PI-EX-SD-24-48

Ex-i solenoid driver for Group IIC gases, loop-powered, pluggable

INTERFACE

Data sheet
103120_en_01

1 Description

The **PI-EX-SD-24-48** solenoid driver connects a signaling device installed in the safe area to a device located in the Ex area. The block itself is installed outside the Ex area or in zone 2.

Solenoid valves, alarm blocks or other intrinsically safe devices can be connected, and basic electrical equipment, such as LEDs, can be operated.

The safety data is designed so that loads can be operated in an IIC group gas.

The PI-EX-SD-24-48 solenoid driver does not require its own power supply; instead, it is simply looped into the circuit.

1.1 Properties

– Single-channel
– Loop-powered
– Output [Ex ia] IIC
– Installation in zone 2
– 2-way electrical isolation
– SIL 3 according to IEC 61508

> **WARNING: Explosion hazard**
> **The device is an associated item of equipment. It is designed for use in zone 2, if the specific conditions are observed.**
> 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.

> **WARNING: Explosion hazard**
> **Observe the safety regulations and installation notes on page 5.**

> Make sure you always use the latest documentation.
> It can be downloaded at www.phoenixcontact.net/download.

> This data sheet is valid for all products listed on the following page:

Table of contents

2 Ordering data

Ex solenoid driver

Description	Type	Order No.	Pcs./Pkt.
Ex-i solenoid driver for Group IIC gases, loop-powered, pluggable	PI-EX-SD-24-48	2865298	1

Accessories

Description	Type	Order No.	Pcs./Pkt.
Motherboard	See "INTERFACE" catalog		
Ex basic terminal block for intrinsically safe signals with knife disconnection and test connections	PI-EX-TB	2835901	10
Intrinsically safe basic terminal block, with knife disconnection, test connections, and surge protection, for mounting on NS 35/7,5	TT-PI-EX-TB	2858386	10
Basic terminal block for **non**-intrinsically safe signals, **with** surge protection	TT-PI-TB	2858373	10
Basic terminal block for **non**-intrinsically safe signals, **without** surge protection	PI-TB	2835943	10
Continuous plug-in bridge, 500 mm long, insulated, can be cut to length, for potential distribution, I_{max} = 32 A, color of the insulating material:			
Red	FBST-500-PLC-RD	2966786	20
Blue	FBST-500-PLC-BU	2966692	20
Gray	FBST-500-PLC-GY	2966838	20

For additional accessories, please refer to the Phoenix Contact "INTERFACE" catalog.

3 Technical data

Input	
Input signal	20 V DC … 30 V DC

Output	
Output characteristic curve (see Figure 1 on page 3)	U_V = 24 V (guaranteed voltage) R_i = 246 Ω (internal resistance)
Output voltage, intrinsically safe	11.8 V at 48 mA
Current limit	At 48 mA

Output characteristic curve

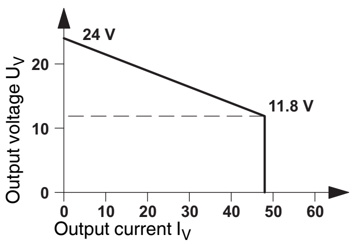


Figure 1 Output characteristic curve for PI-EX-SD-24-48

General data	
Supply voltage range	(No separate supply voltage required)
Maximum current consumption at 24 V DC	130 mA
Maximum power dissipation at 24 V DC	1.7 W
Electrical isolation (input/output)	375 V (peak value according to EN 50020)
Housing material	PBT and polyamide PA, non-reinforced
Inflammability class according to UL 94	V0
Degree of protection	IP20
Color	Green
Dimensions	
Without basic terminal block (width x height) With basic terminal block (width x height x length)	12.4 mm x 108.6 mm 12.4 mm x 147 mm x 145 mm

Ambient conditions	
Ambient temperature (operation)	-20°C ... +55°C (perpendicular mounting of DIN rail) -20°C ... +60°C (horizontal mounting of DIN rail)
Average temperature according to IEC 61508	40°C
Ambient temperature (storage/transport)	-40°C … +80°C
Permissible humidity (operation)	10% ... 95% (relative humidity, no condensation)

Indicators	
Status indicators	Yellow LED (switching state) Red LED (line fault)

EC conformance	
EMC Directive 89/336/EEC	Yes
Ex Directive (ATEX)	Yes

Safety data according to ATEX for intrinsically safe circuits

Maximum output voltage U_o	27.7 V		
Maximum output current I_o	101 mA		
Maximum output power P_o	697 mW		
Gas group	IIA	IIB	IIC
Maximum external inductance L_o	20 mH	2 mH	0.5 mH
Maximum external capacitance C_o	0.44 μF	0.29 μF	0.067 μF
Maximum ratio L_o/R_o			51.1 μH/Ω[1]
True r.m.s. value of maximum AC voltage U_m	250 V AC		
Maximum DC voltage U_m	125 V DC		

[1] Please observe the technical data for the connecting cables used.

Approvals

ATEX	Ex II (1) GD [EEx ia] IIC/IIB/IIA, TÜV 06 ATEX 553193 Ex II 3 G Ex nA II T4 X
UL/CUL	UL applied for

4 Safety regulations and installation notes

4.1 Installation and operation

Follow the installation instructions.

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

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.

NOTE: The circuits inside the device must not be accessed.

Do not repair the device yourself, replace it with an equivalent device. Repairs may only be carried out by the manufacturer.

NOTE: The device must be stopped and immediately removed from the Ex area if it is damaged, was subject to an impermissible load or stored incorrectly, or if it malfunctions.

NOTE: The device is designed to meet IP20 protection when:

– It is installed outside potentially explosive areas.
– The environment around the device is clean and dry.

In order to provide protection against mechanical or electrical damage, install the device in appropriate housing with a suitable degree of protection according to IEC 60529.

4.2 Safety regulations for installation in potentially explosive areas

Regulations for intrinsically safe circuits

WARNING: Explosion hazard
When carrying out **measurements** on the intrinsically safe side, observe the relevant regulations regarding the connection of intrinsically safe equipment.

Only use devices approved for use in intrinsically safe circuits.

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 module must be clearly labeled as non-intrinsically safe.

For the safety data, please refer to the operating instructions and certificates (EC-type examination certificate, other approvals, if necessary).

Installation in zone 2

WARNING: Explosion hazard
The device is an associated item of equipment with "intrinsically safe" explosion protection and is designed for installation in zone 2.

Observe the specified conditions for use in potentially explosive areas.

WARNING: Explosion hazard
Install the device in suitable approved **housing with IP54 protection, minimum**, that meets the requirements of EN 60079-15. Observe the requirements of IEC 60079-14/EN 60079-14.

WARNING: Explosion hazard
Disconnect the block power supply **before**:

– Snapping it on or disconnecting it.
– Connecting or disconnecting cables for non-intrinsically safe circuits.

WARNING: Explosion hazard
Only use category 3G PI EX modules (ATEX 94/9/EC).

Installation in areas with a danger of dust explosions

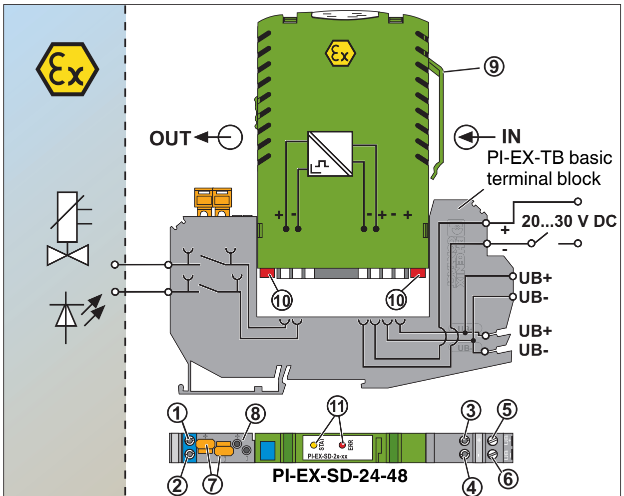
> **WARNING: Explosion hazard**
> The device is **not** designed for use in areas with a danger of dust explosions.

Connection to the intrinsically safe circuit in areas with a danger of dust explosions (zone 20, 21, and 22) is **only** permitted if the equipment connected to this circuit is approved for this zone (e.g., category 1D, 2D or 3D).

4.3 Use in safety-related applications (SIL 3)

When using the PI-EX-SD-24-48 in safety-related applications, observe the instructions in Section 9, as the requirements differ for safety-related functions.

5 Structure



The PI-EX-SD-24-48 can be installed in safe areas or in zone 2.

Figure 2 Structure

1. Output "+"
2. Output "–"
3. Input signal "+"
4. Input signal "–"

   1 - 4 Terminal block screw with integrated test socket

5. 6 Not used
7. Isolating connectors
8. Test sockets
9. Locking clips
10. Keying pin
11. Status indicators

Dimensions

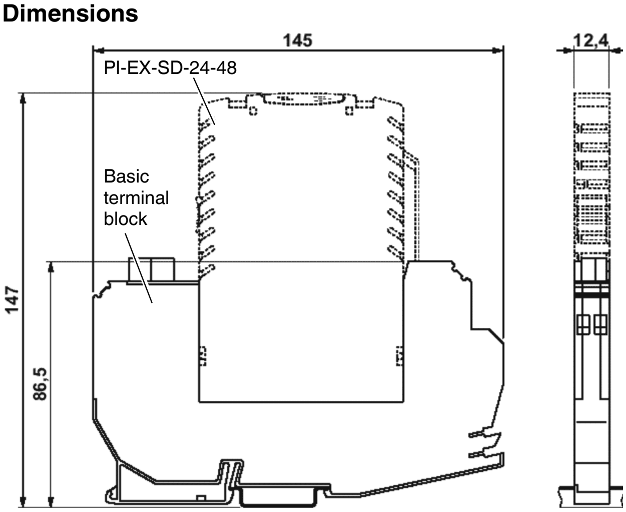


Figure 3 Dimensions (in mm)

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 EN 61340-5-2.

WARNING: Explosion hazard

When used as equipment in **zone 2**, the electronic module must **not be disconnected** from the base element when **connected to the power supply**.

Cables of non-intrinsically safe circuits must only be connected and disconnected **when the power is disconnected**.

6.1 Base elements

The device is designed for installation in the control cabinet and must be plugged into a base element (basic terminal block, electronics base or motherboard). Incorrect connection of the electronic module is prevented by a keyway in the base element and bars in the housing. A locking clip 9 is provided to prevent accidental removal of the device. To remove the electronic module, gently press the locking clip towards the housing; it can then be removed.

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 module must be clearly labeled as non-intrinsically safe.

Connection cross-section (solid/stranded):	0.2 mm^2 ... 2.5 mm^2
Tightening torque:	0.5 Nm ... 0.6 Nm

6.2 Automatic keying of electronic modules

The base element is not keyed by default upon delivery. The user-friendly keying is located in the electronic module and consists of four plastic parts, which are joined together. When the electronic module is first removed, the bottom part of the keying pins (⑩ in Figure 2 on page 7) remains in the base element. In this way, it is automatically keyed to the relevant electronic module.

If an electronic module is accidentally inserted in the wrong place, any plastic parts remaining in the base element can be removed using a screwdriver.

Automatic keying	Electronic module		Base element	
	View from below (locking clip to the right)		View from above (isolating connector to the left)	
	Input	Output	Input	Output
PI-EX-SD-24-48	◁	▷	◁	▷

7 Comparison of safety data

NOTE: Compare the safety data before connecting a device located in the Ex-i area to the PI-EX-SD-24-48.
Also observe the internal capacitance and inductance of the base elements.

Safety data for:

Field devices:	U_i, I_i, P_i, L_i, C_i
Solenoid driver:	U_o, I_o, P_o, L_o, C_o
Base elements:	L_{iB}, $C_{iB,}$

For the values for U_o, I_o, P_o, L_o, and C_o, please refer to "Safety data according to ATEX for intrinsically safe circuits" on page 4.

Capacitance and inductance of base elements

	PI-EX-TB PI-EX-TB/T	**TT-PI-EX-TB TT-PI-EX-TB/T**	**Motherboards Electronics base**
L_{iB}	1 µH	1 µH	0 µH
C_{iB}	1 nF	3 nF	0 nF

Ex-i requirements:

$U_i \geq U_o$
$I_i \geq I_o$
$P_i \geq P_o$

For IIB and IIA:	$L_i + L_c + L_{iB} \leq L_o$ and $C_i + C_c + C_{iB} \leq C_o$	(L_c and C_c or L_o and R_o are dependent on the cables/lines used.)
For IIC:	L_i, C_i = 0 and $L_c/R_c \leq L_o/R_o$	

8 Calculating a valve circuit

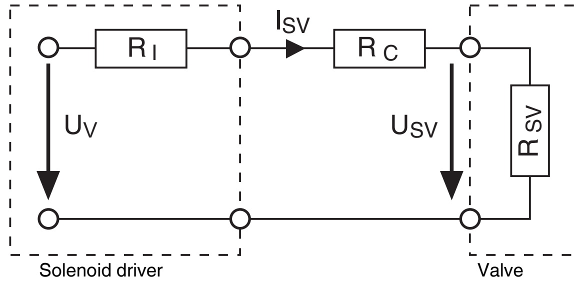


Figure 4 Equivalent circuit

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

- R_i: Internal resistance of the solenoid driver.
- U_V: Guaranteed voltage of the solenoid driver without load.
- I_V: Maximum current that can be supplied by the solenoid driver.
- R_C: Maximum permissible cable resistance when connecting the solenoid driver and valve.
- 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 so that the valve can close tightly.
- U_{SV}: The voltage which is present at the coil with I_{SV}.

R_{SV} and U_{SV} are determined by the copper resistance, which depends on the ambient temperature.

The values for R_{SV} and I_{SV} must be obtained from the valve manufacturer. The values for R_i and U_V can be found in the technical data under "Output" on page 3.

The permissible cable resistance can be determined according to the following formula:

$$R_C = \frac{U_V}{I_{SV}} - R_i - R_{SV}$$

Recommendation:
For R_C, an actual cable resistance of +25 Ω should be calculated.

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

Requirements for operation: $I_V \geq I_{SV}$ and $R_C > 0\ \Omega$.

A list of suitable valves can be found in the Download Center at www.phoenixcontact.net/download.

9 Safety-related applications (SIL 3)

9.1 Installation

Use one of the following base elements:

– PI-EX-TB... basic terminal block
– TT-PI-EX-TB... basic terminal block
– PI-EX-MB... motherboard

9.2 Response times

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

9.3 Operating mode of the safety function

Operating mode according to IEC 61508: "Low demand mode".

9.4 Failure behavior and required response

1. The safe state is entered in the event of an input voltage failure.
2. The safe state is reached by removing the device from the base element.

9.5 Safety integrity requirements

Error rates

– Type A device (according to IEC 61508-2)
– Safety integrity level (SIL) 3

λ_{SAFE}	$\lambda_{DANGEROUS}$	SFF[1]	DC_S[2]	DC_D[2]
284 FIT[3]	0 FIT	100%	0%	0%

[1] SFF = Safe Failure Fraction

[2] DC = Diagnostic Coverage (safe or dangerous)

[3] FIT = Failure in Time (1 FIT = 1 failure/10^9 h)

PFD_{AVG} values

T[PROOF] =	1 year	5 years	10 years
PFD_{AVG}[1] =	0	0	0

[1] PFD = Probability of Failure on Demand

Since the PFD_{AVG} value is 0, it is not necessary to perform regular proof tests. This is, however, still recommended (see Section 9.6).

Failure limit

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

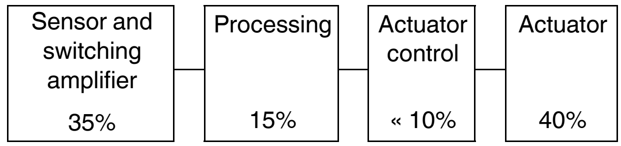


Figure 5 Safety loop

Conditions

– The failure rates of the components used remain constant throughout the period of use.
– 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 signaling device are not taken into consideration.
– The average temperature at which the device is to be used is +40°C. This is based on standard industrial conditions.

9.6 Proof test

Even where the PFD_{AVG} value is 0, it is still recommended that you check the function of the valve burner in conjunction with the entire safety loop.

1. Take appropriate steps to prevent incorrect use. Prevent other areas of the system from being affected by the proof test (e.g., set the control system to test mode).
2. When a voltage of between 20 V and 30 V is applied at the input, check whether a voltage > 0 can be measured at the output terminal blocks. The field device must switch at the same time.
3. Restore the safety circuit to full functionality.
4. Return to normal operation.

10 Appendix

Exida assessment summary (3 pages)

Failure Modes, Effects and Diagnostic Analysis

Project:
Solenoid Driver with Motherboard

Customer:

Phoenix Contact GmbH & Co. KG
Blomberg
Germany

Contract No.: Phoenix Contact 06/06-05
Report No.: Phoenix Contact 06/06-05 R004
Version V2, Revision R0, January 2008

Philipp Neumeier

Management summary

This report summarizes the results of the hardware assessment carried out on the solenoid drivers type PI-EX-SD-**-** with a corresponding motherboard and on the solenoid drivers with top hat rail design, MACX MCR-EX-SL-SD-**-**-LP and MACX MCR-EX-SL-SD-**-**-LP-SP.

Table 1 gives an overview of the different devices. Within each type the different devices have the same circuit diagram.

Table 1: Device overview

Motherboard type:	Top hat rail type:	Output values:
PI-EX-SD-21-25	MACX MCR-EX-SL-SD-21-25-LP / MACX MCR-EX-SL-SD-21-25-LP-SP	21 V / 25 mA
PI-EX-SD-21-40	MACX MCR-EX-SL-SD-21-40-LP / MACX MCR-EX-SL-SD-21-40-LP-SP	21 V / 40 mA
PI-EX-SD-21-45	MACX MCR-EX-SL-SD-21-45-LP / MACX MCR-EX-SL-SD-21-45-LP-SP	21 V / 45 mA
PI-EX-SD-24-48	MACX MCR-EX-SL-SD-24-48-LP / MACX MCR-EX-SL-SD-24-48-LP-SP	24 V / 48 mA
PI-EX-SD-21-60	MACX MCR-EX-SL-SD-21-60-LP / MACX MCR-EX-SL-SD-21-60-LP-SP	21 V / 60 mA

The hardware assessment consists of a Failure Modes, Effects and Diagnostics Analysis (FMEDA). A FMEDA is one of the steps taken to achieve functional safety assessment of a device per IEC 61508. From the FMEDA, failure rates are determined and consequently the Safe Failure Fraction (SFF) is calculated for the device. For full assessment purposes all requirements of IEC 61508 must be considered.

The failure rates used in this analysis are the basic failure rates from the Siemens standard SN 29500.

According to table 2 of IEC 61508-1 the average PFD for systems operating in low demand mode has to be $\geq 10^{-4}$ to < 10^{-3} for SIL 3 safety functions. However, as the modules under consideration are only one part of an entire safety function they should not claim more than 10% of this range, i.e. they should be better than or equal to 1,00E-04.

The solenoid drivers type PI-EX-SD-**-** with a corresponding motherboard and the solenoid drivers with top hat rail design, MACX MCR-EX-SL-SD-**-**-LP and MACX MCR-EX-SL-SD-**-**-LP-SP are considered to be Type A[1] components with a hardware fault tolerance of 0.

For Type A components the SFF has to be 90% to < 99% according to table 2 of IEC 61508-2 for SIL 3 (sub-) systems with a hardware fault tolerance of 0.

The solenoid drivers PI-EX-SD-**-** and MACX MCR-EX-SL-SD-**-**-LP and MACX MCR-EX-SL-SD-**-**-LP-SP are operated in passive mode, and can therefore be regarded as loop powered modules. Because loop powered modules are directly driven from the digital output of a safety PLC there is no additional power supply which can keep the output energized in case of an internal fault. Thus all internal faults have either no effect on the safety function or lead to a safe state.

[1] Type A component: "Non-complex" component (all failure modes are well defined); for details see 7.4.3.1.2 of IEC 61508-2.

Results for solenoid drivers PI-EX-SD-**-** with Motherboard:

The following table shows how the above stated requirements are fulfilled.

Table 2: Summary for PI-EX-SD--** with Motherboard – IEC 61508 failure rates [2]**

λ_{SAFE}	$\lambda_{DANGEROUS}$	SFF	PFD_{AVG}
284 FIT	0 FIT [3]	100%	0,00E+00

Results for top hat rail type solenoid drivers MACX MCR-EX-SL-SD-**-**-LP and MACX MCR-EX-SL-SD-**-**-LP-SP:

The following table shows how the above stated requirements are fulfilled.

Table 3: Summary for MACX MCR-EX-SL-SD--**-LP / MACX MCR-EX-SL-SD-**-**-LP-SP – IEC 61508 failure rates [2]**

λ_{SAFE}	$\lambda_{DANGEROUS}$	SFF	PFD_{AVG}
282FIT	0 FIT [3]	100%	0,00E+00

The above results show that the solenoid drivers PI-EX-SD-**-** with Motherboard and MACX MCR-EX-SL-SD-**-**-LP and MACX MCR-EX-SL-SD-**-**-LP-SP - both when loop powered - can be used for all safety applications.

The calculations are based on the assumption that the devices are mounted in an environment that is IP 54 compliant (e.g. housing, control cabinet or control room).

The failure rates are valid for the useful life of the solenoid drivers PI-EX-SD-**-** and MACX MCR-EX-SL-SD-**-**-LP and MACX MCR-EX-SL-SD-**-**-LP-SP (see Appendix 1).

[2] It is assumed that practical fault insertion tests can demonstrate the correctness of the failure effects assumed during the FMEDAs.

[3] In order to deal with the excluded faults in the quantitative analysis it might be reasonable to consider a dangerous failure rate of 0.1 FIT, leading to a SFF of 99,97% and a PFD_{AVG} of 4,38E-06 for a proof time of 10 years.