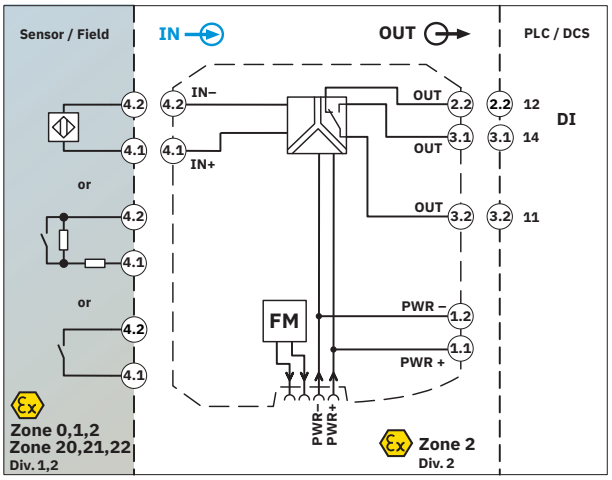
Figure 1 Structure



1 COMBICON plug-in screw or push-in connection terminal
2 Green “PWR” LED, power supply
3 Red “LF” LED, line fault of the sensor cable
4 Yellow “OUT” LED, switching state
5 Switch DIP 1 ... DIP 4
6 Snap-on foot for DIN rail mounting
7 Connection option for DIN rail connector

6.4 Basic circuit diagram with connection terminal blocks

Figure 2 Basic circuit diagram



6.5 Input (intrinsically safe)

Connection of proximity sensors (in accordance with IEN 60947-5-6 NAMUR) and switch contacts with open circuit or resistance circuits, as well as switches

Input: terminal blocks 4.1 (+) and 4.2 (-)

WARNING: Explosion hazard

The safety regulations (5.2 Intrinsic safety) must be strictly observed.

6.6 Output

One relay output (changeover contact)

Terminal blocks 3.2 (grouped contact = 11) and 3.1 (N/O contact = 14)

Terminal blocks 3.2 (grouped contact = 11) and 2.2 (N/C contact = 12)

6.7 Power supply

You must refer to the “MACX and MINI Analog power manual“ for the design of the power supply; it is available to download at www.phoenixcontact.com/products under the item listing.

The supply voltage can be supplied via terminal points 1.1 and 1.2 or via the DIN rail connector.

NOTE

Never connect the supply voltage directly to the DIN rail connector. It is not permitted to draw power from the DIN rail connector or from individual modules.

Supply via the MACX Analog Ex module

Where the total current consumption of the aligned modules does not exceed 400 mA, the power can be supplied directly at the connection terminal blocks of the module.

Up to 16 modules can be supplied depending on the current consumption of the modules.

We recommend connecting a 630 mA fuse (normal-blow or slow-blow) upstream.

Supply via power and error message module

The MACX MCR-PTB (Item No. 2865625) or the MACX MCR-PTB-SP (Item No. 2924184) supply and error message module is used to provide the supply voltage to the DIN rail connector.

Simple or redundant diode-decoupled power supply is possible.

Depending on the current consumption of the modules, up to 150 individual modules can be supplied by a supply that is protected by a fuse.

The module has integrated error evaluation. An auxiliary supply failure or fuse fault is indicated at a relay contact and displayed via a flashing LED.

Supply via a system power supply unit

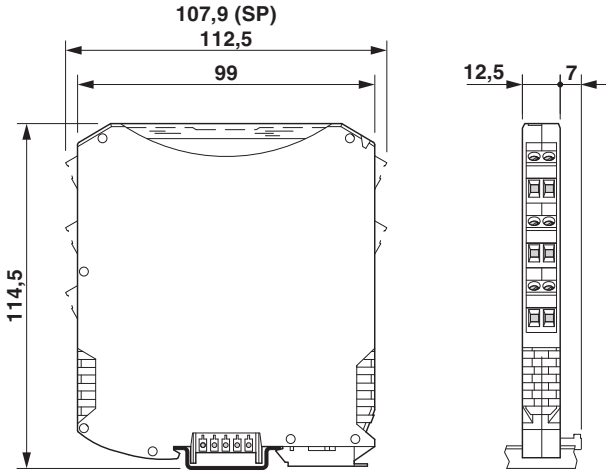
Use the QUINT4-SYS-PS/1AC/24DC/2.5/SC (Item No. 2904614) as the system power supply.

The power supply can be installed on all 35 mm DIN rails in accordance with EN 60715. The normal mounting position is horizontal (input terminals facing down). The minimum clearance to other devices is 30 mm above/below.

If you would like to supply adjacent items using the power supply, use a DIN rail bus distributor. To do so, insert the DIN rail bus adapter ME 22,5 TBUS ADAPTER KMGY (Item No.: 2201756) and the DIN rail connector ME 17,5 TBUS 1,5/ 5-ST-3,81 KMGY (Item No.: 2713645) plugged together in the DIN rail.

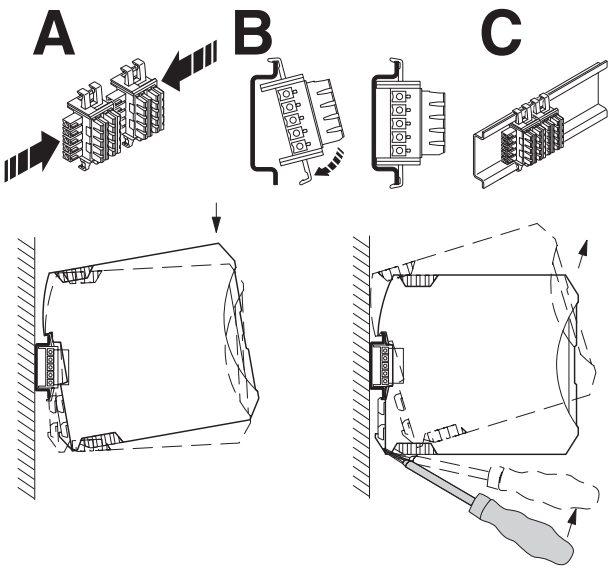
6.8 Dimensions

Figure 3 Dimensions



6.9 Mounting

Figure 4 Mounting and removing



- Mount the device on a 35 mm DIN rail in accordance with EN 60715.
- When using the DIN rail connector, first insert it in the 35 mm DIN rail in accordance with EN 60715 (A – C). DIN rails with a height of 7.5 mm or more can be used. The DIN rail connector is used to bridge the power supply and communication.
- The snap-in direction of device (D) and DIN rail connector (C) must be observed: snap-on foot on the bottom and connector on the left.
- Install the module in a suitable housing to meet the requirements for the protection class.

6.10 Partition plate

If you want to mount Ex i and non-Ex i devices next to each other on a DIN rail, you will require the MCR-DP partition plate (item no. 1430594). The partition plate ensures that Ex i isolating distances are maintained.

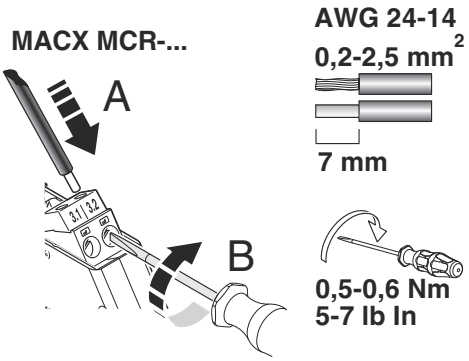
The partition plate is tailored to the MINI Analog, MINI Analog Pro, and MACX Analog device series and the QUINT4 system power supply (item no. 2904614).

The partition plate is compatible with the ME … TBUS DIN rail connectors (e.g., item no. 1090049, 2695439).

6.11 Connecting the cables

Screw connection

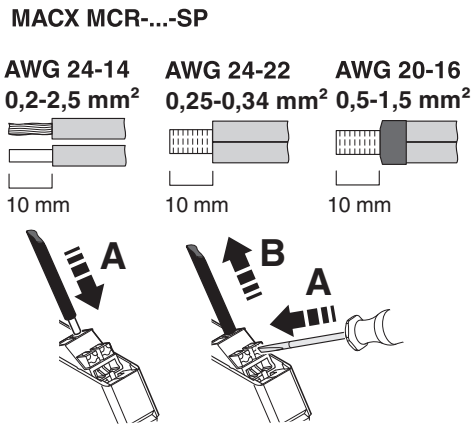
Figure 5 Screw connection



- Strip the wire by approximately 7 mm and crimp the ferrules.
- Insert the wire into the corresponding connection terminal block.
- Use a screwdriver to tighten the screw in the opening above the connection terminal block.
  Tightening torque: 0.6 Nm

Push-in connection (PSPT):

Figure 6 Push-in connection



If you want to use conductors with ferrule:

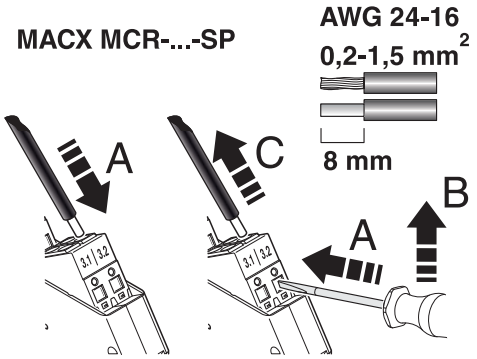
- Strip the wire by approximately 10 mm and crimp ferrules to the end of the wire.
- Insert the wire into the corresponding connection terminal block.
- Push in the pushbutton with a screwdriver to release.

If you want to use conductors without ferrule:

- Strip 10 mm off the wire.
- Push the pushbutton in with a screwdriver.
- Insert the wire into the corresponding connection terminal block.
- Push in the pushbutton with a screwdriver to release.

Push-in connection (TVFKC):

Figure 7 Push-in connection



If you want to use conductors with ferrule:

- Strip the wire by approximately 8 mm and crimp ferrules to the end of the wires.
- Insert the wire into the corresponding connection terminal block.
- Push in the pushbutton with a screwdriver to release.

If you want to use conductors without ferrule:

- Strip 8 mm off the wires.
- Push the pushbutton in with a screwdriver.
- Insert the wire into the corresponding connection terminal block.
- Push in the pushbutton with a screwdriver to release.

6.12 Group error message

Line fault messages from NAMUR signal conditioners that are connected via DIN rail connectors are reported as a group error message by the MACX MCR-PTB(-SP) power and fault signaling module via a relay output and indicated via a flashing LED.

6.13 Startup

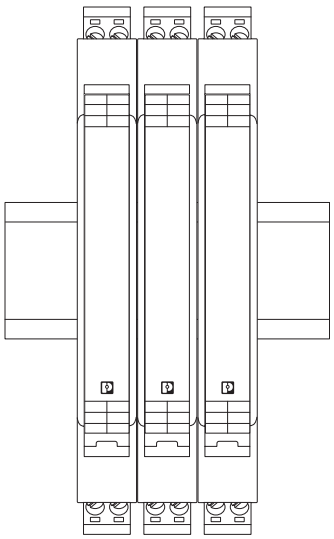
- Before startup, check that the device is operating and wired correctly, in particular with regard to the wiring and marking of the intrinsically safe circuits.

7 Derating

7.1 Operation ≤ 60 °C

The device is designed for operation in any mounting position with an ambient temperature range of -40°C ... +60°C.

Figure 8 Operation ≤60°C



NOTE

The extended operating temperature range of >+60°C ... ≤+70°C only applies to ATEX, CCC EX, INMETRO, and IECEx approvals.

The range up to ≤ +60 °C applies to all other approvals.

7.2 Operation >60°C

Operation >60°C is possible if the following installation conditions are observed.

NOTE: Overheating during operation

Special installation conditions apply for operation in the ambient temperature range of >+60°C ... +70°C.

Ensure minimum spacing of 6.2 mm on all sides of the device and make sure that this is maintained.

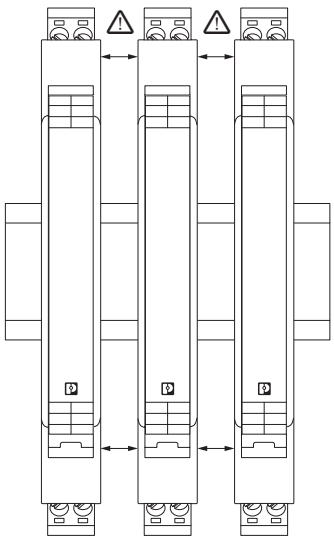
Always install the device vertically with 6.2 mm spacing on a horizontally mounted DIN rail.

If you use the DIN rail connector (ME 6,2 TBUS-2 1,5/5-ST-3,81KMGY, item number 2969401) for power bridging and group error indication, you can additionally use a DIN rail connector that is not then assembled with a device to maintain the minimum spacing.

The spacing between two devices is 12.5 mm.

The free DIN rail connector does not need to be covered, as the contacts are protected mechanically and therefore cannot cause short circuits.

Figure 9 Operation >60°C



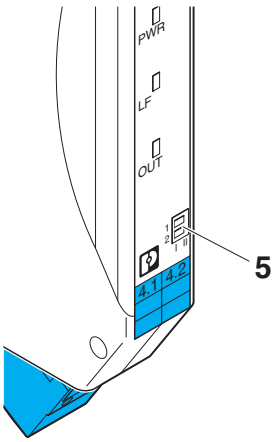
8 Configuration

NOTE

In zone 2, the DIP switches may only be actuated when the power is disconnected or when an explosive atmosphere is not present.

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

Figure 10 DIP switches



8.1 Direction of action (switch DIP 1)

The direction of action is set with DIP switch DIP 1.

DIP 1	Normal phase (I)
DIP 1	Inverse phase (II)

Relay output	Normal phase (I)	Inverse phase (II)
Switched when	I > 2.1 mA	I < 1.2 mA
In normal position when	I < 1.2 mA	I > 2.1 mA

8.2 Line fault detection (switch DIP 2)

Line fault detection is enabled using DIP switch DIP 2.

I = Line fault detection disabled - **(not permitted for safety-related applications)**

II = Line fault detection enabled

When line fault detection is enabled, the relay drops out in the event of a cable interrupt or short circuit to the sensor so that the output is set to the safe, non-conductive state.

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

Operating range in accordance with EN 60947-5-6 for line fault indication:

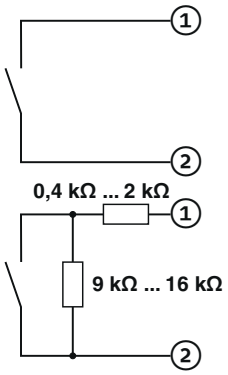
Cable break	0.05 mA < I_{IN} < 0.35 mA
Short-circuit	100 Ω < R_{Sensor} < 360 Ω

If the module is connected to a MACX MCR-PTB(-SP) power module via a DIN rail connector, a group error message is also reported to the higher-level evaluation unit via a floating relay output.

NOTE

For switch contacts with open circuit, line fault detection (LF) must be disabled or the corresponding resistance circuit (e.g., UKK 5-2R/NAMUR (Item No. 2941662) with D-UKK 3/5 (Item No. 2770024)) must be provided directly at the contact.

Figure 11 Switch contact with open circuit, switch contact with resistance circuit



8.3 Truth table

WARNING:
For safety-related applications, only switchposition “DIP 2 = II” is permitted.
For safety-related applications, only switch contacts with resistance circuits are permitted at the input.
DIP switches 3 and 4 do not have a function.

Sensor in input			Input circuit	DIP switch		Output		LED OUT	LF LED
Switch	**Switch contacts with resistance circuit**	**NAMUR**	**State**	**1**	**2**	**N/O contact**	**N/C contact**	**Yellow**	**Red**
Open	Open	Blocking	OK	I	I	Open	Closed		
Closed	Closed	Conductive	OK	I	I	Closed	Open	X	
Open	Open	Blocking	OK	II	I	Closed	Open	X	
Closed	Closed	Conductive	OK	II	I	Open	Closed		
	Open	Blocking	OK	I	II	Open	Closed		
	Closed	Conductive	OK	I	II	Closed	Open	X	
	Any	Any	Wire break	I	II	Open	Closed		X
	Any	Any	Short-circuit	I	II	Open	Closed		X
	Open	Blocking	OK	II	II	Closed	Open	X	
	Closed	Conductive	OK	II	II	Open	Closed		
	Any	Any	Wire break	II	II	Open	Closed		X
	Any	Any	Short-circuit	II	II	Open	Closed		X

NAMUR: proximity switch in accordance with EN 60947-5-6 (NAMUR) or resistance-circuit switch contact

9 Comparison of the safety data

WARNING: Explosion hazard

Compare the safety data before connecting a device located in the Ex i area to this device.

Provide proof of intrinsic safety according to standard IEC/EN 60079-14 and other national standards and installation specifications, if applicable.

Safety data

Field devices	U_i, I_i, P_i, L_i, C_i
Ex i isolation switch amplifier	U_o, I_o, P_o, L_o, C_o

The values for U_o, I_o, P_o, L_o, C_o are to be found under "Safety data in accordance with ATEX and IECEx" in the "Technical data" section.

Example for proof of intrinsic safety

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

L_c and C_c depend on the cables used.

Proof of intrinsic safety (simple intrinsically safe circuit)

In a simple intrinsically safe 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 exploited (see “Safety data in accordance with ATEX and IECEx” in the “Technical data” section).

Proof of intrinsic safety (mixed intrinsically safe circuit)

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

– L_i <1% of L_o **or** C_i <1% of C_o

Here, the full values of C_o and L_o can also be exploited (see “Safety data in accordance with ATEX and IECEx” in the “Technical data” section).

– $L_i \geq 1\%$ of L_o **and** $C_i \geq 1\%$ of C_o

Values of 50% of C_o and L_o are to be used here:

– $C_i + C_c \leq 0.5\ C_o$

– $L_i + L_c \leq 0.5\ L_o$

To implement longer cables, you can also use the certified value pairs as an alternative to the values reduced by 50%; they can be found under “Safety data in accordance with ATEX and IECEx” in the “Technical data” section.

10 Safety-related applications (IEC 61508 Edition 2 with SC 3)

The following notes apply for the devices:

Designation	Item No.
MACX MCR-EX-SL-NAM-R	2865434
MACX MCR-EX-SL-NAM-R-SP	2924045
MACX MCR-SL-NAM-R	2865997
MACX MCR-SL-NAM-R-SP	2924252

The safety-related signal conditioners listed above are certified in compliance with IEC/EN 61508-1:2010 and IEC/EN 61508-2:2010. Test certificate: IN-AT-AS-MRL-24-00163; Rev. 0

10.1 Safety function/wiring

Input

Permitted for safety-related applications:

– NAMUR sensor (in accordance with EN 60947-5-6)
– Switch contact with resistance circuit (0.4 kΩ ... 2 kΩ serial and 9 kΩ ... 16 kΩ parallel)

Note: The resistance circuit regulates the behavior of a NAMUR sensor.

WARNING:
Switch contacts without resistance circuit are not permitted for safety-related applications.

Output

The output state follows the input state; this means that the safety-related function at the output is dependent on the position of switch DIP 1 for channel 1 and DIP 3 for channel 2 (set direction of action).

I	Normal function	If a 0 signal (high-resistance NAMUR sensor, therefore lower current in the input circuit) is present, the relay output switches to the “non-conductive” or “open” state (N/O contact) and “conductive“ or “closed” state (N/C contact).
II	Inverse function	If a 1 signal is present at the input, the relay output switches to the “non-conductive” or “open” state (N/O contact) and “conductive“ or “closed” state (N/C contact).

10.2 Diagnostic function with switch DIP 2 (channel 1) and DIP 4 (channel 2)

For safety-related applications, line fault detection is enabled, i.e., switches DIP 2/DIP 4 are in the II position.

WARNING:
The “DIP 2/DIP 4 = I” switch position is not permitted for safety-related applications.

When line fault detection is enabled, the red LED indicates any faults that occur. If a line fault is detected, the output is disabled (non-conductive). This behavior is not dependent on the position of the DIP 1 and DIP 3 switches.

10.3 Safe state

The ”safe state” of the output is the energy-free state of the relay coil. This means that the N/O contact is open and the N/C contact is closed.

If the supply voltage fails or is switched off and if line faults occur, the relay output switches to the safe state.

(see Section 7.3, Truth table)

10.4 Response times

Following a state change at the input, the output enters the safe state in ≤ 40 ms.

10.5 Operating mode

Operating mode in accordance with IEC/EN 61508: “low demand rate” or “high demand rate”

10.6 Failure behavior and required response

1. The safe state is entered in the event that a line fault is detected or the supply voltage fails.
2. The safe state is achieved by removing the connection terminal blocks.

10.7 Safety integrity requirements

Error rates

The specified safety characteristics only relate to the device and do not include the connected sensors.

- Type A device (according to IEC/EN 61508-2)
- Safety integrity level (SIL) 2
- Systematic capability (SC) 3
- SIL 2 in 1oo1 architecture/HFT 0
- SIL 3 in 1oo2 architecture/HFT 1
- Low demand mode or high demand mode
- MTTR 8 h
- Ambient temperature 40°C
- Proof test coverage (PTC) 99 %
- $\beta = 2\ \%$
- $\beta_D = 1\ \%$
- Process safety time (PST) 0.5 s
- Start-up time 2 s

List of considered configurations

Configuration	Operation	Relay contact	Relay load
C1	Not inverted	N/O contact (RNO)	Load panel IV, up to 250 V AC / 2 A or 30 V DC / 2 A ohmic or low inductive load (cos φ > 0.95)
C2	Not inverted	N/O contact (RNO)	Load panel II, up to 120 V DC / 0.2 A ohmic or low inductive load (cos φ > 0.95)
C3	Inverted	N/O contact (RNO)	Load panel IV, up to 250 V AC / 2 A or 30 V DC / 2 A ohmic or low inductive load (cos φ > 0.95)
C4	Inverted	N/O contact (RNO)	Load panel II, up to 120 V DC / 0.2 A ohmic or low inductive load (cos φ > 0.95)
C5	Not inverted	N/C contact (RNC)	Load panel IV, up to 250 V AC / 2 A or 30 V DC / 2 A ohmic or low inductive load (cos φ > 0.95)
C6	Not inverted	N/C contact (RNC)	Load panel II, up to 120 V DC / 0.2 A ohmic or low inductive load (cos φ > 0.95)
C7	Inverted	N/C contact (RNC)	Load panel IV, up to 250 V AC / 2 A or 30 V DC / 2 A ohmic or low inductive load (cos φ > 0.95)
C8	Inverted	N/C contact (RNC)	Load panel II, up to 120 V DC / 0.2 A ohmic or low inductive load (cos φ > 0.95)

10.8 Failure rates

Non-inverted operation

Failure rates, safety characteristics

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	DC_{avg}	MTBF	Function
6 FIT	165 FIT	7 FIT	55 FIT	77 %	11 %	287 years	N/O contact (RNO) C1
6 FIT	230 FIT	7 FIT	90 FIT	73 %	7 %	229 years	N/O contact (RNO) C2
6 FIT	15 5 FIT	7 FIT	65 FIT	72 %	10 %	287 years	N/C contact (RNC) C5
6 FIT	210 FIT	7 FIT	110 FIT	67 %	6 %	229 years	N/C contact (RNC) C6

Low demand rate (low demand mode)

$T_{[PROOF]}$=	1 year	2 years	4 years	5 years	Function
PFD_{avg}=	$2.40 * 10^{-4}$	$4{,}79 * 10^{-4}$	$9.57 * 10^{-4}$	$1{,}20 * 10^{-3}$	N/O contact (RNO) C1
PFD_{avg}=	$3{,}93 * 10^{-4}$	$7{,}86 * 10^{-4}$			N/O contact (RNO) C2
PFD_{avg}=	$2{,}84 * 10^{-4}$	$5.67 * 10^{-4}$	$1{,}13 * 10^{-3}$		N/C contact (RNC) C5
PFD_{avg}=	$4{,}81 * 10^{-4}$	$9.61 * 10^{-4}$			N/C contact (RNC) C6

The values for 1 and 2 years mean that the calculated PFD_{avg} values are within the permitted range for SIL 2 according to Table 2 of IEC/EN 61508-1. They meet the requirement to not cover more than 10% of the safety circuit, i.e., they are better than or equal to $1.00 * 10^{-3}$.

Inverted operation

Failure rates, safety characteristics

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	DC_{avg}	MTBF	Function
7 FIT	168 FIT	6 FIT	55 FIT	77 %	11 %	286 years	N/O contact (RNO) C3
7 FIT	233 FIT	6 FIT	90 FIT	73 %	7 %	229 years	N/O contact (RNO) C4
7 FIT	158 FIT	6 FIT	65 FIT	73 %	9 %	287 years	N/C contact (RNC) C7
7 FIT	213 FIT	6 FIT	110 FIT	67 %	6 %	229 years	N/C contact (RNC) C8

Low demand rate (low demand mode)

$T_{[PROOF]}$=	1 year	2 years	4 years	5 years	Function
PFD_{avg}=	$2.40 * 10^{-4}$	$4,79 * 10^{-4}$	$9,58 * 10^{-4}$	$1,20 * 10^{-3}$	N/O contact (RNO) C3
PFD_{avg}=	$3,93 * 10^{-4}$	$7,86 * 10^{-4}$			N/O contact (RNO) C4
PFD_{avg}=	$2,84 * 10^{-4}$	$5.67 * 10^{-4}$	$1,13 * 10^{-3}$		N/C contact (RNC) C7
PFD_{avg}=	$4,81 * 10^{-4}$	$9.61 * 10^{-4}$			N/C contact (RNC) C8

The PFD_{avg} values for one, two, and three years are within the permissible range for SIL 2 in accordance with Table 2 of IEC/EN 61508-1. They meet the requirement of not covering more than 10% of the safety circuit or they are better than or equal to $1.00 * 10^{-3}$.

The PFD_{avg} values for four and five years are within the permissible range for SIL 2 in accordance with Table 2 of IEC/EN 61508-1. They do not, however, meet the requirement of not covering more than 10% of the safety circuit or they are not better than or equal to $1.00 * 10^{-3}$.

Failure limit

Based on an operating mode with a low demand rate. The percentage of the device at PFH/PFD for the entire safety loop is less than 10%.

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

High demand rate (high demand mode)

	C1	C2	C3	C4	C5	C6	C7	C8
PFH	$5.46 * 10^{-8}$	$8.96 * 10^{-8}$	$5.46 * 10^{-8}$	$8.96 * 10^{-8}$	$6,46 * 10^{-8}$	$1.10 * 10^{-7}$	$6,46 * 10^{-8}$	$1.10 * 10^{-7}$
Cycles/year	1000	100	1000	100	1000	100	1000	100

The switching frequency during the useful life of the relay should be taken into consideration.

Due to the cable inductance, low ohmic inductive loads are permitted (cos phi > 0.95).

Exception: switching frequency of 1000 cycles/year

Permissible switching frequency: 6/min

10.9 Conditions

- The failure rates of the components used remain constant throughout the period of use.
- The propagation of errors by the device in the system is not taken into consideration.
- Errors during parameterization are not taken into consideration.
- The repair time (replacement) should be eight hours.
- The failure rates of the external power supply are not taken into consideration.
- Line fault detection is enabled.
- The average temperature at which the device is to be used is +40°C. In this case, normal industrial conditions are assumed.
- The specified error rates are based on an ambient temperature of +40°C. For an ambient temperature of +60°C, the error rates must be multiplied by factor 2.5. Factor 2.5 is based on guide values.
- In safety-related applications, the operating temperature must not be allowed to fall below -25°C.

10.10 Mission time

Although a constant failure rate is assumed for most probabilistic estimation methods, this only applies if the mission time of elements is not exceeded. Once their mission time has elapsed (i.e., if the probability of failure increases significantly over time), the results of most probabilistic calculation methods are therefore not very meaningful. Therefore, any probabilistic estimate should include a specification of the mission time of the elements. The mission time strongly depends on the element itself and its operating conditions – in particular on the temperature (e.g., electrolytic capacitors can be very sensitive). Experience has shown that the mission time is often within a range of 8 to 12 years. However, it can be significantly shorter if elements are operated close to their specification limits.

According to DIN EN 61508-2:2011 (note N3) national footnote: Longer mission times shall be achieved by appropriate measures taken by the manufacturer and the operator.

Measures by the manufacturer

The signal conditioners and measuring transducers from Phoenix Contact which do not have a wide-range power supply unit for the power supply (without “UP” in the type key) already have an electrolytic capacitor-free circuit technology for the function of the device.

Examples of measures that can be taken by the operator:

- Application-specific maintenance measures
- Verification by error detection

Many years of experience have shown that signal conditioners and measuring transducers from Phoenix Contact can have a longer mission time if the ambient conditions support a long mission time. For example, the reduction of critical application conditions, thanks to a constant and low ambient temperature that is less than +40°C.

Please note that the mission time refers to the (constant) failure rate of the device and is considered under worst case conditions. The actual service life may be longer.

10.11 Installation and startup

NOTE: Installation, operation, and maintenance may only be carried out by professionals.

During installation, observe the instructions in the package slip:

Designation	MNR No.
PACKB.MACX MCR-SL-2NAM-R-UP(-SP)	9055397
PACKB.MACX MCR-EX-SL-2NAM-R-UP(-SP)	9051070

The package slip is supplied with the device. It can also be downloaded at: www.phoenixcontact.com/products.

- Configure the device according to your safety demand in accordance with the truth table. Note the switch positions that are not permitted for safety-related applications.
- Connect the device according to the installation notes.
- Check that the device operates correctly with the sensor or switch with resistance circuit connected.
- Start up the safety circuit and check that it operates correctly.
- To avoid impermissible currents, connect an external 4 A (T) fuse on the contact side of the relay.
- When installed, an external temperature monitoring system must be used.
- The device must be installed in a control cabinet with key lock and at least IP54 degree of protection.
- Provide the device with a SELV/PELV power supply that ensures 20 ms outage suppression. For applications up to SIL 3, you must use two independent power supplies or a power supply with undervoltage detection <15 V.
- Implement the safety functions in accordance with the standards, and adhere to the specified procedures for application and maintenance.
  Observe these requirements for the correct use and maintenance of the full functionality of the components.
- Validate the system configuration, the start-up times (<2 s), and the response times prior to startup and if the system configuration is changed.
- In two-channel operation, ensure an external comparison between the two output signals, for instance by a cross-comparison within the safety PLC.

10.12 Notes on operation

In normal operation, only the green LED (PWR) is permanently on.

The yellow LEDs (OUT1/OUT2) indicate the switching state of the relay output.

When line fault detection is enabled, the red LEDs (LF1/LF2) indicate any faults that occur. The safe state is entered in the event that a line fault is detected or the supply voltage fails.

10.13 Startup and restart

Switch on or restart the device

The output enters the state without oscillation (according to the truth table). A reset is not required.

What happens when a line fault is detected and what must the user do?

The fault is indicated by the red LED and the output enters the “non-conductive” state regardless of the input signal and operating mode (normal or inverse mode).
The user must eliminate the line fault (short circuit or break in the sensor cable).

The device output is not blocked when fault detection is triggered (no lock or reset). Undefined line states that occur during repairs can switch the output. The user must prevent this from happening by disconnecting the supply voltage or removing the connection terminal blocks.

Other options that have the same result and do not present an additional hazard are also permitted.

The line fault is removed

The user must ensure that a defined state is entered using the truth table. The device is restarted in the same way as during initial startup. The device then behaves as described under “Startup or restart of the device”.

10.14 Recurring checks

The function of the entire safety loop must be checked regularly according to IEC/EN 61508 and IEC/EN 61511.

The intervals for checking are specified by the intervals of each individual device within the safety loop.

It is the operator's responsibility to select the type of checks and the checking intervals in the specified time period.

Checking must be carried out in such a way that the correct function of the safety equipment in conjunction with all components can be verified.

Possible procedure for recurring checks for discovering dangerous and undetected device failures

1. Apply an appropriate signal at the input of the device in order to obtain the non-conductive state at the output.
2. Check whether the output is non-conductive.
3. Check the conductive state in the same manner.
4. Restore the safety circuit to full functionality.
5. Resume normal operation.

Around 99% of the possible “du” (“dangerous undetected”) failures in the device are discovered with this test.

If the device fails the function test, it must be taken out of operation and the process put into a safe state by other means.

10.15 Repair

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

However, if a device should fail, send it back to Phoenix Contact immediately. The type of malfunction and possible cause must also be stated.

Please use the original packaging or other suitable safe packaging when sending devices back for repairs or recalibration.

Phoenix Contact GmbH & Co. KG
Abteilung Service und Reparatur
Flachsmarktstr. 8
32825 Blomberg
GERMANY

10.16 Standards

The devices are developed and tested 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

10.17 Abbreviations

Abbreviation		Meaning
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: ability of a function unit to continue with the execution of a demanded function despite existing faults or deviations
λ_D	Rate of dangerous failures	Proportion of dangerous failures per hour
λ_{DD}	Rate of dangerous detected failures	Proportion of detected dangerous failures per hour
λ_{DU}	Rate of dangerous undetected failures	Proportion of undetected dangerous failures per hour
λ_S	Rate of safe failures	Proportion of safe failures per hour
λ_{SD}	Rate of safe detectable failures	Proportion of detectable safe failures per hour
λ_{SU}	Rate of safe undetectable failures	Proportion of undetectable safe failures per hour
MTBF	Mean time between failures	Mean time between consecutive failures
PFD_{avg}	Average probability of failure on demand	Average probability of dangerous failure on demand of a safety function
PFH_D	Probability of a dangerous failure per hour	Probability of failure per hour for the safety function
SFF	Safe failure fraction	Proportion of safe failures: proportion of failures without the potential to set the safety-related system to a dangerous or impermissible function state
SIL	Safety integrity level	International standard IEC 61508 defines four discrete safety integrity levels (SIL 1 to 4). Each level corresponds to a probability range for the failure of a safety function. The higher the safety integrity level of safety-related systems, the lower the probability that the demanded safety functions will not be performed.

11 Safety-related applications (IEC 61508 Edition 2)

The following notes apply for the devices:

Designation	Item No.
MACX MCR-EX-SL-NAM-R	2865434
MACX MCR-EX-SL-NAM-R-SP	2924045
MACX MCR-SL-NAM-R	2865997
MACX MCR-SL-NAM-R-SP	2924252

A hardware assessment (exida FMEDA report) is available for the devices listed above:
Phoenix Contact 07/06-39 R005 Version V3, Revision R2; May 2018.

11.1 Safety function/wiring

Input

Permitted for safety-related applications:

– NAMUR sensor (in accordance with EN 60947-5-6)
– Switch contact with resistance circuit (0.4 kΩ ... 2 kΩ serial and 9 kΩ ... 16 kΩ parallel)

Note: The resistance circuit regulates the behavior of a NAMUR sensor.

WARNING:
Switch contacts without resistance circuit are not permitted for safety-related applications.

Output

The output state follows the input state, i.e., the safety-related function at the output is dependent on the position of switch DIP 1 (set direction of action).

I	Normal function	If a 0 signal (high-resistance NAMUR sensor, therefore lower current in the input circuit) is present, the relay output switches to the “non-conductive” or “open” state (N/O contact) and “conductive“ or “closed” state (N/C contact).
II	Inverse function	If a 1 signal is present at the input, the relay output switches to the “non-conductive” or “open” state (N/O contact) and “conductive“ or “closed” state (N/C contact).

11.2 Diagnostic function of switch DIP 2

For safety-related applications, line fault detection is enabled, i.e., switch DIP 2 is in the II position.

WARNING:
Switch position “DIP 2 = I” is not permitted for safety-related applications.

When line fault detection is enabled, the red LED indicates any faults that occur. If a line fault is detected, the output is disabled (non-conductive). This behavior is not dependent on the position of switch DIP 1.

11.3 Safe state

The ”safe state” of the output is the energy-free state of the relay coil. This means that the N/O contact is open and the N/C contact is closed.

If the supply voltage fails or is switched off and if line faults occur, the relay output switches to the safe state.

11.4 Response times

Following a state change at the input, the output enters the safe state in ≤ 40 ms.

11.5 Operating mode

Operating mode in accordance with IEC/EN 61508: “low demand rate” or “high demand rate”

11.6 Failure behavior and required response

1. The safe state is entered in the event that a line fault is detected or the supply voltage fails.
2. The safe state is achieved by removing the connection terminal blocks. With the exception of the N/C contact in the output.

11.7 Safety integrity requirements

Safety characteristics in accordance with IEC 61508 Edition 2

- Device type A
- Safety integrity level (SIL) 2
- Systematic Capability (SC) 2
- HFT 0
- 1oo1 architecture
- Low demand mode or high demand mode
- MTTR 24 h
- Mission time 10 years
- Ambient temperature 40°C
- Proof test coverage (PTC) 95%

List of considered configurations

Configuration	Operation	Relay contact	Relay load
C1	Not inverted	N/O contact (RNO)	Load panel IV, up to 250 V AC / 2 A or 30 V DC / 2 A ohmic or low inductive load (cos φ > 0.95)
C2	Not inverted	N/O contact (RNO)	Load panel II, up to 120 V DC / 0.2 A ohmic or low inductive load (cos φ > 0.95)
C3	Inverted	N/O contact (RNO)	Load panel IV, up to 250 V AC / 2 A or 30 V DC / 2 A ohmic or low inductive load (cos φ > 0.95)
C4	Inverted	N/O contact (RNO)	Load panel II, up to 120 V DC / 0.2 A ohmic or low inductive load (cos φ > 0.95)
C5	Not inverted	N/C contact (RNC)	Load panel IV, up to 250 V AC / 2 A or 30 V DC / 2 A ohmic or low inductive load (cos φ > 0.95)
C6	Not inverted	N/C contact (RNC)	Load panel II, up to 120 V DC / 0.2 A ohmic or low inductive load (cos φ > 0.95)
C7	Inverted	N/C contact (RNC)	Load panel IV, up to 250 V AC / 2 A or 30 V DC / 2 A ohmic or low inductive load (cos φ > 0.95)
C8	Inverted	N/C contact (RNC)	Load panel II, up to 120 V DC / 0.2 A ohmic or low inductive load (cos φ > 0.95)

11.8 Failure rates

Non-inverted operation

Failure rates, safety characteristics

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	DC_{avg}	MTBF	Function
6 FIT	165 FIT	7 FIT	55 FIT	76 %	9 %	287 years	N/O contact (RNO) C1
6 FIT	230 FIT	7 FIT	90 FIT	72 %	7 %	229 years	N/O contact (RNO) C2
6 FIT	15 5 FIT	7 FIT	65 FIT	72 %	9 %	287 years	N/C contact (RNC) C5
6 FIT	210 FIT	7 FIT	110 FIT	67 %	6 %	229 years	N/C contact (RNC) C6

Low demand rate (low demand mode)

$T_{[PROOF]}$=	1 year	2 years	4 years	5 years	Function
PFD_{avg}=	$2.39 * 10^{-4}$	$4.78 * 10^{-4}$	$9.56 * 10^{-4}$	$1.19 * 10^{-3}$	N/O contact (RNO) C1
PFD_{avg}=	$3.92 * 10^{-4}$	$7.84 * 10^{-4}$			N/O contact (RNO) C2
PFD_{avg}=	$2.83 * 10^{-4}$	$5,66 * 10^{-4}$	$1,13 * 10^{-3}$		N/C contact (RNC) C5
PFD_{avg}=	$4.82 * 10^{-4}$	$9,64 * 10^{-4}$			N/C contact (RNC) C6

The values for 1 and 2 years mean that the calculated PFD_{avg} values are within the permitted range for SIL 2 according to Table 2 of IEC/EN 61508-1. They meet the requirement to not cover more than 10% of the safety circuit, i.e., they are better than or equal to $1.00 * 10^{-3}$.

Inverted operation

Failure rates, safety characteristics

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	DC_{avg}	MTBF	Function
7 FIT	168 FIT	6 FIT	55 FIT	76 %	9 %	286 years	N/O contact (RNO) C3
7 FIT	233 FIT	6 FIT	90 FIT	73 %	6 %	229 years	N/O contact (RNO) C4
7 FIT	158 FIT	6 FIT	65 FIT	72 %	9 %	287 years	N/C contact (RNC) C7
7 FIT	213 FIT	6 FIT	110 FIT	67 %	5 %	229 years	N/C contact (RNC) C8

Low demand rate (low demand mode)

$T_{[PROOF]}$=	1 year	2 years	4 years	5 years	Function
PFD_{avg}=	$2.39 * 10^{-4}$	$4.78 * 10^{-4}$	$9.56 * 10^{-4}$	$1.19 * 10^{-3}$	N/O contact (RNO) C3
PFD_{avg}=	$3.92 * 10^{-4}$	$7.84 * 10^{-4}$			N/O contact (RNO) C4
PFD_{avg}=	$2.83 * 10^{-4}$	$5,66 * 10^{-4}$	$1,13 * 10^{-3}$		N/C contact (RNC) C7
PFD_{avg}=	$4.82 * 10^{-4}$	$9,64 * 10^{-4}$			N/C contact (RNC) C8

The PFD_{avg} values for 1, 2, 3, and 4 years are within the permissible range for SIL 2 in accordance with Table 2 of IEC/EN 61508-1. They meet the requirement of not covering more than 10% of the safety circuit or they are better than or equal to $1.00 * 10^{-3}$.

The PFD_{avg} value for 5 years is within the permissible range for SIL 2 in accordance with Table 2 of IEC/EN 61508-1. However, it does not meet the requirement of not covering more than 10% of the safety circuit or is not better than or equal to $1.00 * 10^{-3}$.

Failure limit

Based on an operating mode with a low demand rate. The percentage of the device at PFH/PFD for the entire safety loop is less than 10%.

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

High demand rate (high demand mode)

	250 V AC / 2 A	120 V DC / 0.2 A	24 V DC / 2 A	Function
PFH	$5.46 * 10^{-8}$	$8.96 * 10^{-8}$	$5.46 * 10^{-8}$	N/O contact (RNO)
PFH	$6{,}46 * 10^{-8}$	$1{,}1 * 10^{-7}$	$6{,}46 * 10^{-8}$	N/C contact (RNC)
Cycles/year	1000	100	1000	

The switching frequency during the useful life of the relay should be taken into consideration.

Due to the cable inductance, low ohmic inductive loads are permitted (cos phi > 0.95).

Exception: switching frequency of 1000 cycles/year

Permissible switching frequency: 6/min

11.9 Conditions

- The failure rates of the components used remain constant throughout the period of use.
- The propagation of errors by the device in the system is not taken into consideration.
- Errors during parameterization are not taken into consideration.
- The repair time (replacement) should be eight hours.
- The failure rates of the external power supply are not taken into consideration.
- Line fault detection is enabled.
- The average temperature at which the device is to be used is +40°C. In this case, normal industrial conditions are assumed.
- The specified error rates are based on an ambient temperature of +40°C. For an ambient temperature of +60°C, the error rates must be multiplied by factor 2.5. Factor 2.5 is based on guide values.

11.10 Installation and startup

NOTE: Installation, operation, and maintenance may only be carried out by professionals.

During installation, observe the instructions in the package slip:

Designation	MNR No.
PACKB.MACX MCR-SL-NAM-R(-SP)	9049388
PACKB.MACX MCR-EX-SL-NAM-R(-SP)	9040232

The package slip is supplied with the device. It can also be downloaded at: www.phoenixcontact.com/products.

- Configure the device according to your safety demand in accordance with the truth table. Note the switch positions that are not permitted for safety-related applications.
- Connect the device according to the installation notes.
- Check that the device operates correctly with the sensor or switch with resistance circuit connected.
- Start up the safety circuit and check that it operates correctly.
- To avoid impermissible currents, connect an external 4 A (T) fuse on the contact side of the relay.
- When installed, an external temperature monitoring system must be used.
- The device must be installed in a control cabinet with key lock and at least IP54 degree of protection.
- The power supply used must compensate brief interruptions (≤ 20 ms).

11.11 Notes on operation

In normal operation, only the green LED (PWR) is permanently on.

The yellow LEDs (OUT1/OUT2) indicate the switching state of the relay output.

When line fault detection is enabled, the red LED (LF) indicates any faults that occur. The safe state is entered in the event of a line fault being detected or a supply voltage failure.

11.12 Startup and restart

Switch on or restart the device

The output enters the state without oscillation (according to the truth table). A reset is not required.

What happens when a line fault is detected and what must the user do?

The fault is indicated by the red LED and the output enters the “non-conductive” state regardless of the input signal and operating mode (normal or inverse mode).
The user must eliminate the line fault (short circuit or break in the sensor cable).

The device output is not blocked when fault detection is triggered (no lock or reset). Undefined line states that occur during repairs can switch the output. The user must prevent this from happening by disconnecting the supply voltage or removing the connection terminal blocks.

Other options that have the same result and do not present an additional hazard are also permitted.

The line fault is removed

The user must ensure that a defined state is entered using the truth table. The device is restarted in the same way as during initial startup. The device then behaves as described under “Startup or restart of the device”.

11.13 Recurring checks

The function of the entire safety loop must be checked regularly according to IEC/EN 61508 and IEC/EN 61511.

The intervals for checking are specified by the intervals of each individual device within the safety loop.

It is the operator's responsibility to select the type of checks and the checking intervals in the specified time period.

Checking must be carried out in such a way that the correct function of the safety equipment in conjunction with all components can be verified.

Possible procedure for recurring checks for discovering dangerous and undetected device failures

1. Apply an appropriate signal at the input of the device in order to obtain the non-conductive state at the output.
2. Check whether the output is non-conductive.
3. Check the conductive state in the same manner.
4. Restore the safety circuit to full functionality.
5. Resume normal operation.

Around 99% of the possible “du” (“dangerous undetected”) failures in the device are discovered with this test.

If the device fails the function test, it must be taken out of operation and the process put into a safe state by other means.

11.14 Repair

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

However, if a device should fail, send it back to Phoenix Contact immediately. The type of malfunction and possible cause must also be stated.

Please use the original packaging or other suitable safe packaging when sending devices back for repairs or recalibration.

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32825 Blomberg
GERMANY

11.15 Standards

The devices are developed and tested 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

11.16 Abbreviations

Abbreviation		Meaning
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: ability of a function unit to continue with the execution of a demanded function despite existing faults or deviations
λ_D	Rate of dangerous failures	Proportion of dangerous failures per hour
λ_{DD}	Rate of dangerous detected failures	Proportion of detected dangerous failures per hour
λ_{DU}	Rate of dangerous undetected failures	Proportion of undetected dangerous failures per hour
λ_S	Rate of safe failures	Proportion of safe failures per hour
λ_{SD}	Rate of safe detectable failures	Proportion of detectable safe failures per hour
λ_{SU}	Rate of safe undetectable failures	Proportion of undetectable safe failures per hour
MTBF	Mean time between failures	Mean time between consecutive failures
PFD_{avg}	Average probability of failure on demand	Average probability of dangerous failure on demand of a safety function
PFH_D	Probability of a dangerous failure per hour	Probability of failure per hour for the safety function
SFF	Safe failure fraction	Proportion of safe failures: proportion of failures without the potential to set the safety-related system to a dangerous or impermissible function state
SIL	Safety integrity level	International standard IEC 61508 defines four discrete safety integrity levels (SIL 1 to 4). Each level corresponds to a probability range for the failure of a safety function. The higher the safety integrity level of safety-related systems, the lower the probability that the demanded safety functions will not be performed.

12 Safety-related applications (IEC 61508 Edition 1)

The following notes apply for the devices:

Designation	Item No.
MACX MCR-EX-SL-NAM-R	2865434
MACX MCR-EX-SL-NAM-R-SP	2924045
MACX MCR-SL-NAM-R	2865997
MACX MCR-SL-NAM-R-SP	2924252

A hardware assessment (FMEDA report) is available for the devices listed above: Exida 07/06-39 R005 V2R2.

12.1 Circuits

Input

Permitted for safety-related applications:

– NAMUR sensor (in accordance with EN 60947-5-6)
– Switch contact with resistance circuit (0.4 kΩ ... 2 kΩ serial and 9 kΩ ... 16 kΩ parallel)

Note: The resistance circuit regulates the behavior of a NAMUR sensor.

WARNING:
Switch contacts without resistance circuit are not permitted for safety-related applications.

Output

The safety-related function at the output is dependent on the position of switch DIP 1 (set direction of action).

I	Normal function	In the event of a 0 signal (NAMUR sensor in a high-resistance state, therefore low current in the input circuit), the output switches to the “non-conductive” or “open” state.
II	Inverse function	In the event of a 1 signal at the input, the output switches to the “non-conductive” or “open” state.

12.2 Diagnostic function of switch DIP 2

For safety-related applications, line fault detection is enabled, i.e. the switch DIP 2 is in the 'II' position.

WARNING:
Switch position “DIP 2 = I” is not permitted for safety-related applications.

When line fault detection is enabled, the red LED indicates any faults that occur. If a line fault is detected, the output is disabled (non-conductive). This behavior is not dependent on the position of switch DIP 1.

12.3 Safe state

“Safe state” means that the N/O contact is open and the N/C contact is closed.

If the supply voltage fails or is switched off, the relay output goes into the safe state.

12.4 Response times

Following a state change at the input, the output enters the safe state in ≤ 40 ms.

12.5 Operating mode

Operating mode in accordance with IEC/EN 61508:
“Low demand mode”

12.6 Failure behavior and required response

1. The safe state is entered in the event that a line fault is detected or the supply voltage fails.
2. The safe state is achieved by removing the connection terminal blocks.

12.7 Safety integrity requirements

Error rates

- Type A device (according to IEC/EN 61508-2)
- Safety integrity level (SIL) 2
- HFT 0
- MTTR 24 h
- 1oo1 architecture
- Ambient temperature 40°C

Non-inverted operation

Failure rate in FIT

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	DC_S	DC_D
6	242	7	60	78.8 %	2.4 %	10 %

The MTBF is 304 years.

PFD_{avg} values

$T_{[PROOF]}$=	1 year	2 years	5 years
PFD_{avg}=	$2.90 * 10^{-4}$	$5.79 * 10^{-4}$	$1.45 * 10^{-4}$

Inverted operation

Failure rate in FIT

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	DC_S	DC_D
1	249	6	64	78 %	0.4 %	8 %

The MTBF is 304 years.

PFD_{avg} values

$T_{[PROOF]}$=	1 year	2 years	5 years
PFD_{avg}=	$3.08 * 10^{-4}$	$6.15 * 10^{-4}$	$1.54 * 10^{-3}$

The value for 5 years means that the calculated PFD_{avg} values are within the permitted range for SIL 2 according to Table 2 of IEC/EN 61508-1. However, they do not meet the requirement to not cover more than 10% of the safety circuit, i.e., to be better than or equal to $1.00 * 10^{-3}$.

The values for 1 and 2 years mean that the calculated PFD_{avg} values are within the permitted range for SIL 2 according to Table 2 of IEC/EN 61508-1. They meet the requirement to not cover more than 10% of the safety circuit, i.e., they are better than or equal to $1.00 * 10^{-3}$.

Failure limit

Based on an operating mode with a low demand rate. The percentage of the device at PFH/PFD for the entire safety loop is less than 10%.

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

12.8 Conditions

- The failure rates of the components used remain constant throughout the period of use.
- The propagation of errors by the device in the system is not taken into consideration.
- Errors during parameterization are not taken into consideration.
- The repair time (replacement) should be eight hours.
- The failure rates of the external power supply are not taken into consideration.
- Line fault detection is enabled.
- The average temperature at which the device is to be used is +40°C. In this case, normal industrial conditions are assumed.
- The specified error rates are based on an ambient temperature of +40°C. For an ambient temperature of +60°C, the error rates must be multiplied by factor 2.5. Factor 2.5 is based on guide values.

12.9 Installation and startup

NOTE: Installation, operation, and maintenance may only be carried out by professionals.

During installation, observe the instructions in the package slip:

Designation	MNR No.
PACKB.MACX MCR-EX-SL-NAM-R(-SP)	9040232
PACKB.MACX MCR-SL-NAM-R(-SP)	9049388

The package slip is supplied with the device. It can also be downloaded at: www.phoenixcontact.com/products.

- Configure the device according to your safety demand in accordance with the truth table. Note the switch positions that are not permitted for safety-related applications.
- Connect the device according to the installation notes.
- Check that the device operates correctly with the sensor or switch with resistance circuit connected.
- Start up the safety circuit and check that it operates correctly.

12.10 Notes on operation

In normal operation, only the green LED (PWR) is permanently on.

The yellow LEDs (OUT1/OUT2) indicate the switching state of the relay output.

When line fault detection is enabled, the red LED (LF) indicates any faults that occur. The safe state is entered in the event of a line fault being detected or a supply voltage failure.

12.11 Startup and restart

Switch on or restart the device

The output enters the state without oscillation (according to the truth table). A reset is not required.

What happens when a line fault is detected and what must the user do?

The fault is indicated by the red LED and the output enters the “non-conductive” state regardless of the input signal and operating mode (normal or inverse mode).
The user must eliminate the line fault (short circuit or break in the sensor cable).

The device output is not blocked when fault detection is triggered (no lock or reset). Undefined line states that occur during repairs can switch the output. The user must prevent this from happening by disconnecting the supply voltage or removing the connection terminal blocks.

Other options that have the same result and do not present an additional hazard are also permitted.

The line fault is removed

The user must ensure that a defined state is entered using the truth table. The device is restarted in the same way as during initial startup. The device then behaves as described under “Startup or restart of the device”.

12.12 Recurring checks

The function of the entire safety loop must be checked regularly according to IEC/EN 61508 and IEC/EN 61511.

The intervals for checking are specified by the intervals of each individual device within the safety loop.

It is the operator's responsibility to select the type of checks and the checking intervals in the specified time period.

Checking must be carried out in such a way that the correct function of the safety equipment in conjunction with all components can be verified.

Possible procedure for recurring checks for discovering dangerous and undetected device failures

1. Apply an appropriate signal at the input of the device in order to obtain the non-conductive state at the output.
2. Check whether the output is non-conductive.
3. Check the conductive state in the same manner.
4. Restore the safety circuit to full functionality.
5. Resume normal operation.

Around 99% of the possible “du” (“dangerous undetected”) failures in the device are discovered with this test.

If the device fails the function test, it must be taken out of operation and the process put into a safe state by other means.

12.13 Repair

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

However, if a device should fail, send it back to Phoenix Contact immediately. The type of malfunction and possible cause must also be stated.

Please use the original packaging or other suitable safe packaging when sending devices back for repairs or recalibration.

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12.14 Standards

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

IEC/EN 61508: 2001	Functional Safety of electrical/electronic/programmable electronic safety-related systems
IEC/EN 61326-1: 2006	Electrical equipment for measurement, control and laboratory use - EMC requirements

12.15 Abbreviations

Abbreviation		Meaning
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: ability of a function unit to continue with the execution of a demanded function despite existing faults or deviations
λ_D	Rate of dangerous failures	Proportion of dangerous failures per hour
λ_{DD}	Rate of dangerous detected failures	Proportion of detected dangerous failures per hour
λ_{DU}	Rate of dangerous undetected failures	Proportion of undetected dangerous failures per hour
λ_S	Rate of safe failures	Proportion of safe failures per hour
λ_{SD}	Rate of safe detectable failures	Proportion of detectable safe failures per hour
λ_{SU}	Rate of safe undetectable failures	Proportion of undetectable safe failures per hour
MTBF	Mean time between failures	Mean time between consecutive failures
PFD_{avg}	Average probability of failure on demand	Average probability of dangerous failure on demand of a safety function
PFH_D	Probability of a dangerous failure per hour	Probability of failure per hour for the safety function
SFF	Safe failure fraction	Proportion of safe failures: proportion of failures without the potential to set the safety-related system to a dangerous or impermissible function state
SIL	Safety integrity level	International standard IEC 61508 defines four discrete safety integrity levels (SIL 1 to 4). Each level corresponds to a probability range for the failure of a safety function. The higher the safety integrity level of safety-related systems, the lower the probability that the demanded safety functions will not be performed.

13 Digital nameplate

The digital nameplate provides the option of obtaining product-specific data related to a specific serial number.

If you scan the QR code (digital nameplate) on the device, you can, for example, retrieve documents on the production status as well as clearly identify the hardware and firmware status of the device at hand.

Figure 12 Scan QR code

