

MACX MCR-EX-SL-RPSSI-I(-SP)



Repeater power supply and input isolating amplifier, Ex-i

Data sheet
103568_en_02

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1 Description

The repeater power supply and input signal conditioner is designed for the intrinsically safe (Ex i) and electrically isolated operation of measuring transducers and mA current sources installed in the hazardous area.

2-wire measuring transducers are supplied with energy via a powered input with intrinsic safety. 4-wire measuring transducers and mA current sources can be operated via a non-powered input. The analog 0/4 ... 20 mA measured value from the hazardous area is electrically isolated 1:1 when transmitted to the non-hazardous area.

You can operate the output of the module actively or passively. The analog measured value on the Ex or non-Ex side can be overlaid with digital (HART) communication signals and transmitted bidirectionally.

You can connect additional resistance in the output circuit in order to increase the HART impedance in low-ohmic systems using a terminal point.

Sockets are integrated into the COMBICON connectors for connecting HART communicators.

The devices are certified for safety-related applications up to SIL 2 according to IEC 61508. Installation in zone 2 is permitted.

Features

- 1-channel
- 0/4 mA ... 20 mA input, intrinsically safe, [Ex ia], powered and not powered
- Measuring transducer supply voltage > 16 V
- 0/4 ... 20 mA output, active up to 1000 Ω load or passive
- Bidirectional HART signal transmission
- Error indication according to NAMUR NE 43
- SIL 2 according to IEC 61508/EN 61508
- Installation in Ex zone 2 permitted
- Safe 3-way electrical isolation
- Power supply possible via DIN rail connector
- Plug-in connection terminal blocks, with either screw or push-in connection technology
- Housing width of 12.5 mm
- Low power dissipation
- High transmission accuracy



WARNING: Explosion hazard

The device is an associated item of equipment (category 1) with "intrinsic safety" protection type and can be installed in zone 2 potentially explosive areas as a category 3 device. It meets the requirements of EN 60079-0:2012, EN 60079-11:2012, and EN 60079-15:2010.

When installing and operating the device, the applicable safety directives (including national safety directives), accident prevention regulations, as well as general technical regulations must be observed.

Observe the safety notes in the "Safety regulations and installation notes" section.



Make sure you always use the latest documentation.

It can be downloaded from the product at phoenixcontact.net/products.

This document is valid for the products listed in the "Ordering data".

This document applies as of 2015 to items with serial numbers greater than 11219366762 (screw connection) and greater than 11219366763 (push-in connection).

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3 Ordering data

Description	Type	Order No.	Pcs. / Pkt.
Ex i repeater power supply and input signal conditioner, HART. Transmits supplied or active 0/4 - 20 mA signals from the hazardous area to a load (active or passive) in the safe area. 3-way electrical isolation; SIL 2 according to IEC 61508, with screw connection	MACX MCR-EX-SL-RPSSI-I	2865340	1
Ex i repeater power supply and input signal conditioner, HART. Transmits supplied or active 0/4 - 20 mA signals from the hazardous area to a load (active or passive) in the safe area. 3-way electrical isolation; SIL 2 according to IEC 61508, with push-in connection	MACX MCR-EX-SL-RPSSI-I-SP	2924016	1
Accessories	Type	Order No.	Pcs. / Pkt.
DIN rail connector for DIN rail mounting. Universal for TBUS housing. Gold-plated contacts, 5-pos. Plug component, Number of positions: 5, Pitch: 3.81 mm	ME 6,2 TBUS-2 1,5/5-ST-3,81 GN	2869728	10
Power and fault signaling module with screw connection, including corresponding ME 17,5 TBUS 1,5/ 5-ST-3,81 GN DIN rail connector	MACX MCR-PTB	2865625	1
Power and fault signaling module with push-in connection, including corresponding ME 17,5 TBUS 1,5/ 5-ST-3,81 GN DIN rail connector	MACX MCR-PTB-SP	2924184	1

Note

For additional accessories, visit phoenixcontact.net/products.

4 Technical data

Input data Repeater power supply operation

Description of the input	Active current input, intrinsically safe
Current input signal	4 mA ... 20 mA
Current limitation	25 mA
Transmitter supply voltage	> 16 V (20 mA) > 15.3 V (22.5 mA)
Underload/overload signal range	0 mA ... 24 mA (Extended transmission range for diagnostics)

Input data Signal conditioner operation

Description of the input	Passive current input, intrinsically safe
Current input signal	0 mA ... 20 mA 4 mA ... 20 mA
Voltage drop	< 3.5 V
Underload/overload signal range	0 mA ... 24 mA (Extended transmission range for diagnostics)

Output Repeater power supply operation

Output description	Current output (active and passive)
Current output signal	4 mA ... 20 mA (active) 4 mA ... 20 mA (14 ... 26 V ext. source voltage)
Underload/overload signal range	0 mA ... 24 mA (Extended transmission range for diagnostics)
Transmission Behavior	1:1 to input signal
Load/output load current output	< 1000 Ω (20 mA) < 825 Ω (24 mA)
Output ripple	< 20 mV _{rms}
Output behavior in the event of an error as per NE 43	0 mA (Cable break in the input) ≥ 22.5 mA (Cable short-circuit in the input)

MACX MCR-EX-SL-RPSSI-I(-SP)**Output Signal conditioner operation**

Output description	Current output (active and passive)
Current output signal	0 mA ... 20 mA (active) 4 mA ... 20 mA (active) 0 mA ... 20 mA (14 ... 26 V ext. source voltage) 4 mA ... 20 mA (14 ... 26 V ext. source voltage)
Underload/overload signal range	0 mA ... 24 mA (Extended transmission range for diagnostics)
Transmission Behavior	1:1 to input signal
Load/output load current output	< 1000 Ω (20 mA) < 825 Ω (24 mA)
Output ripple	< 20 mV _{rms}
Output behavior in the event of an error as per NE 43	0 mA (Cable break in the input) 0 mA (Cable short-circuit in the input)

Supply Repeater power supply operation

Nominal supply voltage	24 V DC
Supply voltage range	19.2 V DC ... 30 V DC (24 V DC (-20% ... +25%))
Max. current consumption	< 76 mA (24 V DC / 20 mA / 1000 Ω) < 55 mA (24 V DC / 20 mA / 250 Ω)
Power loss	
Output active	< 1.1 W (24 V DC / 20 mA / 1000 Ω)
Output active	< 0.95 W (24 V DC / 20 mA / 250 Ω)
Passive output	< 1.2 W (24 V DC / 20 mA / 0 Ω)
Power consumption	
Output active	< 1.8 W (20 mA / 1000 Ω)
Output active	< 1.3 W (20 mA / 250 Ω)

Supply Signal conditioner operation

Nominal supply voltage range	19.2 V DC ... 30 V DC (24 V DC (-20% ... +25%))
Max. current consumption	< 44 mA (24 V DC / 20 mA / 1000 Ω) < 27 mA (24 V DC / 20 mA / 250 Ω)
Power loss	
Output active	< 0.75 W (24 V DC / 20 mA / 1000 Ω)
Output active	< 0.65 W (24 V DC / 20 mA / 250 Ω)
Passive output	< 0.95 W (24 V DC / 20 mA / 0 Ω)

General data

Transmission error, typical	< 0.05 % (of final value)
Maximum transmission error	< 0.1 % (of final value)
Temperature coefficient, typical	< 0.004 %/K
Maximum temperature coefficient	< 0.01 %/K
Step response (10-90%)	< 200 μs (for jump 4 mA ... 20 mA, load 600) < 600 μs (for jump 0 mA ... 20 mA, load 600)
Protection against polarity reversal	Yes
HART function	Yes
Protocols supported	HART
Signal bandwidth	as per HART specifications
Degree of protection	IP20
Inflammability class according to UL 94	V0
Surge voltage category	II
Pollution degree	2
Diameter Test socket in the connector	2 mm
Status display	Green LED (supply voltage)
Dimensions W/H/D	12.5 mm / 112.5 mm / 114.5 mm (MACX MCR-EX-SL-RPSSI-I) 12.5 mm / 116 mm / 114.5 mm (MACX MCR-EX-SL-RPSSI-I-SP)
Type of housing	PA 66-FR green

MACX MCR-EX-SL-RPSSI-I(-SP)

Connection data	Screw connection	Push-in connection
Conductor cross section, solid	0.2 mm ² ... 2.5 mm ²	0.2 mm ² ... 1.5 mm ²
Conductor cross section, stranded	0.2 mm ² ... 2.5 mm ²	0.2 mm ² ... 1.5 mm ²
Conductor cross section AWG	24 ... 14	24 ... 16
Stripping length	7 mm	8 mm
Tightening torque	0.5 Nm ... 0.6 Nm	


Ambient conditions	
Ambient temperature (operation)	-20 °C ... 60 °C (Any mounting position)
Ambient temperature (storage/transport)	-40 °C ... 80 °C
Permissible humidity (operation)	10 % ... 95 % (non-condensing)
Maximum altitude for use above sea level	≤ 2000 m

Electrical isolation	
Input/output/power supply	
Rated insulation voltage (surge voltage category II; pollution degree 2, safe isolation as per EN 61010-1)	300 V _{rms}
50 Hz, 1 min., test voltage	2.5 kV
Input/output	
Peak value in accordance with EN 60079-11	375 V
Input/power supply	
Peak value in accordance with EN 60079-11	375 V

Safety data as per ATEX		
Operating modes	Repeater power supply operation	Signal conditioner operation
Max. output voltage U _o	25.2 V	
Max. output current I _o	93 mA	
Max. output power P _o	587 mW	
Group (Max. external inductivity L _o / Max. external capacitance C _o)	IIB : 4 mH / 820 nF	
	IIC : 2 mH / 107 nF	
Max. voltage U _i		≤ 30 V
Max. current I _i		≤ 150 mA
Max. internal inductance L _i		negligible
Max. internal capacitance C _i		negligible
Safety-related maximum voltage U _m	253 V AC (125 V DC)	

Conformance with EMC Directive 2004/108/EC	
Noise immunity according to EN 61000-6-2	
When being exposed to interference, there may be minimal deviations.	
Noise emission according to EN 61000-6-4	

Conformance / approvals

Conformance	CE-compliant, additionally EN 61326
ATEX (BVS 08 ATEX E 054X)	<ul style="list-style-type: none"> ⊕ II (1) G [Ex ia Ga] IIC/IIB ⊕ II (1) D [Ex ia Da] IIIC ⊕ II 3 (1) G Ex nA [ia Ga] IIC/IIB T4 Gc ⊕ I (M1) [Ex ia Ma] I
IECEX (IECEX BVS 08.0016X)	<ul style="list-style-type: none"> [Ex ia Ga] IIC/IIB [Ex ia Da] IIIC Ex nA [ia Ga] IIC/IIB T4 Gc [Ex ia Ma] I
UL, USA / Canada ( , C.D.-No 83104549)	<ul style="list-style-type: none"> 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,D Associated apparatus for use in Class III, Division 1 Associated apparatus for use in Class I, Zone 0,1,2, Groups IIC,IIB,IIA
Shipbuilding GL (DNV GL 11 564-14HH)	C, EMC2
Functional Safety in accordance with IEC 61508 (BVS PB 03/08-2)	to SIL 2

5 Safety regulations and installation notes

5.1 Installation notes

- The device is associated equipment (category 1) of explosion production class “intrinsic safety” and can be installed in zone 2 potentially explosive areas as a category 3 device. It meets the requirements of EN 60079-0:2012, EN 60079-11:2012, EN 60079-15:2010, EN 60079-26:2007, IEC 60079-0 ed. 6.0, IEC 60079-11 ed. 6.0, and IEC 60079-15 ed. 4.0.
- Installation, operation, and maintenance may only be carried out by qualified electricians. Follow the installation instructions as described. When installing and operating the device, the applicable regulations and safety directives (including national safety directives), as well as general technical regulations, must be observed. For the safety technology data, see this packing slip and the certificates (EC examination certificate and other approvals if appropriate).
- 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 protection (IEC 60529/EN 60529) of the device is intended for use in a clean and dry environment. The device must not be subject to mechanical strain and/or thermal loads, which exceed the limits described.
- To protect the device against mechanical or electrical damage, install it in a suitable housing with appropriate degree of protection as per IEC 60529.
- The device must be stopped if it is damaged, has been subjected to an impermissible load, stored incorrectly, or if it malfunctions.
- During servicing and maintenance work, disconnect the device from all effective power sources, provided you are not dealing with SELV or PELV circuits.
- 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.

5.2 Intrinsic safety

- The device is approved for intrinsically safe (Ex-i) circuits up to Ex zone 0 (gas) and Ex zone 20 (dust). 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 EC 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 Zone 2

- Observe the specified conditions for use in potentially explosive areas! Install the device in a suitable approved housing (with a minimum of IP54 protection) that meets the requirements of EN 60079-15. Observe the requirements of EN 60079-14.
- In potentially explosive areas, it is only permissible to snap the device on or off the DIN rail connector and to connect or disconnect non-intrinsically-safe cables when the power is disconnected.
- 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.

5.4 Potentially dust-explosive areas

- The device is not suitable for installation in zone 22.
- If you nevertheless intend to use the the device in Zone 22, you must install it in a housing according to IEC/EN 60079-31. Observe the maximum surface temperatures in this case. Adhere to the requirements of IEC/EN 60079-14.
- Only make the connection to the intrinsically safe circuit in potentially dust-explosive areas of zones 20, 21 and 22 if the equipment connected to this circuit is certified for this zone (e.g., category 1D, 2D or 3D).

5.5 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.

5.6 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.

6 Installation



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 IEC 61340-5-1.

6.1 Structure

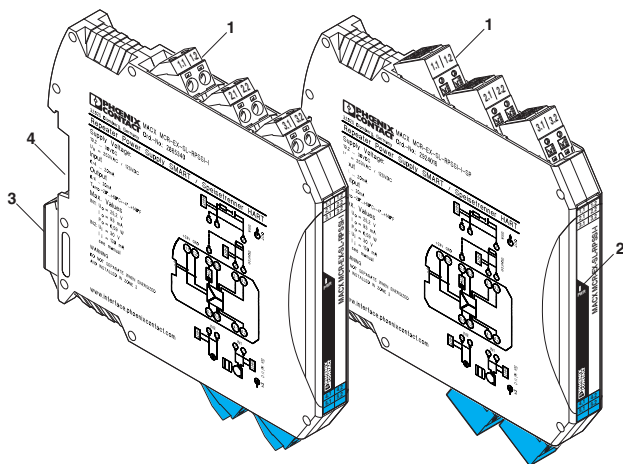


Figure 1 Structure

- 1 COMBICON plug-in, screw, or push-in connection terminal with integrated test socket
- 2 Green "PWR" LED, power supply
- 3 Snap-on foot for DIN rail mounting
- 4 Connection option for DIN rail connector

6.2 Basic circuit diagram with connection terminal blocks

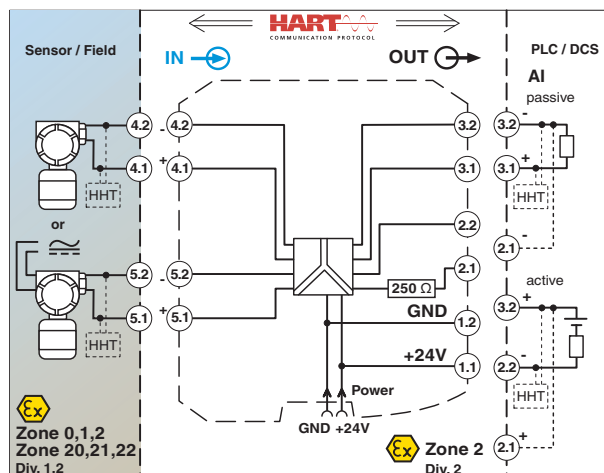


Figure 2 Basic circuit diagram

Input (intrinsically safe)

- Repeater power supply operation (2-wire transmitter or 2-wire measuring transducer) at terminal block 4.1 (+) and 4.2 (-)
- Input signal conditioner operation (4-wire transmitter or current sources) at terminal blocks 5.1 (+) and 5.2 (-)

HART communicators (HHT) can be connected as shown in the basic circuit diagram. Test sockets (diameter 2.3 mm) have been integrated for this purpose.



WARNING: Explosion hazard
Always adhere to the safety regulations (1.2. Intrinsic safety).

Output

Operating mode	Connection of input card to terminal
Source – passive input card	3.1 (+) and 3.2 (-)
Drain – active input card	3.2 (+) and 2.2 (-)

Output (with bidirectional HART communication)

Operating mode	Circuit impedance	Connection	
		Input board	HART communicator
Source – passive input card	$\geq 250 \Omega$	3.1 (+) and 3.2 (-)	3.1 and 3.2
	$< 250 \Omega$	3.1 (+) and 2.1 (-)	3.1 and 3.2
Drain – active input card	$\geq 250 \Omega$	3.2 (+) and 2.2 (-)	2.2 and 3.2
	$< 250 \Omega$	2.1 (+) and 2.2 (-)	2.2 and 3.2

External HART communicators (HHT) can be connected as shown in the basic circuit diagram and described in the table above. Test sockets (2.3 mm in diameter) have been integrated in the screw connection terminal blocks for this.

Level conversion

No level conversion is provided between input and output.
 4 ... 20 mA input signals become 4 ... 20 mA output signals.
 0 ... 20 mA active input signals become electrically isolated 0 ... 20 mA output signals.

6.3 Power supply**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.

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

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 (Order No. 2865625) or the MACX MCR-PTB-SP (Order 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.

6.4 Dimensions

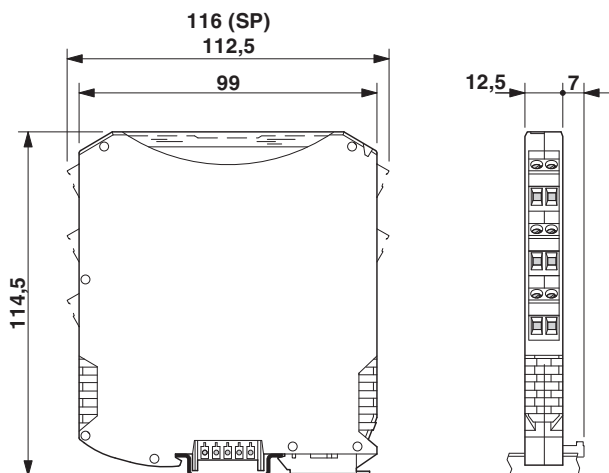


Figure 3 Dimensions

6.5 Assembly

**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.

**EN / UL 61010-1:**

- 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 for an overcurrent protection device ($I \leq 16 \text{ A}$) in the installation.
- To protect the device against mechanical or electrical damage, install it in a suitable housing with appropriate degree of protection as per IEC 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 Veff. 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 to the input, output, and power supply are extra-low voltages (ELV). Depending on the application, hazardous contact voltage ($>30 \text{ V AC}$ / $>60 \text{ V DC}$) to ground may occur. Safe electrical isolation from the other connections exists for this case.

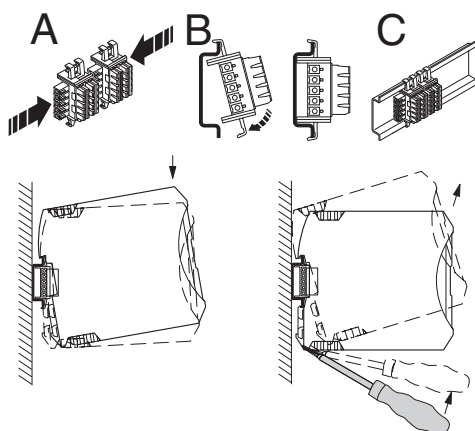


Figure 4 Mounting and removing

- Mount the device on a 35 mm DIN rail according to EN 60715.
- When using the DIN rail connector, first insert it in the 35 mm DIN rail according to 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 the device and DIN rail connector must be observed: snap-on foot on the bottom and plug on the left.
- Install the module in a suitable housing to meet the requirements for the protection class.
- 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.

6.6 Connecting the cables

- Screw terminal blocks: fit the litz wires with ferrules, permitted conductor cross section: 0.2 mm² to 2.5 mm²
- Push-in terminal blocks: fit the litz wires with ferrules, permitted conductor cross section: 0.2 mm² to 1.5 mm²
- Install intrinsically safe and non-intrinsically safe cables separately

Screw Connection

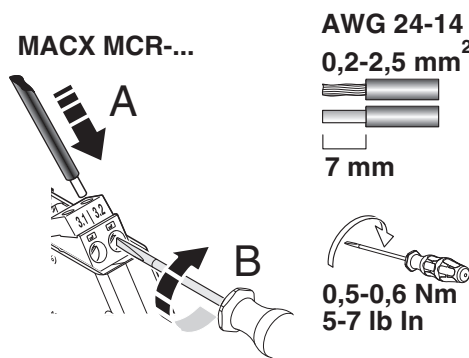


Figure 5 Screw connection

- 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:

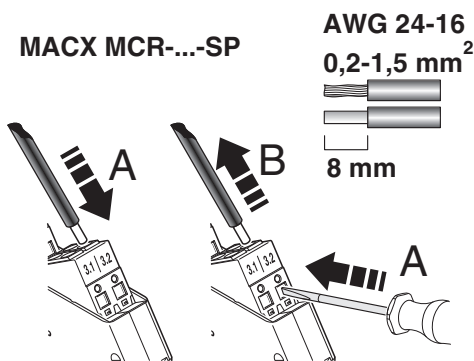


Figure 6 Push-in connection

- Insert the wire into the corresponding connection terminal block.

7 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 repeater power supply	U_o, I_o, P_o, L_o, C_o

The values for U_o, I_o, P_o, L_o, C_o can be found under "Safety data according to ATEX" in the "Technical data" section.

Example for proof of intrinsic safety for intrinsically safe circuits with one source

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

L_c and C_c depend on the cables used.

8 Safety-related applications

The following notes apply for the devices:

Designation	Order No.
MACX MCR-EX-SL-RPSSI-I	2865340
MACX MCR-EX-SL-RPSSI-I-SP	2924016

The safety-related repeater power supplies and signal conditioners listed above are certified as conforming to DIN EN 61508-1:2011 and DIN EN 61508-2:2011. Test certificate: BVS Pb 03/08; 2nd amendment dated 2014-01-22.

8.1 Safety demand

The repeater power supplies and signal conditioners have only been configured with simple analog components, as such supply voltage monitoring has been incorporated as part of the internal monitoring measures. Due to the 4 ... 20 mA signal range, the subsequent external controller which is configured accordingly can likewise detect whether the output signal is in the valid range or is outside this range. Safety is ensured by the fact that the output signal switches to the safe state in the event of an error.

Safety function

The safety function of the device involves the electrically isolated forwarding of a 4 ... 20 mA standard signal (live zero) with a maximum deviation of 2% in relation to the final value. In the event of an error, the system enters the safe state (fail-safe state).

Safe state and error definition

Output values $< 3.6 \text{ mA}$ or $> 21 \text{ mA}$ are considered the safe state (failsafe state) of the system.

Safe failures (λ_{SU}) are therefore errors where the repeater power supply and signal conditioner provide an output signal that deviates from the input signal by no more than 2%.

Dangerous undetected failures (λ_{DU}) are errors where the repeater power supply and signal conditioner do not follow a change in the input signal or provide an output signal that deviates from the input signal by more than 2% and is not outside the valid range.

Dangerous detected failures (λ_{DD}) are errors that are detected by the monitoring circuit. The output signal of the repeater power supply and signal conditioner is then set to a value $< 3.6 \text{ mA}$ and $> 21 \text{ mA}$.

Errors that result in a **High** ($\lambda_H > 21 \text{ mA}$) or **Low** ($\lambda_L < 3.6 \text{ mA}$) output signal are also **dangerous detected failures**, as they can be detected and evaluated by the subsequent controller that is configured accordingly.

8.2 Safety integrity requirements

Error rates

This information applies for all operating modes.

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

Operating mode: repeater power supply, output active

The failure rates in FIT for the entire device are as follows:

λ_{SU}	λ_{SD}	λ_{DU}	λ_{DD}	SFF	DC_D
247	0	56.7	333.3	91.09 %	85.46 %

The total failure rate is: 711 FIT

The MTBF is 161 years.

The average probability of the specified function failing on demand for "low demand" mode and the probability of a dangerous failure per hour for "continuous demand" mode are calculated based on the failure rates.

PFD_{avg} values

T [PROOF]	1 year	2 years	3 years	4 years	5 years
PFD _{avg}	2.52 * 10 ⁻⁴	5.00 * 10 ⁻⁴	7.49 * 10 ⁻⁴	9.97 * 10 ⁻⁴	12.5 * 10 ⁻⁴

$$PFH = 5.67 * 10^{-8}/h$$

The requirements for the PFH value for a SIL 2 system are therefore met.

The values for 1, 2, 3, and 4 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 $1.00 * 10^{-3}$.

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 $1.00 * 10^{-3}$.

Failure limit

Based on an operating mode with a low demand rate. In SIL 2 applications, if the percentage of the device for the entire safety chain is assumed to be a maximum of 10%, the maintenance interval can be increased to up to 4 years.

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

Operating mode: repeater power supply, output passive

The failure rates in FIT for the entire device are as follows:

λ_{SU}	λ_{SD}	λ_{DU}	λ_{DD}	SFF	DC_D
199	0	54.7	297	90.07 %	84.45 %

The total failure rate is: 711 FIT

The MTBF is 161 years.

The average probability of the specified function failing on demand for "low demand" mode and the probability of a dangerous failure per hour for "continuous demand" mode are calculated based on the failure rates.

PFD_{avg} values

T [PROOF]	1 year	2 years	3 years	4 years	5 years
PFD _{avg}	2.42 * 10 ⁻⁴	4.82 * 10 ⁻⁴	7.22 * 10 ⁻⁴	9.61 * 10 ⁻⁴	12.0 * 10 ⁻⁴

$$PFH = 5.47 * 10^{-8}/h$$

The requirements for the PFH value for a SIL 2 system are therefore met.

The values for 1, 2, 3, and 4 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 $1.00 * 10^{-3}$.

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 $1.00 * 10^{-3}$.

Failure limit

Based on an operating mode with a low demand rate. In SIL 2 applications, if the percentage of the device for the entire safety chain is assumed to be a maximum of 10%, the maintenance interval can be increased to up to 4 years.

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

MACX MCR-EX-SL-RPSSI-I(-SP)**Operating mode: signal conditioner, output active**

The failure rates in FIT for the entire device are as follows:

λ_{SU}	λ_{SD}	λ_{DU}	λ_{DD}	SFF	DC _D
231	0	54.1	283	90.48 %	83.98 %

The total failure rate is: 711 FIT

The MTBF is 161 years.

The average probability of the specified function failing on demand for "low demand" mode and the probability of a dangerous failure per hour for "continuous demand" mode are calculated based on the failure rates.

PFD_{avg} values

T [PROOF]	1 year	2 years	3 years	4 years	5 years
PFD _{avg}	2.40 * 10 ⁻⁴	4.76 * 10 ⁻⁴	7.13 * 10 ⁻⁴	9,50 * 10 ⁻⁴	11.9 * 10 ⁻⁴

$$PFH = 5.41 * 10^{-8}/h$$

The requirements for the PFH value for a SIL 2 system are therefore met.

The values for 1, 2, 3, and 4 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 $1.00 * 10^{-3}$.

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 $1.00 * 10^{-3}$.

Failure limit

Based on an operating mode with a low demand rate. In SIL 2 applications, if the percentage of the device for the entire safety chain is assumed to be a maximum of 10%, the maintenance interval can be increased to up to 4 years.

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

Operating mode: signal conditioner, output passive

The failure rates in FIT for the entire device are as follows:

λ_{SU}	λ_{SD}	λ_{DU}	λ_{DD}	SFF	DC _D
183	0	52	246.7	89.20 %	82.61 %

The total failure rate is: 711 FIT

The MTBF is 161 years.

The average probability of the specified function failing on demand for "low demand" mode and the probability of a dangerous failure per hour for "continuous demand" mode are calculated based on the failure rates.

PFD_{avg} values

T [PROOF]	1 year	2 years	3 years	4 years	5 years
PFD _{avg}	2.30 * 10 ⁻⁴	4.58 * 10 ⁻⁴	6.86 * 10 ⁻⁴	9,14 * 10 ⁻⁴	11.40 * 10 ⁻⁴

$$PFH = 5,20 * 10^{-8}/h$$

The requirements for the PFH value for a SIL 2 system are therefore met.

The values for 1, 2, 3, and 4 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 $1.00 * 10^{-3}$.

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 $1.00 * 10^{-3}$.

Failure limit

Based on an operating mode with a low demand rate. In SIL 2 applications, if the percentage of the device for the entire safety chain is assumed to be a maximum of 10%, the maintenance interval can be increased to up to 4 years.

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

8.3 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.
- The repair time (replacement) should be eight hours.
- The failure rates of the external power supply are not taken into consideration.
- The average temperature at which the device is to be used is +40°C.
- 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.

8.4 Installation and startup



NOTE: Installation, operation, and maintenance may only be carried out by qualified specialist personnel.

During installation, observe the instructions in the package slip:

Designation	MNR No.
PACKB.MACX MCR-EX-SL-RPSSI-I(-SP)	9040227

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

Lockable housing with IP54 protection is recommended for the installation of the devices.

- Connect the device according to the installation notes.
- Make sure that the connected sensor and measuring transducer correspond to the intended configuration.
- Check that the device operates correctly with the measuring transducer and sensor connected.
- A calibrated sensor simulator and a calibrated digital multimeter may be required in order to check the device with the measuring transducer connected.
- Start up the safety circuit and check that it operates correctly.

8.5 Notes on operation

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

During normal error-free operation, the output signal of the repeater power supply and signal conditioner is in the range from 3.6 ... 21 mA. If a fault or error occurs during operation, the connected safety-related controller establishes that a measured value is outside of normal operation and initiates appropriate measures. As it cannot be established whether the error was caused by the repeater power supply and signal conditioner or by the devices connected upstream of the repeater power supply and signal conditioner, you must check the entire safety loop from the sensor to the output of the receiver power supply and signal conditioner.

After being switched off and on again, the required voltages are established in the device. Signal transmission is then performed without further action.

8.6 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

A calibrated simulator (0/4 ... 20 mA current) or a sensor simulator and one or ideally two calibrated digital multimeters are required in order to check the devices.

1. Take appropriate steps to prevent incorrect use.
2. Disconnect the safety circuit from further processing.
3. Connect the current simulator to the input of the repeater power supply/signal conditioner, or the sensor simulator to the input of the measuring transducer.
4. Connect the digital multimeters to the input and output of the repeater power supply/signal conditioner.
5. At the input of the device, set a signal in the range from 4 ... 20 mA or at the input of the connected measuring transducer, set a suitable signal with the sensor simulator.
6. Measure the current in the repeater power supply/signal conditioner. The output must be set to the same value.

7. Setting ≤ 3.6 mA or > 21 mA verifies that the subsequent processing can detect signals that are out of range and evaluate them accordingly. If the output value deviates from the input value by more than 3 times the specified class accuracy rating, the device should be checked. In the event of an error, the device should be replaced with an equivalent device.
8. Restore the safety circuit to full functionality.
9. Resume normal operation.

8.7 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

8.8 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

8.9 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
β	Common cause factor	Proportion of undetected failures as a result of a common cause
β_D	Common cause factor, diagnostic	Proportion of failures as a result of a common cause which are detected by the diagnostic test.
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	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.



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