HVT 300-SIL-DX

High Voltage Transmitter for Safety Applications

Features

- Supply via Terminals and DIN-Rail
- USB 2.0 Interface
- RS485 Modbus Connection via TBUS
- Measurement inputs with reinforced insulation
- SIL 2 according to IEC/EN 61508
- Device type B according to IEC/EN 61508
- Safety function indication via mA output + Relays 3/4
- Error indication according to NAMUR NE 43
- LED status: Power, Error and Alarm

Description

The HVT 300-SIL-DX is used e.g. for balance voltage monitoring in chlor-alkali electrolysis systems or as a voltage converter in test systems for the automotive sector. The redundant measuring input enables self-monitoring for the reliable detection of an error. The absolute value of the measured DC voltage is output as a 0 / 4-20 mA signal.
For signaling the safety function, 2 relays and the mA output are available, which can be interconnected with each other or with the alarm outputs 1 and 2.

WARNING: high voltage / risk of death
The device is electrical equipment with voltage inputs for up to 1000 VDC. It is designed for use in secure operating environments. The specified safety conditions must be observed for installation and operation and security policies (including national security policies), accident prevention regulations and general technical regulations are observed. Please also note the safety regulations and instructions for Installation on page 4 and 5.

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Manual HVT300-SIL-DX

WINSMART-Support from version 4.0
MODBUS-RTU Communication

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Disclaimer
We have checked the content of the printed document for compliance with the described hardware and software. Nevertheless, deviations cannot be excluded and consequently we cannot assume any guarantee for complete accordance. The data in this printed document are checked regularly. Corrections and additions are made in the following version in each case. We would be grateful for any suggestions for improvement.

Technical modifications reserved

Content

1 Safety instructions and installation

Note: Installation, operation and maintenance may only be carried out by qualified specialist personnel. When installing and operating the device, the applicable safety guidelines (including the national safety guidelines), accident prevention regulations and general technical regulations must be observed.

Note: The circuits in the device must not be accessed.
Do not repair the device yourself, but replace it with an equivalent device. Repairs may only be carried out by the manufacturer.

Note: The device is suitable for protection class IP20 if:

- It is installed outside of potentially explosive areas
- The environment is clean and dry

Install the device in a suitable housing with a suitable degree of protection according to IEC 60529 to protect against mechanical and electrical damage.
The safety-relevant data can be found in the operating instructions or in other certificates (if necessary).

2 Safety Instruction Classifiction

This manual contains instructions that you have to observe for your personal safety as well as to avoid material damage. These instructions are highlighted using a triangular warning sign and shown as follows, depending on the degree of risk.

HAZARD
means that death or severe physical injury will occur if the appropriate precautionary measures are not taken.

WARNING
means that death or severe physical injury may occur if the appropriate precautionary measures are not taken.

CAUTION
with a triangular warning sign means that minor physical injury may occur if the appropriate precautionary measures are not taken.

CAUTION
without a triangular warning sign means that material damage may occur if the appropriate precautionary measures are not taken.

ATTENTION
means that an undesired result or state may ensue if the corresponding instruction is not followed.

NOTE
denotes important information about the product, handling of the product or the respective part of the documentation, is aimed at drawing special attention to the latter and should be complied with.

In addition to the instructions in this manual, the generally applicable safety and accident prevention regulations must be observed. If the information contained in this document should not be sufficient in any specific case, you can obtain more detailed information from our telephone service. Please read this manual carefully prior to installation and commissioning.

3 General Instructions

This device left the plant in flawless condition in terms of its safety features. To preserve this condition and ensure safe operation of the device, the user has to observe the instructions and warning notes indicated in this operating manual.

For the sake of clarity the manual does not contain complete detailed information on all product types and can therefore not take into account every conceivable case with respect to installation, operation and maintenance.
Should you wish further information or should special problems arise that are not treated in sufficient detail in the manual, you can obtain the necessary information by telephone.
Moreover, we point out that the content of the manual shall not constitute part of or amend a previous or existing contract, agreement or legal relationship. All obligations of Mütec Instruments GmbH shall result from the respective contract of purchase, which also contains the complete and solely valid warranty terms. These contractual warranty terms shall neither be extended nor limited by the information contained in the manual.
The content reflects the technical state of the art regarding printing. It is subject to technical modifications in the course of further development.

WARNING
Flawless and safe operation of this device requires proper transport, proper storage, installation and assembly as well as careful operation and maintenance. The device may only be used for the purposes specified in this operating manual.

DISCLAIMER
All modifications to the device fall within the responsibility of the user unless expressly specified otherwise in the operating manual.

VALIDITY
The data sheet is only valid for the HVT300 described and the hardware / firmware version specified in the technical data

QUALIFIED PERSONNEL
Qualified personnel are persons who, due to their training, experience and instruction as well as their knowledge of relevant standards, regulations, accident prevention regulations and operating conditions, have been authorized by the person responsible for the safety of the system to carry out the necessary planning and activities and thereby recognize and recognize possible dangers can avoid.

REQUIREMENTS
The qualified personnel must have knowledge of the following topics:

- Handling and knowledge of and about security products
- Applicable EMC regulations
- Applicable regulations for work safety and accident prevention
- Installation or assembly of the safety product
- Commissioning, monitoring and maintenance of the security product
- Knowledge of devices / systems in accordance with the standards of safety technology for electrical circuits
- Training or instruction in accordance with the standards of safety technology in the care and use of appropriate safety equipment

SAFETY INSTRUCTIONS

The safety regulations of electrical engineering and the trade association must be observed and adhered to. Failure to observe the safety regulations can result in death, severe physical injury or extensive property damage.

DIRECT / INDIRECT TOUCHING

Protection against direct and indirect contact in accordance with VDE 0100 Part 410 must be guaranteed for all components connected to the system. In the event of an error, there must be no dangerous carry-over of voltage (single-fault security).

ASSEMBLY, COMMISSIONING, MODIFICATION

Assembly, commissioning, modification and retrofitting may only be carried out by qualified personnel. Before starting work, the device must be disconnected from the power supply. The wiring must be carried out and checked according to the intended use. Reliable function is only guaranteed if the device is installed in a dust- and moisture-proof switch cabinet or a housing (min. IP54). Separate cable routing for the high voltage on the one hand and all other circuits on the other is recommended

SWAPPING AND REVERSING THE CONNECTIONS

Take measures to prevent mix-ups, polarity reversal or manipulation of the connections

DEVICE IN OPERATION

During operation, the input section of the HVT300 is under dangerously high voltage. Do not remove any protective cover (blind cap between the terminal blocks) or cables on the terminals during operation. Suitable / effective protective circuits must be provided for inductive loads on the relay circuits. The protective circuit with suppressor diodes or varistors must always be in parallel with the load.

BROKEN DEVICE

The device may be damaged after an error. Correct and safe operation is then no longer guaranteed and the device should therefore be replaced. Only the manufacturer or a person authorized by the manufacturer may open the housing and repair the device. Otherwise any guarantee will be lost.

DECOMMISSIONING AND DISPOSAL

The device must be disposed of in accordance with environmental regulations. It must be ensured that a defective device cannot be used again.

ELECTROSTATIC DISCHARGE

Potentially electrostatic components may be destroyed by voltage that is far below the limits of human perception. Such voltage occurs even when you touch a component or electrical connections of a component and are not electrostatically discharged. The damage that occurs to a component because of overvoltage usually cannot be detected immediately and does not become noticeable until after a longer operating period.
The device contains components that can be damaged or destroyed by electrostatic discharge. When handling the device, observe the necessary safety measures against electrostatic discharge (ESD) in accordance with EN 61340-5-1 and EN 61340-5-2.

4 Technical Data

4.1 Certificate

Functional Safety	SIL 2 according to IEC 61508

4.2 Analog Input E1 (Terminals T-17/18 and T-21)
Analog Input E2 (Terminals T-19 and T-22)

For the measuring inputs a filter of 1st order (0.1 – 99.9 s) can be parameterized! Galvanic isolation to all circuit parts and supply.

Inputs E1 and E2

Measurement range:	0 .... +/- 1000 VDC (continuously configurable)
Overloadability:	max. 1200 VDC (permanent)
Input resistance:	6 MΩ, 12 MΩ (optional)

Accuracy

Typical:	< 0,1 % vom Endwert
Maximum:	< 0,05 % vom Endwert

4.3 Analog Ouput (Terminals T-11 + T-12)

For the analog outputs a filter of 1st order (0.1 – 9.9 s) can be parameterized!
Enhanced galvanic isolation to all circuit elements and power supply!

Constant current

Max. range:	0...22 / 22...0 mA
Standard range:	0/4-20 mA
Load:	max. 500 Ω at 22 mA
Accuracy:	0,02 % of final value
Load effect:	< 0,005 %
Rise time:	min. 250 ms, max. 250 ms + 9,9 s + 99,9 s

4.4 Contact outputs Rel1/Rel2 (Terminals T-1 + T-2 and T-5 + T-6)

Configuration:	WINSMART␣-Software
Contact:	normally open
Alarm delay:	freely configurable between 0 ... 9,9 s
Switching hysteresis:	freely configurable between 0 ... 99,9 %
Operating mode:	open or closed current principle
Alarm function:	Signal monitoring and indication of maintenance requirement
Switching power:	max. 62,5 VA / max. 30 W
Switching voltage:	max. 125 V AC or 110 V DC
Switching current:	max. 1 A
Min. contact voltage:	10 mVDC
Min. contact current:	10 µA
Contact material:	AG Pd + 10 µAu
Relay type:	according to IEC 947-5-1 / EN60947

4.5 SIL2 contact outputs REL3/REL4 (Terminals T-7 + T-8 and T-9 + T-10)

Operating mode:	closed current
Alarm function:	safety function activated
Contact position:	closed in good condition
Switching power:	max. 62,5 VA / max. 30 W
Switching voltage:	max. 125 V AC or 110 V DC
Switching current:	max. 1 A
Min. contact voltage:	10 mV DC
Min. contact current:	10 µA
Contact material:	AG Pd + 10 µAu
Relay type:	according to IEC 947-5-1 / EN60947

The safety function is activated by relays Rel3 and Rel4, which operate on the closed current principle and whose setting cannot be parameterized. The relay contacts, which are closed when in good condition, offer the possibility of series connection with the relay contacts of other devices for collective alarm monitoring. A further series connection with REL1, REL2 or the analogue output and the contacts of REL3 and REL4 is also possible.

4.6 Status LEDs

Power:	green LED	Supply
Error/SIL2-Alarm:	red LED	Safety function activated
Alarm (REL1, REL2):	yellow LEDs	Limit alarm

4.7 USB Interface (front socket)

Galvanic isolation to all other circuit elements and power supply!

USB type:	USB 2.0

4.8 RS485 Interface (T-BUS contacts T-B1 + T-B2)

Galvanic isolation to all other circuit elements and power supply!

RS485:	half duplex, without scheduling
Baud rate:	9600 bps
Device address:	1-248

4.9 Supply (Terminals T-3 + T-4 or T-B4 + T-B5)

Supply	24 VDC (min. 20 VDC, max. 30 VDC)
Power consumption	1,4 W (at 24VDC and 4 mA Output) 1,9 W (at 24VDC, 20 mA Output and 4 relays online)
PE grounding	T-BUS contact: T-B3; additional PE connection by ME-MAX PCB contact when mounted on a grounded DIN-Rail.

4.10 General Data

Environmental

Operation:	-10 °C … +60 °C
Storage/Transport:	-20 °C … +70 °C
Perm. Humidity:	10 % … 95 % r. H. without condensation
Max. operating altitude:	≤ 2000m above mean sea level

Temperature coefficient

Maximum:	< 0,01 %/K
Typical:	< 0,005 %/K

Galvanic isolation

3 port isolation:	Input / output / supply
Input / Output:	4,3 kV AC test voltage
Input / Supply:	4,3 kV AC test voltage
Overvoltage category:	CAT II: 1000 V AC/DC pollution level 1 according to IEC 61010-1

Electrical connection

T-1 … T-12 (4-pole):	screwed connector / grey / 5,0 mm^2
T-17 … T-23 (3-pole):	screwed connector / grey / 7,5 mm^2
T-B1 … T-B5 (5-pole):	TBUS connector / 4,0 mm^2
Wire:	0,2 mm^2 / 2,5 mm^2 (min/max)
Braid:	0,2 mm^2 / 2,5 mm^2 (min/max)
Conductor cross-section:	AWG/kcmil = 14/24 (min/max)
Stripping length:	7 mm
Connection:	pluggable screw
Tightening torque:	0,5 … 0,6 Nm

PCB

Material:	FR4
CTI range:	PLC Group 1 (>400 V to 599 V)

Housing

Material:	Polyamide – light grey
Protection class:	IP20
Flammabillity class/UL 94:	V0
Weight:	250 g
Form of construction:	terminal box for mounting rails
Housing mounting type:	35 mm DIN-rail
Assembly/installation:	arbitrary

4.11 Standards

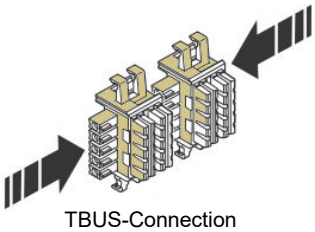
EMC	Product Family Standard EN 61326-1 Emission: Class A Immunity: Industry area
LVD	Low Voltage Directive IEC 61010-1

4.12 Self-Monitoring

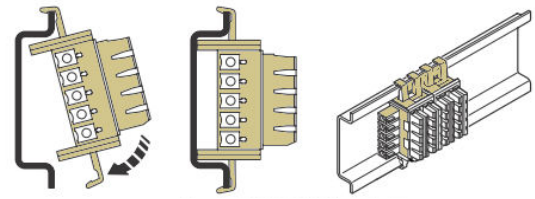
Measuring input:	1 monitoring measurement circuit with adjustable tolerance
Analog output:	1 monitoring measurement circuit with adjustable tolerance
Supply voltage:	2 monitoring measurement circuit
Reference voltage:	redundant and monitored
EPROM memory:	cycling tests to ensure relative integrity
µP-Controller:	self monitoring / DuoTec®-Technology
Relay (REL1 … REL4):	indirect contact monitoring

4.13 Installation

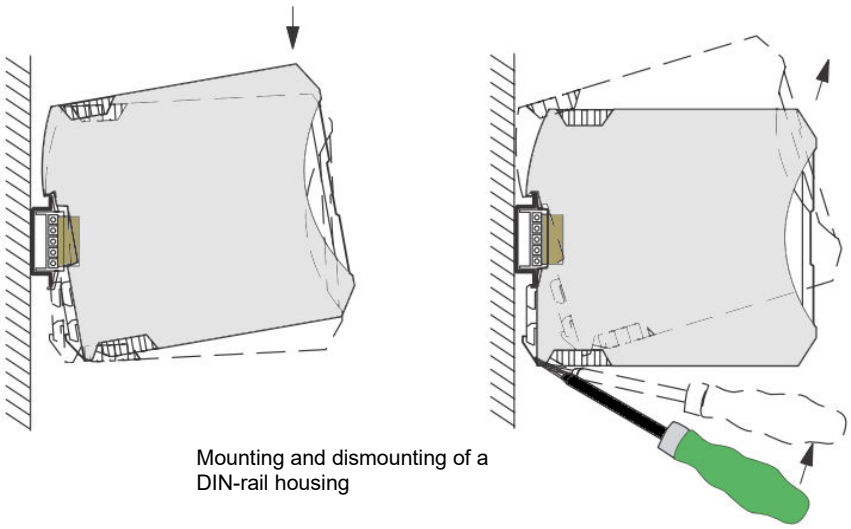
The ME-MAX housing can be combined with a 5-pin TBUS connector / DIN rail connector. The RS485 interface and the supply voltage can be easily wired through the TBUS connector that is snapped into the DIN rail. The TBUS connection is self-establishing in the grid of the devices involved. This makes time-consuming pre-configuration or reworking the TBUS connection on site obsolete.



TBUS-Connection



TBUS-Connector with DIN-rail



Mounting and dismounting of a DIN-rail housing

Technical Data:
5-pole connector in 3.81mm pitch
8A maximum contact load
Gold plating ensures high contact quality.
Designed for mounting to NS 35/7.5 or NS 35/15 DIN rails

Important note:
The device may only be attached to or removed from the TBUS-Connection when power is switched off!

Attach the housing to a 35 mm DIN-rail according to EN 60715. For installation, mount the snap-lock to the DIN-rail and lock it. For dismounting, use a screw-driver to unlock the snap-lock.

Fig. 1

4.13 Electrostatic Discharge

Electrostatically sensitive assemblies can be destroyed by voltages that are far below the human perception limit. These voltages occur when you touch a component or electrical connections of a module without being electrostatically discharged. The damage that occurs to a module due to an overvoltage can usually not be recognized immediately, but only becomes noticeable after a long period of operation. The device contains components that can be damaged or destroyed by electrostatic discharge. When handling the device, observe the necessary safety measures against electrostatic discharge (ESD) in accordance with EN 61340-5-1 and EN 61340-5-2.

4.14 Housing Dimensions

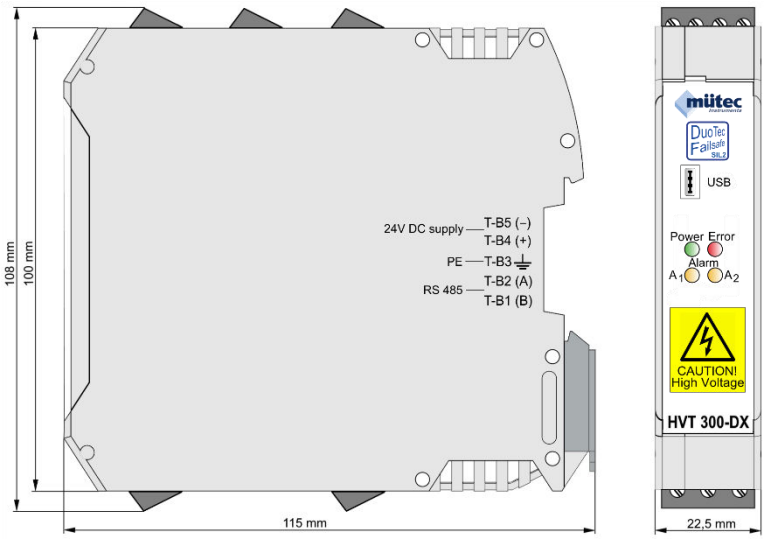


Fig. 2

4.15 Block diagram

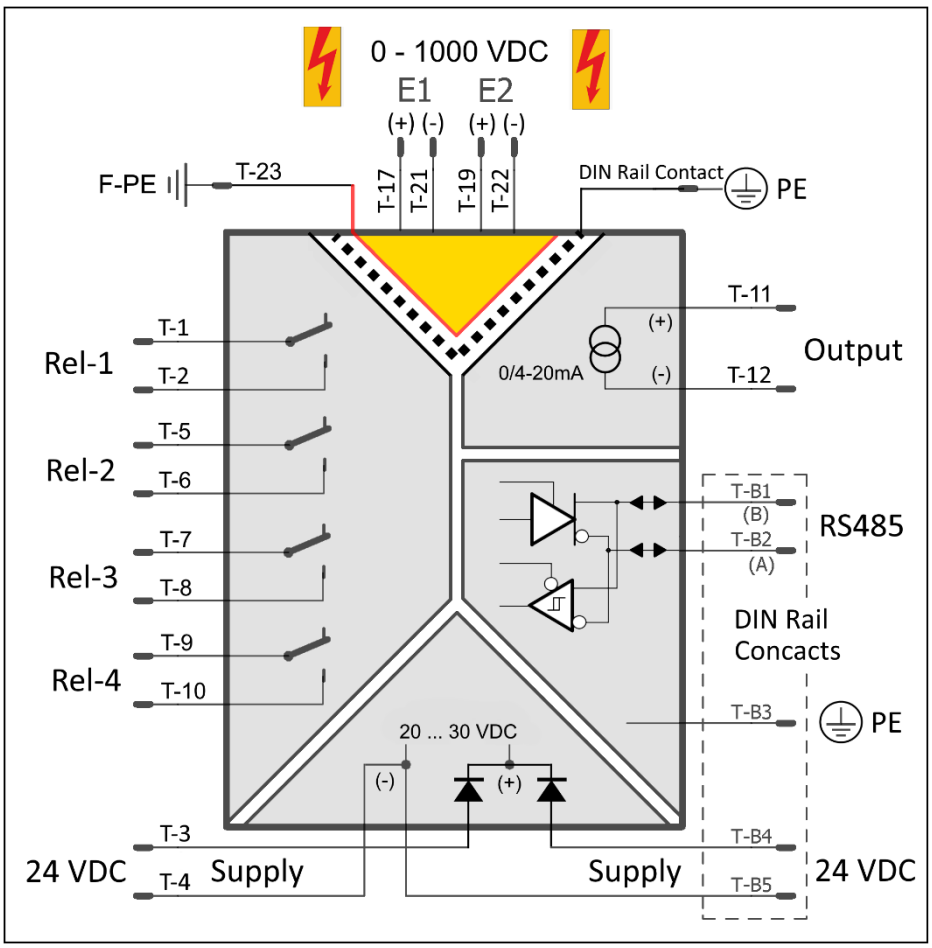


Fig. 3

4.16 Nameplate

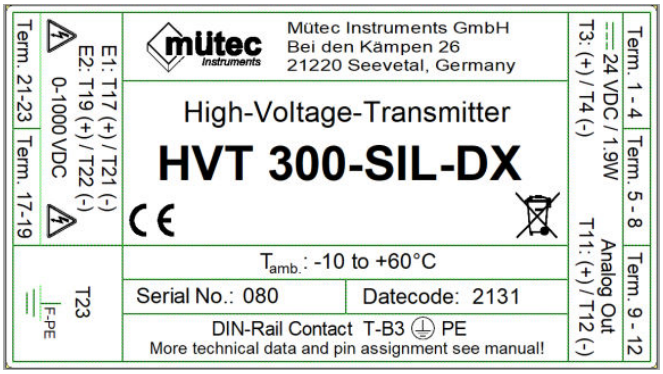


Fig. 4

5 Variants of Input Connections

5.1 Absolute Value Measurement

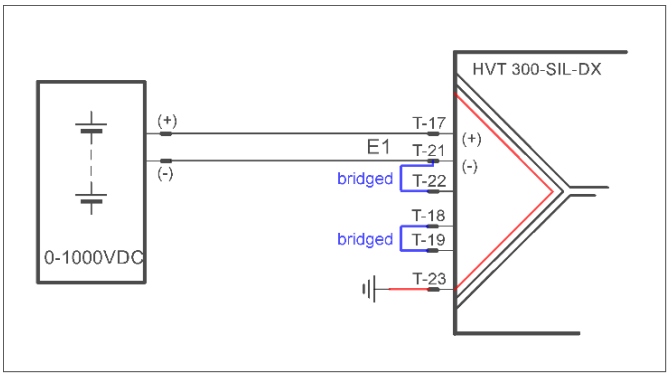


Fig. 5

The absolute value measurement with only one measuring input is a possibility of interconnection with the signal source (e.g. 0-1000 VDC) and the transmitter, if the terminals T-18 and T-19 are bridged

However, it does not meet the requirements of the IEC 61508 standard according to SIL2. A line break in the measuring circuit would be detected by the transmitter with 0 VDC, since the connection to the Measurement input E1 is interrupted. However, the maximum voltage value in the signal source could still be 1000 VDC and mean a massive danger or danger to life!

5.2 Redundant Absolute Value Measurement

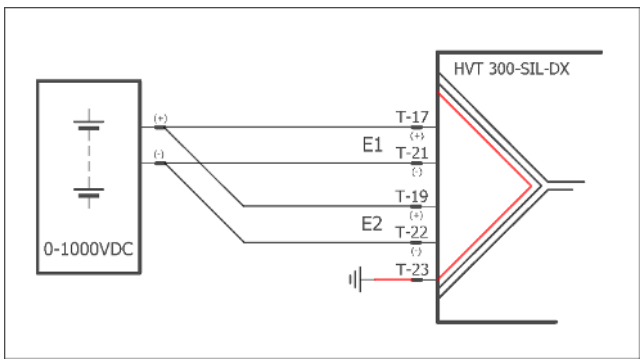


Fig. 6

A line break monitoring is available for all 4 input lines, if the measurement signal has a value > 0 V. The transmitter then detects the line break and triggers the safety function. A series connection of the mA output with the REL3 or REL4 contact (NO) ensures that with the triggering of the safety function, the mA value is always 0 mA.

6 Jumper (Option)

Jumper JP1 und JP2:

Depending on the position of the jumper JP1 for the contact of the relay REL-1, this is made available as a break or make contact at the terminals T-1 and T-2. Depending on the position of the jumper JP2 for the contact of the relay REL-2, this is provided as a break or make contact on the terminals T-6 and T-15.

Der Zugang zu den Jumpern erfolgt über entsprechend gekennzeichnete Ausbrüche auf der rechten Seite des Hutschienengehäuses.

7 Loop resistance mA Output

Analog output (AA) data for constant current: max. 22 mA at a load ≤ 500 Ω
The maximum load for the analog output is the sum of the forward and return lines and the input resistance (shunt) of the following module:

$$R_{Load,\ max} = 2x\ R_{Line} + R_{Shunt} \leq 500\ \Omega$$

The following applies to the line resistance:

$$R_{Line} = l \times \varrho \times A^{-1}\ [\Omega]$$

$\varrho = 0{,}0178 \quad [\Omega\ mm^2\ m^{-1}]$
$A = 0{,}25 \times d^2 \times \pi \quad [mm^2]$

Maximum line length (distance):

$$l = 0{,}5\ (500\ \Omega - R_{Shunt}) \times \varrho^{-1} \times A \quad [m]$$

Wire length depending on the wire cross section and the shunt resistor:

R_{Shunt} [Ω]	$L_{diameter}$ [mm]	$L_{cross\text{-}section}$ [mm^2]	L_{Length} [m]	L_{Length} [km]
100	0,6	0,283	3179	3,18
	0,7	0,385	4325	4,33
	0,8	0,502	5640	5,64
	0,9	0,636	7146	7,15
	1,0	0,785	8820	8,82

R_{Shunt} [Ω]	$L_{diameter}$ [mm]	$L_{cross\text{-}section}$ [mm^2]	L_{Length} [m]	L_{Length} [km]
200	0,6	0,283	2385	2,39
	0,7	0,385	3244	3,24
	0,8	0,502	4230	4,23
	0,9	0,636	5360	5,36
	1,0	0,785	6615	6,62

R_{Shunt} [Ω]	$L_{Durchmesser}$ [mm]	$L_{Querschnitt}$ [mm^2]	$L_{Länge}$ [m]	$L_{Länge}$ [km]
300	0,6	0,283	1590	1,59
	0,7	0,385	2163	2,16
	0,8	0,502	2820	2,82
	0,9	0,636	3573	3,57
	1,0	0,785	4410	4,41

8 Safety Function

The safety function is a function that is carried out by a safety-related E / E / PE system, a safety-related system of other technology or external risk reduction facilities. The goal is to achieve or maintain a safe system state in case of a a dangerous incident.

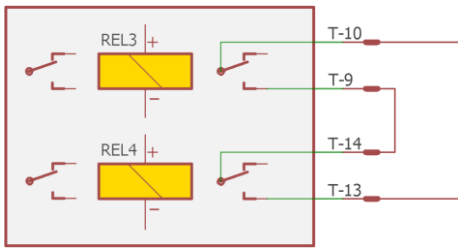


Fig. 7

The signaling of the safety function with REL3 + REL4 is fixed in the device and cannot be changed. The relays are operated according to the closed-circuit principle, so that in the good state (safety function is not activated) the contacts on T-9/10 and T-13/14 are always closed.

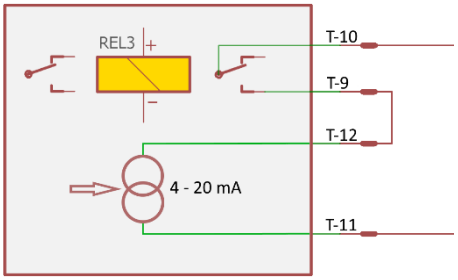


Fig. 8

The safety-related mA output can also be integrated for reporting the safety function, as shown in Figure 9. This enables the highest availability of the safety function. The permissible deviation from the setpoint between 0.2% and 5.0% can be parameterized for the analog output as well as for the input signal. Any exceeding of these limit values is recognized as an error and signaled externally with an analog value of 0 mA.

9 Safety-Relevant Features

Properties	FMEDA
Category	SIL 2
Device type	Type B
HFT	0
SFF	95 %
DC	89 %
Safe failure rate	331 FIT
Safe detected failure rate	0 FIT
Safe undetected failure rate	331 FIT
Dangerous failure rate	362 FIT
Dangerous detected failure rate	325 FIT
Dangerous undetected failure rate	37 FIT

10 Safety-Oriented Applications for SIL 2

Safety integrity requirements (see Technical Report 123.493-10 – rev. 1.0)

Error rates:
Type B-Gerät (according to EN 61508-2), Safety Integrity Level (SIL) 2

λ_{sd}	λ_{su}	λ_{dd}	λ_{du}	SFF
0	331	325	37	95%

λ_{su} includes errors that do not lead to error triggering!
SFF = Safe Failure Fraction
FIT = Failure in Time (1 FIT = 1 Failure / 10^9 h)

PFD_{AVG} values of the MSK 200-SIL-DX:
The beta factor is 2% and was derived from IEC / EN 61508-6, Appendix D.

T [Proof]	1 Year	5 Years	10 Years	20 Years
PFD_{AVG}	1,8E-4	8E-4	1,6E-3	3E-3
% SIL 2	1,8%	8%	16 %	30%

PFD_{AVG} = Average probability of failure on demand
T [Proof] = Detection test interval

The calculated PFDAVG values are within the permissible range for SIL 2 in accordance with Table 2 of IEC / EN 61508-1 and meet the requirement not to cover more than 16 % of the permissible range after 10 years.

PFS_{AVG} for 1 year: 1,4E-3

PFS_{AVG} = Average probability of safe failure

Failure limit:
The operating mode with a low request rate is used as a basis. The proportion of the MSK 200-SIL-DX at the PFD_{AVG} value of the entire safety chain should not exceed 30%.

Signal source	MSK 200-SIL-DX	Signal processing (PLS)
35 %	30 %	35 %

Conditions:

- The failure rates of the components used are constant over the period of use.
- The spread of errors by the device in the system is not considered.
- The repair time (= exchange) should be less than 72 hours.
- The average temperature at which the device is to be used is + 40 ° C.
  Normal industrial conditions are assumed.
  The specified error rates refer to an ambient temperature of + 40 ° C.
  For an ambient temperature of + 60 ° C, the error rates must be a factor of 2.5 be multiplied. This factor is based on experience.

Verification test:

Take the right steps to avoid misuse. By simulating the values <3.6 mA and >22 mA, it can be verified whether the subsequent devices in the signal chain can also process the signal outside the measuring range. In the event of an error, the device must be replaced with an equivalent one. Then restore the full function of the safety circuit. Finally, check normal operation.