



HVT 400-DX

**Failsafe
High Voltage Monitor
For up to 1.500 V**



Application

Electrification in the automotive sector continues to advance and the operating voltages for the powertrains and batteries are increasing. Today, 800 V is already standard, but developments up to 1200 V are in the pipeline. This poses a particular challenge to the safety of personnel during production and testing of these high voltage components.

The **HVT 400-DX** voltage monitor is used for safety monitoring to minimize the risk with the high voltage. A special application are the automotive test benches for the high voltage components. Only the falling below of a configurable voltage threshold releases the secured access.

Features

- SIL 2 according to IEC/EN 61508
- 1500V input range
- Redundant input with line break detection
- Device type B according to IEC/EN 61508
- Safety function via mA-output and two relays
- Limit alarm monitoring via two relay outputs
- Redundant supply via terminals and DIN rail connector
- USB 2.0 interface
- RS485 / Modbus RTU interface
- failure display according to NAMUR NE 43
- LED status: Power, Error, Alarm

Mütec Instruments – Your safe choice

Manual HVT400-SIL-DX

WINSMART-Support from version 4.0
MODBUS-RTU Communication

Doc-Nr.: 647
Revision: 2.1
Issue date: 12/2022

Manufacturer:

Mütec Instruments GmbH
Bei den Kämpfen 26
21220 Seevetal
Deutschland

Tel.: +49 (0) 4185 8083-0
Fax: +49 (0) 4185 808380
E-Mail: info@muetec.de
Internet: www.muetec.de

Licence-, trademark and copyright notes

Modbus™ is a registered trademark of Modicon Inc.
Windows™ is a registered trademark of Microsoft Corp.

Copyright © Mütec Instruments GmbH

All rights reserved

This document is copyright protected. It supports the user in making reliable and efficient use of the unit. Transmission and duplication of this document as well as utilization and disclosure of its content are prohibited unless expressly permitted. Any breach or infringement shall result in liability for damages. The software described in this document is licensed and may only be used and copied in accordance with the terms of the licence.

All rights reserved.

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

Mütec Instruments – Your safe choice

Bei den Kämpfen 26
D-21220 Seevetal-Ramelsloh

Tel.: +49 4185/8083-0
Fax: +49 4185/8083-80

Mail: muetec@muetec.de
Web: www.muetec.de

Content

1	Safety instructions and installation	4
2	Safety Instruction Classification	4
3	General Instructions	6
4	Technical Data	10
4.1	Certificate	10
4.2	Measurement Input	10
4.3	Analog Output	10
4.4	Limit Alarm Relay Outputs	10
4.5	SIL2 Diagnostic Alarm Relay Outputs	11
4.6	LEDs	11
4.7	Interfaces	11
4.8	Supply	11
4.9	General Data	11
4.10	Standards	12
4.11	Self-Monitoring	12
4.12	Installation	13
4.13	Electrostatic Discharge	13
4.14	Housing Dimensions	14
4.15	Block diagram	14
4.16	Nameplate	15
5	Variants of Input Connections	15
5.1	Measurement in 2-wire connection	15
5.2	Measurement in 4-wire connection	16
6	Loop resistance calculation of the of the mA output	17
7	Safety	18
7.1	Safety Function	18
7.2	Safe State	18
7.3	Possible Architectures	18
7.4	Safety-Relevant Features	19
7.5	Safety-Oriented Applications for SIL 2	19

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 Classification

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 must 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 during 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 HVT400 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 INTERCHANGING 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 HVT400 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

SIL2 according to IEC 61508

4.2 Measurement Input

A parameterizable 1st order filter of (0.1 - 99.9) s is available for the measurement inputs. To improve the EMC, a hinged ferrite can be placed on the cable for the measurement input (Mütec Instruments order no.: E30724)

NOTE: The HVT 400 has a different Pin-In than the HVT 300. Please double-check the wiring during commissioning!

Inputs E1 and E2 (T-17 + T-19 and T-21 + T-23)

Input range:	0 ... +/- 1500V AC/DC (configurable)
Measurement span:	Continuously configurable
Input resistance:	12 MΩ each channel

Accuracy

Typical:	< 0,1 % of final value
Maximum:	< 0,05 % of final value

4.3 Analog Output

A parameterizable 1st order filter of (0.1 - 9.9) s is available for the analog output. Galvanic isolation to all circuit parts and to the power supply.

AO (T-11 + T-12)

Constant current

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

4.4 Limit Alarm Relay Outputs

Relays REL1/REL2 (T-1+ T-2 and T-5 + T-6)

Configuration:	WINSMART®-Software
Contact:	Normally open or normally closed
Alarm delay:	Configurable (0 ... 9,9 s)
Hysteresis:	Configurable (0 ... 99,9 %)
Function:	Signal monitoring (optional: failure alarm)
Switching power:	max. 37,5 VA / max. 30 W
Switching voltage:	max. 125 V AC / 30 V DC
Switching current:	max. 0,3 A AC / 1 A DC
Min. contact voltage:	10 mVDC
Min. contact current:	10 μA
Material:	AG Pd + 10 μAu
Relay type:	According to IEC 947-5-1/ EN60947

4.5 SIL2 Diagnostic Alarm Relay Outputs

Relays REL3/REL4 (T-7+ T-8 and T-9 + T-10)

Type:	Normally open
Function:	Safety function activated
Contact:	Closed in good condition
Switching power:	max. 37,5 VA / max. 30 W
Switching voltage:	max. 125 V AC / 30 V DC
Switching current:	max. 0,3 A AC / 1 A DC
Min. contact voltage:	10 mVDC
Min. contact current:	10 µA
Material:	AG Pd + 10 µAu
Relay type:	According to IEC 947-5-1/ EN60947

The safety function is activated by the relays REL3 and REL4, which are operated in the closed-circuit current principle and whose function cannot be parameterised. The relay contacts, which are closed in the good state, offer the possibility of series connection with the mA output and/or the contacts of REL1 and REL2.

4.6 LEDs

Power:	green LED	Supply
Error:	red LED	Safety function
Output:	yellow LED	Limit alarm

4.7 Interfaces

Galvanic isolation of the USB and RS485 from the auxiliary power and all other circuit parts. USB / RS485 (front socket, T-BUS contacts T-B1 + T-B2)

USB 2.0:	Front socket for PC connection
RS485:	Half-duplex, no scheduling
Baudrate:	9600 bps
Device address:	1-248

4.8 Supply

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

Supply voltage	24 VDC (min. 20 VDC, max. 30 VDC)
Power consumption	1,4 W (24VDC / 4 mA output) 1,9 W (24VDC / 20 mA output)

4.9 General Data

Environmental Conditions

Operation:	-10 °C ... +60 °C
Storage/Transport:	-20 °C ... +70 °C
Perm. Rel. Humidity (during operation):	10 % ... 95 % r. H. no. Cond.
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: 1500 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 (>400V to 599V)
Housing	
Material:	Polyamide – light grey
Protection class:	IP20
Flammability 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

4.10 Standards

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

4.11 Self-Monitoring

Input:	1 monitoring measurement circuit with adjustable tolerance
Output:	1 monitoring measurement circuit with adjustable tolerance
Supply:	2 monitoring measurement circuits
Reference voltages:	redundant and monitored
Memory:	cycling tests to ensure relative integrity
MUCs:	self monitoring / DuoTec®-Technology
Relays (REL1 ... REL4):	indirect contact monitoring

4.12 Installation

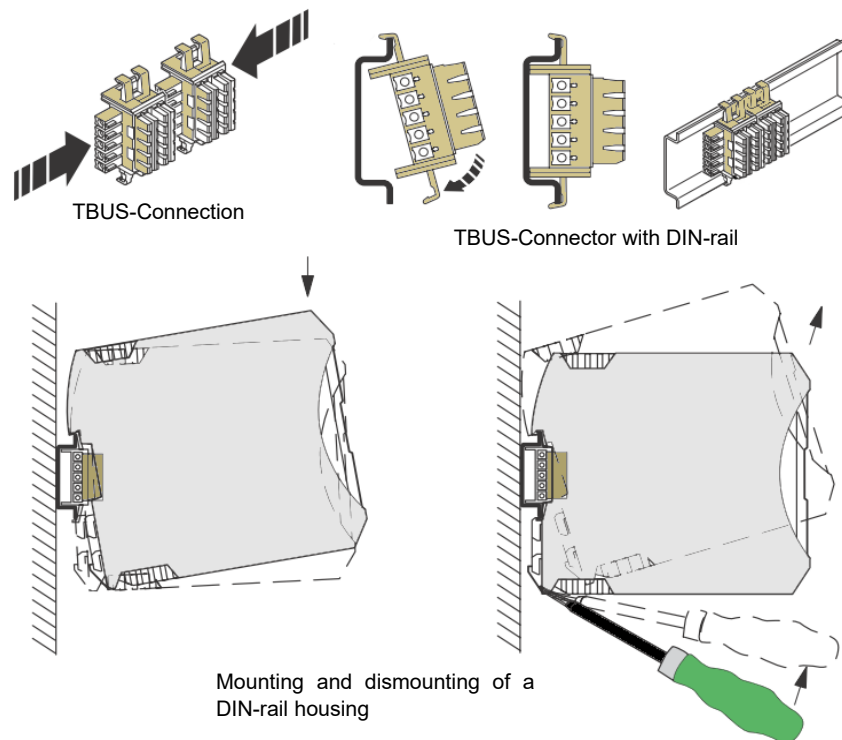


Figure 1 - DIN-rail housing and mounting

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.

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

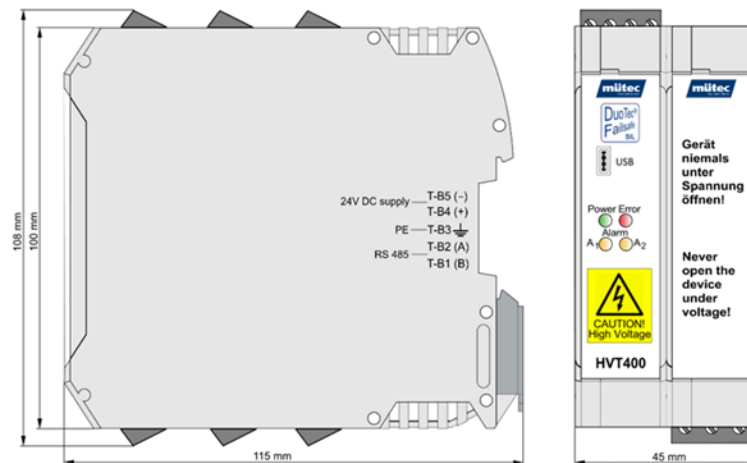


Figure 2: Housing Dimensions

4.15 Block diagram

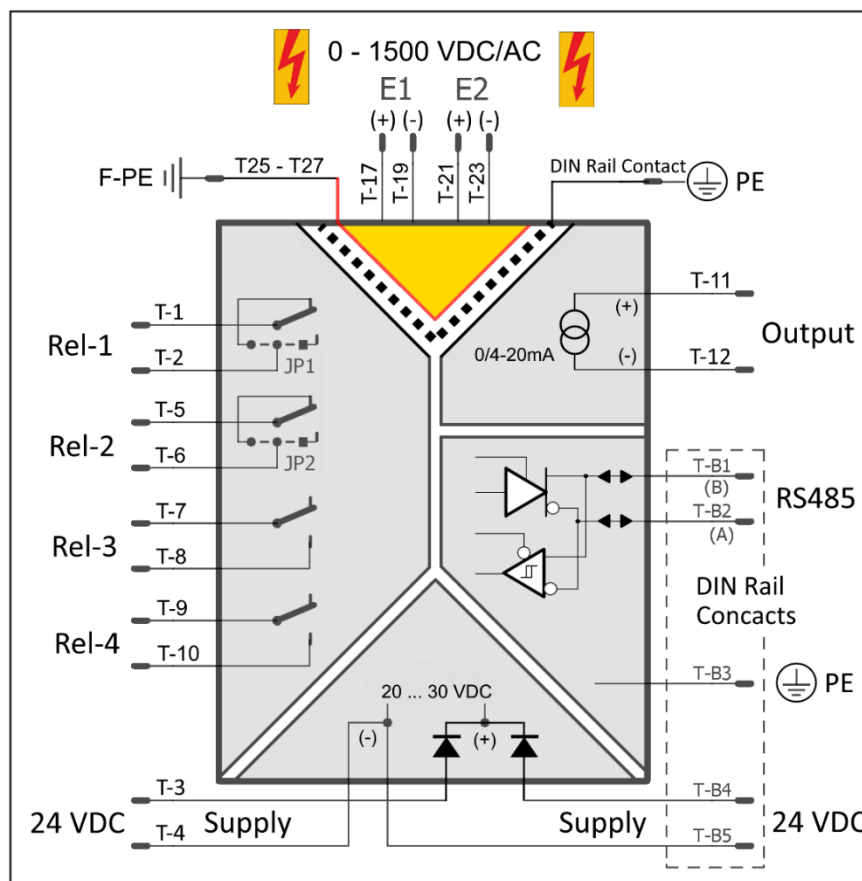


Figure 3: Block diagram and galvanic isolations

4.16 Nameplate

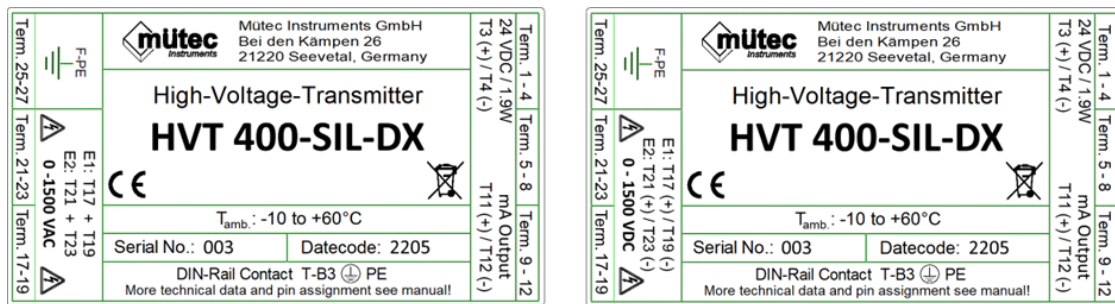


Figure 4: Name plate

5 Variants of Input Connections

5.1 Measurement in 2-wire connection

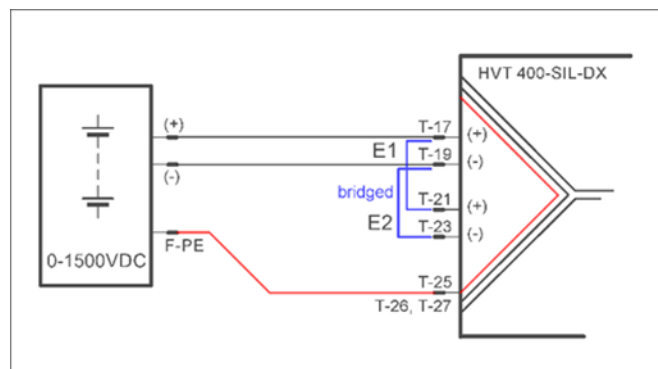


Figure 5: 2-wire input configuration

The absolute value measurement with only one measuring input is a possibility of interconnection with the signal source and the transmitter, if the terminals T-17 and T-21, as well as T-19 and T-23 are bridged



Hazard

A line break in the measuring circuit would be detected by the transmitter with 0 VDC, because the connection to the measuring input is interrupted. However, the max. voltage value of the signal source could still be 1500 VAC/DC and thus mean a massive hazard or danger to life!

5.2 Measurement in 4-wire connection

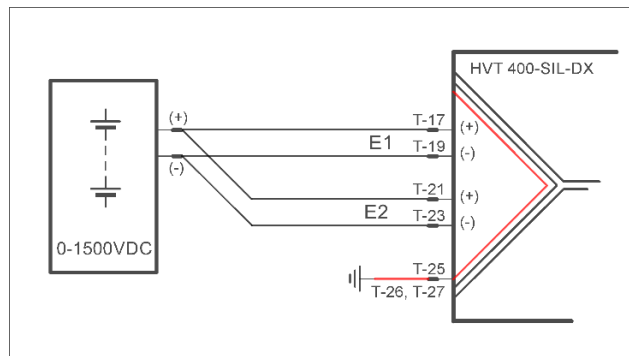


Figure 6: 4-wire input configuration

Only the 4-Lt. circuit enables the comparison of both mV signals at the measuring inputs of the mV transmitter. An increased lead resistance and associated voltage drop on one lead results in a difference between the two mV signals.

on a supply line results in a difference between the two mV signals. Depending on the set tolerance value for self-monitoring (WINSMART mask: monitoring measures), the safety function is triggered, causing the SIL2 relays REL3/4 to de-energise and the mA output to jump to the alarm value.

Note:

Connecting the mA output in series with the contact (NO) of relay 3 or 4 ensures that the value in the analogue output always jumps to 0 mA when the safety function is triggered. always jumps to 0 mA. Line break monitoring also exists here for all lines.

6 Loop resistance calculation of the of the mA output

Analog output (AO) data for constant current: max. 22 mA at a load $\leq 500 \Omega$.

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:

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

The following applies to the line resistance: $R_{\text{Line}} = l \times \rho \times A^{-1} [\Omega]$

$$\rho = 0,0178 [\Omega \text{ mm}^2 \text{ m}^{-1}]$$

$$A = 0,25 \times d^2 \times \pi [\text{mm}^2]$$

Maximum line length (distance):

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

Table 1: Wire length depending on the wire cross section and the shunt resistor

R_{Shunt} [Ω]	L_{Diameter} [mm]	$L_{\text{cross-sec}}$ [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
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
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

7 Safety

7.1 Safety Function

In case parameters are exceeding the accuracy settings the analogue output current of the device switches to the safe state. The diagnostic relays (REL3 and REL4) indicate the internal status of the diagnostics. The safety function consists of the logical combination of limit relays (REL1/REL2) or analog output and the status of the diagnostic relays (REL3/REL4).

A combination (see safety manual) of a signal output and a diagnostic relay (REL3/REL4) is mandatory for a safe output

7.2 Safe State

In case of a SIL-relevant internal error, e.g. processor failure or a supply voltage drop, as well as in the case of an external error, such as input cable break, the device sets itself in a pre-defined safe state. In the safe state, the diagnostic relays (REL3 + REL4) switch to open (NO, de-energized). The limit relays (REL1, REL2) and the mA-output (AO) switch to user-defined states. It is highly recommended to set the AO safe state to 0 mA

7.3 Possible Architectures

The architecture of the single device is 1oo1. The input circuit is galvanic isolated from the output circuit. Input and output circuits are using micro controllers to perform the measurement and to operate the output circuits. Diagnostics are performed by e.g., comparison of redundant structures, feedback of the output currents and relay contact monitoring.

The SFF for the device is 90-99% in order to comply with IEC 61508-2, Table 3 for fault tolerance 0 and type B technology.

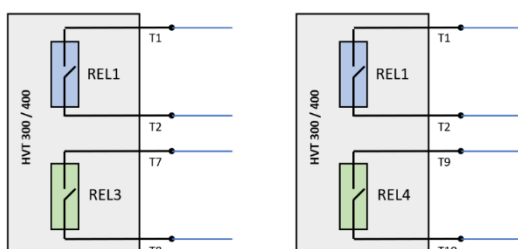


Figure 7: In case the diagnostic relay REL3 is either externally evaluated (left) or connected in series (right), the limit relays REL1 (or REL2) can be used as a safe output

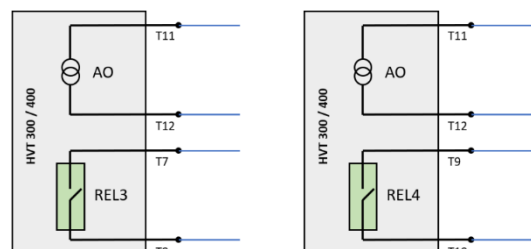


Figure 8: The analog output AO can also be used as a safe output, if one of the diagnostic relays REL3 or REL4 is externally evaluated (left) or connected in series (right).

7.4 Safety-Relevant Features

Properties	FMEDA
Category	SIL 2
Device type	Type B
HFT	0
SFF	97 %
DC	94 %
Safe failure rate	391 FIT
Safe detected failure rate	0 FIT
Safe undetected failure rate	391 FIT
Dangerous failure rate	353 FIT
Dangerous detected failure rate	331 FIT
Dangerous undetected failure rate	22 FIT

7.5 Safety-Oriented Applications for SIL 2

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

Error rates:

λ_{sd}	λ_{su}	λ_{dd}	λ_{du}	SFF
0	391	331	22	95 %

- Type B-Device (according to EN 61508-2), Safety Integrity Level (SIL) 2
- 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

T _{Proof}	1 Year	5 Years	10 Years
PFD _{AVG}	9.6E-5	4.8E-4	9.6E-4
% SIL2	1.0 %	4.8 %	9.6 %

- PFD_{AVG} = Average probability of failure on demand
- T_{Proof} = Detection test interval

The calculated PFD_{AVG} 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 HVT 400-SIL-DX at the PFD_{AVG} value of the entire safety chain should not exceed 30%.

Signal Source	HVT 400-DX	Signal Processing (PLC)
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

If you have any questions or concerns, please do not hesitate to contact us!

Mütec Instruments GmbH

Bei den Kämpfen 26
D-21220 Seevetal-Ramelsloh
Germany

Tel.: + 49 (0)4185-8083-0
Fax: + 49 (0)4185-8083-80
Mail: muetec@muetec.de
Web: www.muetec-instruments.de



Follow us on LinkedIn!
www.linkedin.com/company/muetec

