

MACX MCR-EX-SL-SD-24-48-LP(-SP)



Solenoid driver, Ex i, loop-powered, current limitation at 48 mA

Data sheet
103468_en_02

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1 Description

The device is designed for intrinsically and galvanically isolated control of intrinsically safe solenoid valves, alarm transmitters, and alarm indicators installed in the Ex area.

The intrinsically safe output circuit has a linear characteristic curve with an off-load voltage of 24 V DC and a current limit at 48 mA.

The devices are input loop-powered and therefore do not require additional auxiliary power.

The power needed is transmitted via the control signal on the input side.

The input and the output are electrically isolated from each other.

Sockets are integrated into the COMBICON connectors for connecting measuring devices.

The devices are certified for safety-related applications up to SIL 3 according to IEC 61508.

Installation in Zone 2 in accordance with Ex n protection is permitted.

Features

- 1-channel
- 19.2 V DC ... 30 V DC input, loop-powered
- Intrinsically safe output [Ex ia] IIC, IIIC
- 48 mA output current limitation
- Input loop-powered, no additional auxiliary power required
- Up to SIL 3 according to IEC/EN 61508
- Installation in Ex zone 2 permitted
- Safe electrical isolation between input and output
- Mechanically compatible with the DIN rail connector
- Plug-in connection terminal blocks, either screw or spring-cage connection technology (Push-in technology)
- Housing width of 12.5 mm



WARNING: Explosion hazard

The device is an item of associated equipment (category 1) with "intrinsic safety" protection and can be installed in Zone 2 potentially explosive areas as a category 3 device. It meets the requirements of EN 60079-0:2012+A11:2013, EN 60079-11:2012, and EN 60079-15:2010 and IEC 60079-0 ed. 6.0, IEC 60079-11 ed. 6.0, and IEC 60079-15 ed. 4.0.

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.



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 2017 for items with serial numbers greater than 1355645950.

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3 Ordering data

Description	Type	Order No.	Pcs./Pkt.
Ex i solenoid driver. For the intrinsically safe control of Ex i solenoid valves, alarm modules or LEDs installed in the Ex area. Current limitation at 48 mA. For gases up to Group IIC, loop-powered, electrical isolation, SIL 3. Screw connection.	MACX MCR-EX-SL-SD-24-48-LP	2865609	1
Ex i solenoid driver. For the intrinsically safe control of Ex i solenoid valves, alarm modules or LEDs installed in the Ex area. Current limitation at 48 mA. For gases up to Group IIC, loop-powered, electrical isolation, SIL 3. Push-in connection.	MACX MCR-EX-SL-SD-24-48-LP-SP	2924126	1
Accessories	Type	Order No.	Pcs./Pkt.
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
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
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), with HART multiplexer connection	TC-D37SUB-AIO16-EX-PS-UNI	2902932	1
Plastic label, Sheet, white, unlabeled, can be labeled with: BLUEMARK CLED, BLUEMARK LED, CMS-P1-PLOTTER, PLOTMARK, Mounting type: Adhesive, Lettering field: 11 x 9 mm	UC-EMLP (11X9)	0819291	10
Plastic label, can be ordered: by sheet, white, labeled according to customer specifications, Mounting type: Adhesive, Lettering field: 11 x 9 mm	UC-EMLP (11X9) CUS	0824547	1
Plastic label, Sheet, yellow, unlabeled, can be labeled with: BLUEMARK CLED, BLUEMARK LED, CMS-P1-PLOTTER, PLOTMARK, Mounting type: Adhesive, Lettering field: 11 x 9 mm	UC-EMLP (11X9) YE	0822602	10
Plastic label, can be ordered: by sheet, yellow, labeled according to customer specifications, Mounting type: Adhesive, Lettering field: 11 x 9 mm	UC-EMLP (11X9) YE CUS	0824548	1
Plastic label, Sheet, silver, unlabeled, can be labeled with: BLUEMARK CLED, BLUEMARK LED, CMS-P1-PLOTTER, PLOTMARK, Mounting type: Adhesive, Lettering field: 11 x 9 mm	UC-EMLP (11X9) SR	0828094	10
Plastic label, can be ordered: by sheet, silver, labeled according to customer specifications, Mounting type: Adhesive, Lettering field: 11 x 9 mm	UC-EMLP (11X9) SR CUS	0828098	1

MACX MCR-EX-SL-SD-24-48-LP(-SP)

Accessories	Type	Order No.	Pcs./Pkt.
Plastic label, Card, white, unlabeled, can be labeled with: THERMOMARK PRIME, THERMOMARK CARD, Mounting type: Adhesive, Lettering field: 11 x 9 mm	US-EMLP (11X9)	0828789	10
Plastic label, Card, yellow, unlabeled, can be labeled with: THERMOMARK PRIME, THERMOMARK CARD, Mounting type: Adhesive, Lettering field: 11 x 9 mm	US-EMLP (11X9) YE	0828871	10
Plastic label, Card, silver, unlabeled, can be labeled with: THERMOMARK PRIME, THERMOMARK CARD, Mounting type: Adhesive, Lettering field: 11 x 9 mm	US-EMLP (11X9) SR	0828872	10
Device marker, Sheet, white, unlabeled, can be labeled with: TOPMARK LASER, Mounting type: Adhesive, Lettering field: 11 x 9 mm	LS-EMLP (11X9) WH	0831678	10
Device marker, Sheet, yellow, unlabeled, can be labeled with: TOPMARK LASER, Mounting type: Adhesive, Lettering field: 11 x 9 mm	LS-EMLP (11X9) YE	0831732	10
Device marker, Sheet, silver, unlabeled, can be labeled with: TOPMARK LASER, Mounting type: Adhesive, Lettering field: 11 x 9 mm	LS-EMLP (11X9) SR	0831705	10
Test plugs, with solder connection up to 1 mm ² conductor cross section, color: silver	MPS-MT	0201744	10
Insulating sleeve, color: black	MPS-IH BK	0201731	10
Insulating sleeve, color: gray	MPS-IH GY	0201728	10
Insulating sleeve, color: green	MPS-IH GN	0201702	10
Insulating sleeve, color: yellow	MPS-IH YE	0201692	10
Insulating sleeve, color: blue	MPS-IH BU	0201689	10
Insulating sleeve, color: red	MPS-IH RD	0201676	10
Insulating sleeve, color: white	MPS-IH WH	0201663	10

4 Technical data

Input data	
Voltage input signal	19.2 V DC ... 30 V DC (24 V DC -20%...+25%)
Max. current input signal	85 mA (at $U_e = 24$ V DC)
Output	
Output voltage	10.5 V DC (At 48 mA)
Non-load voltage	24 V DC
Short-circuit-proof	yes
Current limitation	48 mA
Output resistor	275.7 Ω (Internal resistance R_i)
Typical response time	20 ms
General data	
Power dissipation	< 1.41 W
Maximum temperature coefficient	0.01 %/K
Degree of protection	IP20
Flammability rating according to UL 94	V0
Overvoltage category	II
Degree of pollution	2
Status display	Yellow LED (switching state / status, lights up when output circuit is active)
Dimensions W/H/D	12.5 mm / 99 mm / 114.5 mm (MACX MCR-EX-SL-SD-24-48-LP) 12.5 mm / 99 mm / 114.5 mm (MACX MCR-EX-SL-SD-24-48-LP-SP)
Type of housing	PA 66-FR green
Ambient conditions	
Ambient temperature (operation)	-40 °C ... 60 °C (any mounting position, pay attention to the derating curve in the data sheet)
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	
Output/input	
Peak value in accordance with EN 60079-11	375 V
Rated insulation voltage (overvoltage category II; degree of pollution 2, safe isolation as per EN 61010-1)	300 V_{rms}
50 Hz, 1 min., test voltage	2.5 kV

MACX MCR-EX-SL-SD-24-48-LP(-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, flexible	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	

Safety data as per ATEX

Max. output voltage U _o	27.7 V
Max. output current I _o	101 mA
Max. output power P _o	697 mW
Group (Max. external inductivity L _o / Max. external capacitance C _o)	IIC : 4 mH / 0.085 μF IIB : 17 mH / 0.663 μF IIA : 35 mH / 2.2 μF
Max. internal inductance L _i	negligible
Max. internal capacitance C _i	negligible
Safety-related maximum voltage U _m	253 V AC (125 V DC)



Further L_o/C_o value pairs can be found in the ATEX and IECEx certificates.

Conformance with EMC directive

Noise immunity according to EN 61000-6-2

Noise emission according to EN 61000-6-4

Conformance/Approvals

Conformance	CE-compliant, additionally EN 61326
ATEX (IBE _{XU} 07 ATEX 1133X)	⊕ II (1) G [Ex ia Ga] IIC/IIB/IIA ⊕ II (1) D [Ex ia Da] IIIC ⊕ II 3 (1)G Ex nA [ia IIC Ga] IIC T4 Gc X
IECEx (IECEx IBE 08.0002X)	[Ex ia Ga] IIC/IIB/IIA [Ex ia Da] IIIC Ex nA [ia IIC Ga] IIC T4 Gc
UL, USA/Canada (Ⓢ, 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,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
SIL in accordance with IEC 61508	to 3

5 Safety regulations and installation notes

5.1 Installation notes

- The device is a piece of equipment (category 1) which belongs to the "Intrinsic Safety" ignition protection class and can be installed in Ex zone 2 as a category 3 device. It meets the requirements of EN 60079-0:2012+A11:2013, EN 60079-11:2012, EN 60079-15:2010, 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 data, refer to this document and the certificates (EU 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.
- 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 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 Zone 2

- Observe the specified conditions for use in potentially explosive areas! Install the device in a suitable, approved housing that meets the requirements of IEC/EN 60079-15 and has at least IP54 protection. Also observe the requirements of IEC/EN 60079-14.
- In potentially explosive areas, only connect and 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.
- 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:

- 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 a 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 present at the input and output are extra-low voltages (ELV). Depending on the application, hazardous voltage (>30 V) to ground may occur. For this event, a safe electrical isolation from the other connection has been implemented.



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 IEC 61340-5-1.

6.3 Structure

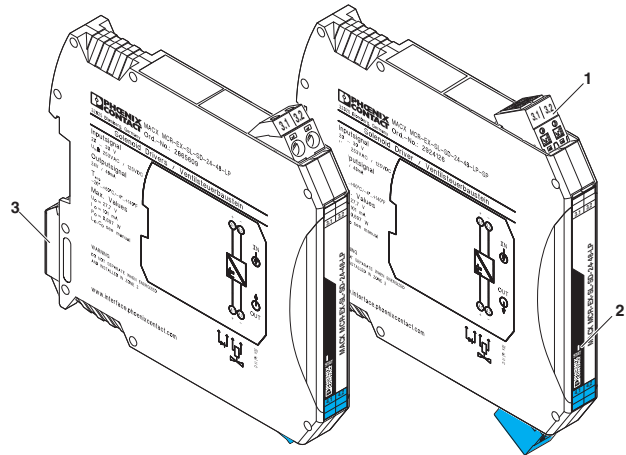


Figure 1 Structure

- 1 COMBICON plug-in, screw, or push-in connection terminal with integrated test socket
- 2 Yellow "STAT" LED: switching state, lights up when output circuit is active
- 3 Snap-on foot for DIN rail mounting

6.4 Basic circuit diagram with connection terminal blocks

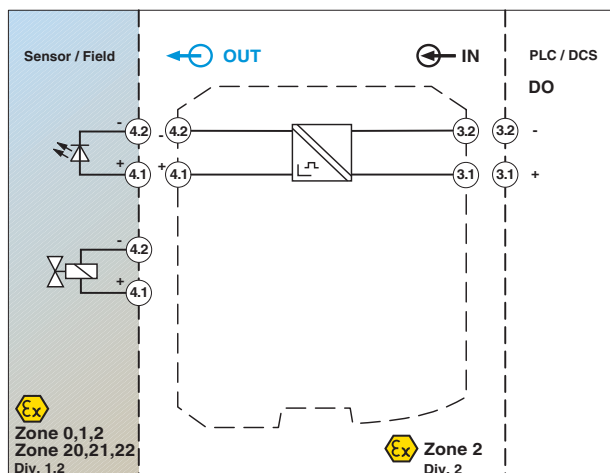


Figure 2 Basic circuit diagram

6.5 Signal input

Terminal blocks 3.1 (+) and 3.2 (-), loop-powered

6.6 Signal output (Ex-i)

Terminals 4.1 (+) and 4.2 (-)

6.7 Dimensions

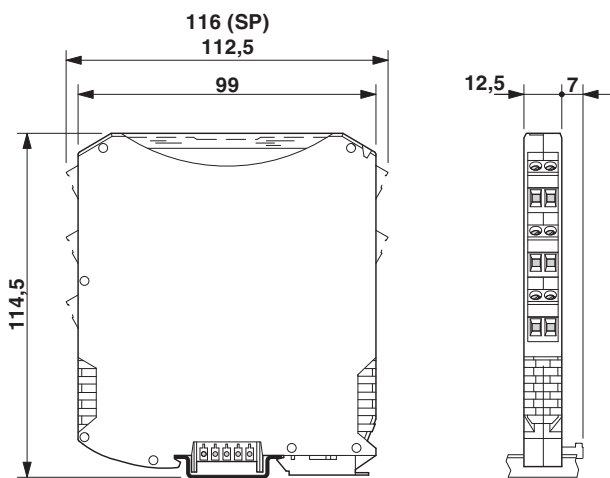


Figure 3 Dimensions

6.8 Assembly

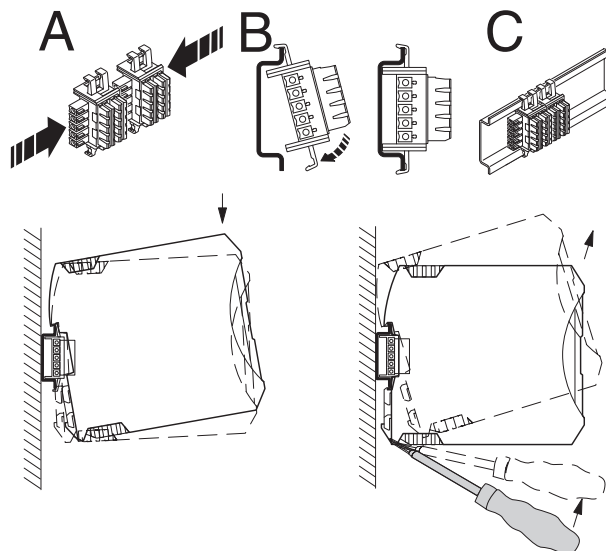


Figure 4 Mounting and removing

- Mount the device on a 35 mm DIN rail according to EN 60715.
- The device is loop-powered and therefore does not require a separate power supply. The DIN rail connectors are used to supply active devices. A DIN rail connector is not required to operate this solenoid driver. However, the devices can be snapped onto a DIN rail connector. An electrically conductive connection is not established. This means that it is not necessary to disconnect an existing DIN rail connector element connection.
- 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.

6.9 Connecting the cables

Screw Connection

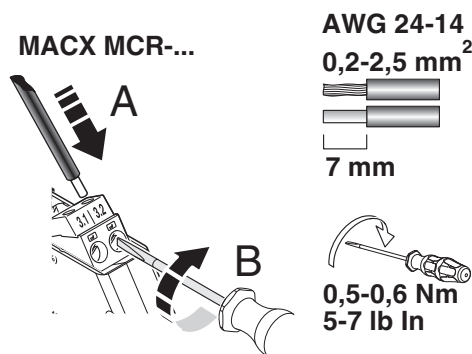


Figure 5 Screw connection

- Strip the wire by approximately 7 mm and crimp ferrules to the end of the wires.
- 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:

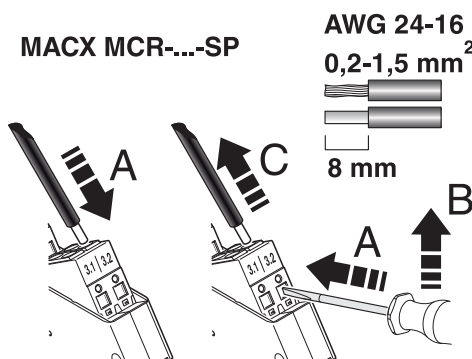


Figure 6 Push-in connection

- 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.

6.10 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 Output characteristic curve

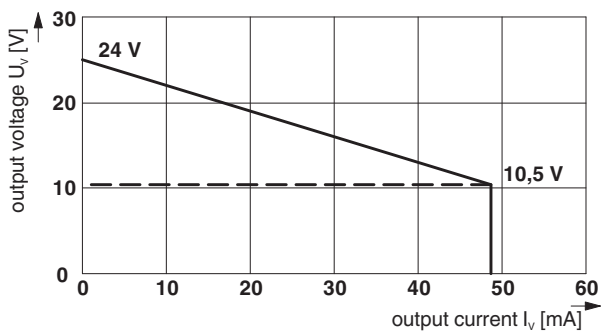


Figure 7 Output characteristic curve

Off-load voltage U_v [V]	24
Output current I_v [mA]	48

8 Derating

The curve shows the maximum output current depending on the mounting position and ambient temperature range.

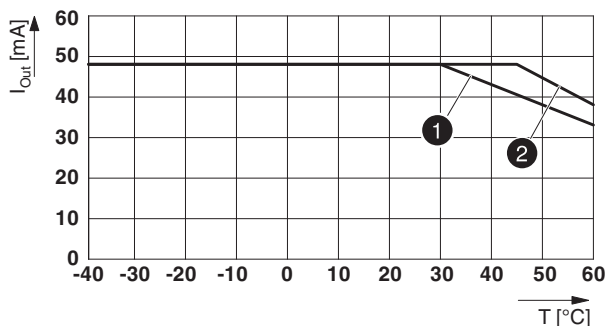


Figure 8 Derating diagram

- 1 = DIN rail perpendicular
- 2 = Horizontal DIN rail

9 Calculating a valve circuit

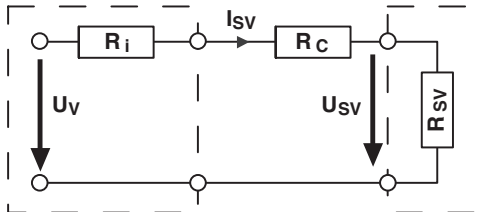
In order to connect a solenoid valve to the module, it is necessary to compare the safety data, and calculate the measurements.

- R_i Internal resistance of the solenoid driver (see technical data)
- U_v Guaranteed voltage of the solenoid driver without load (see technical data)
- I_v Current that can be supplied by the solenoid driver
- R_c Maximum permissible cable resistance when solenoid driver and valve are interconnected
- R_{sv} Effective coil resistance of the solenoid valve (the copper resistance of the coil depends on the temperature)
- I_{sv} The current required by the solenoid coil in order for the valve to pick up
- U_{sv} The voltage which is present at the coil with I_{sv} .

R_{sv} and U_{sv} are dependent on the ambient temperature due to the copper resistance.

The values for R_{sv} and I_{sv} must be obtained from the valve manufacturer.

Calculate the cable resistance R_c using the following formula.



$$R_c \cong \frac{U_v}{I_{sv}} - R_i - R_{sv}$$

Figure 9 Equivalent circuit

We recommend calculating the following value for the cable resistance R_c : actual cable resistance + 25 Ω .

In the event of a negative resistance, it is no longer possible to guarantee that the connection will function.

Function requirements: $I_v \geq I_{sv}$ and $R_c > 0 \Omega$



A list of suitable valves can be found at phoenixcontact.net/products.

10 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 solenoid driver	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
$U_i \geq U_o$	-
$I_i \geq I_o$	-
$P_i \geq P_o$	-
$L_i + L_c \leq L_o$	$L_i < 1\%$ 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.

Alternatively for the condition " $L_i \geq 1\%$ of L_o and $C_i \geq 1\%$ of C_o ", further L_o/C_o value pairs are available (see EU-type examination certificate and/or IECEx Certificate of Conformity).

11 Safety-related applications

The following notes apply for the devices:

Designation	Order No.
MACX MCR-EX-SL-SD-24-48-LP	2865609
MACX MCR-EX-SL-SD-24-48-LP-SP	2924126

A hardware assessment (FMEDA report) is available for the devices listed above: Exida 06/06-05 R004 V2R0 (January 18, 2008) and Exida 16/04-017 R025 V1R1 (March 10, 2017)

The values of the current FMEDA report Exida 16/04-017 R025 V1R1 (March 10, 2017) are documented below in accordance with IEC 61508-1:2010.

11.1 Safety function

The solenoid driver is a single-channel device. The **safety function** relates to the forwarding of a control signal to the downstream valve. The safe state of the device is an input that has not been activated and therefore an output that is de-energized.

The safe state is entered in the event of an input voltage failure or by removing the device connection terminal blocks.

In accordance with IEC 61508, the device is suitable for the following operating modes:

- Low demand rate
- Continuous demand rate
- High demand rate

11.2 Safety integrity requirements

Error rates

- Type A device (according to IEC/EN 61508-2)
- Safety integrity level (SIL) 3
- HFT 0
- 1oo1 architecture
- MTTR 24 h
- Ambient temperature 40°C

Failure rate in FIT

λ_{SU}	λ_{SD}	λ_{DU}	λ_{DD}	SFF	DC _D
50	0	0	0	100 %	0 %

The MTBF is 237 years.

PFD_{avg} values

T [PROOF]	1 year	5 years	10 years
PFD _{avg}	0.0	0.0	0.0

PFH = 0/h

The device is therefore suitable for SIL 3 applications.

Due to a PFD_{avg} value of 0, it is not necessary to perform regular proof tests. This is, however, still recommended.

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

The maintenance/test interval depends on the characteristic data of all devices involved in the safety chain. The intervals may be shorter or longer depending on this characteristic data.

In SIL 3 applications, it is recommended that the maximum possible test interval is determined together with data from the other devices involved in the safety chain.

11.3 Fall time in the safe state

Following a state change at the input (input has not been not activated), the output enters the safe state in < 60 ms (or < 20 ms from 8 mA current consumption of the valve when switched on).

11.4 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 24 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. 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.

11.5 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-SD-24-48-LP(-SP)	9040242

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

- Connect the device according to the installation notes.
- Make sure that the connected actuator corresponds to the function data.
- Check that the device operates correctly with the actuator connected.
- Start up the safety circuit and check that it operates correctly.

11.6 Notes on operation

The yellow LED (STAT) indicates the switching state and lights up when the output circuit is active.

11.7 Recurring checks

Even where the PFD_{avg} value is 0, it is still recommended that you check the function of the device in conjunction with the entire safety circuit.

1. Take appropriate steps to prevent incorrect use.
2. Prevent other areas of the system from being affected by the proof test (e.g., set the controller to test mode).
3. When a voltage between 19.2 V and 30 V is applied at the input, check whether a voltage > 0 V can be measured at the output terminal blocks. The field device must switch simultaneously.
4. Restore the safety circuit to full functionality.
5. Resume normal operation.

11.8 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
Flachmarktstr. 8
32825 Blomberg
GERMANY

11.9 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

11.10 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
MTTR	Mean time to repair	Mean time to repair following a system failure
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
PL	Performance level	The performance level indicates the capability of safety-related parts of a control system to carry out a safety function in foreseeable conditions (PL: a, b, c, d, e)
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.
T[PROOF]		Proof test interval



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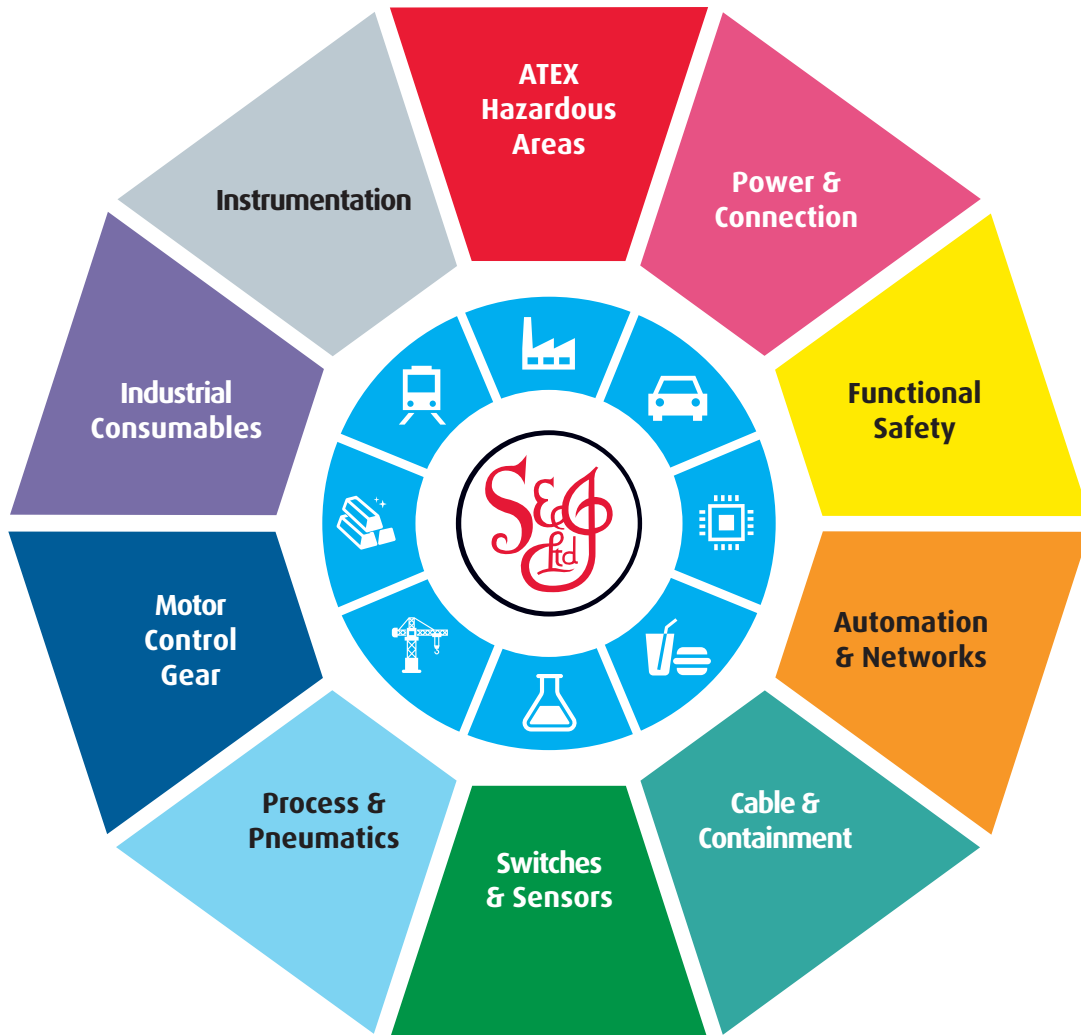
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