JUMO Ex-i
Repeater power supply and input isolating amplifier

Safety Manual

70753000T99Z001K000

V1.00/EN/00770263/2022-05-13

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1.1 Safety information

General

This manual contains information that must be observed in the interest of your own safety and to avoid material damage. This information is supported by symbols which are used in this manual as indicated.

Please read this manual before starting up the device. Store this manual in a place that is accessible to all users at all times.

If difficulties occur during startup, please do not intervene in any way that could jeopardize your warranty rights!

Warning symbols

WARNING!

This symbol in connection with the signal word indicates that **personal injury** may occur if the respective precautionary measures are not carried out.

CAUTION!

This symbol indicates that **components could be destroyed** by electrostatic discharge (ESD = Electro Static Discharge) if the respective cautionary measures are not taken.

Only use the ESD packages intended for this purpose to return device inserts, assembly groups, or assembly components.

NOTICE!

This note in connection with the signal word indicates that **material damage or data loss** will occur if the respective precautionary measures are not taken.

Note symbols

NOTE!

This symbol refers to **important information** about the product, its handling, or additional benefits.

REFERENCE!

This symbol refers to **additional information** in other sections, chapters, or other manuals.

1 Introduction

1.2 Description

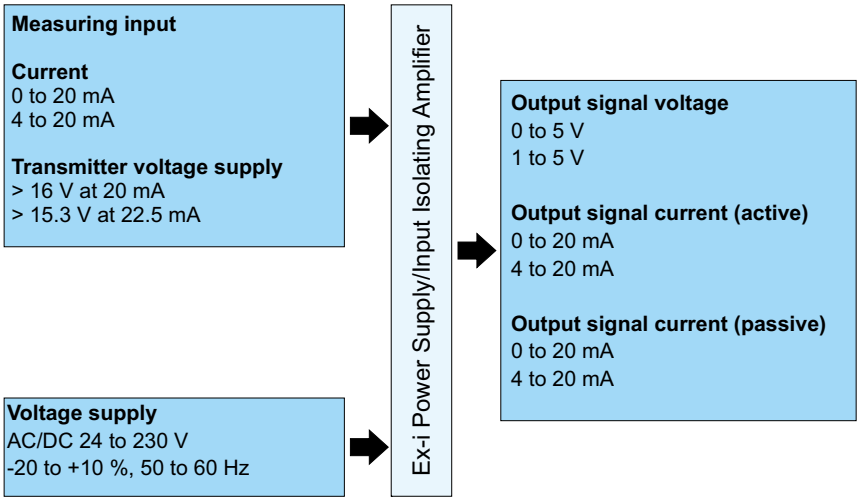
The JUMO Ex-i power supply/input isolating amplifier 707530 is designed for operating intrinsically safe transmitters (Ex-i) and mA current sources installed in potentially explosive (Ex) areas. The connected 2-wire transmitters are supplied with energy and analog 0/4 to 20 mA measured values are transmitted from the potentially explosive area to the non-explosive area.

The external connection defines whether the device operates in supply isolating amplifier mode or isolating amplifier mode. The output of the module can be operated in active or passive mode. Digital (HART) communication signals can be superimposed over the analog measured value on the Ex or non Ex side and transmitted bidirectional.

To increase the HART impedance in low-resistance systems an additional resistor can be activated in the output circuit using the switch on the device's front. The device provides a 3-way electrical isolation and the energy supply is designed as wide range power supply (24 to 230 V).

SIL measuring chains up to SIL2 and, in the event of a 2-channel setup, up to SIL3, are possible with the Ex-i repeater power supply and input isolating amplifier.

1.3 Block diagram



2 Safety requirements and installation instructions

2.1 Installation instructions

– The device is associated equipment with an EPL [Ga], [Da] (category 1) of the ignition protection type "intrinsic safety" and can be installed as a device with the EPL Gc (category 3) in the potentially explosive area of Zone 2. The intrinsically safe electrical circuits can be routed up to Zone 0 / Zone 20. It meets the requirements from the following standards.

  EN 60079-0, EN 60079-11, EN 60079-15

  For detailed information, please refer to the declarations of conformity.
– The installation, operation, and maintenance must be carried out by personnel with electrotechnical qualifications. Follow the described installation instructions.
– Adhere to the applicable conditions and safety regulations (including national safety regulations) and the general rules of engineering during set-up and operation.
– Observe the safety information, conditions, and limits of use specified in the product documentation. Comply with them.
– Opening or modifying the device is not admissible. Do not repair the device yourself; instead, you should replace it with an equivalent device. Repairs must only be performed by the manufacturer. The manufacturer is not liable for damage resulting from violations of this.
– The protection type IP20 (IEC/EN 60529) of the device is intended for a clean and dry environment. Do not expose the device to any mechanical and/or thermal stresses that exceed the described limits.
– Only use the device up to a pollution degree of 2 according to IEC 60664-1.
– The connected, non-intrinsically safe electrical circuits must have a maximum overvoltage category II according to IEC 60664-1.
– The device must be taken out of operation if it is damaged, has been improperly stressed or stored, or malfunctions.
– The device complies with the EMC regulations for industrial areas (EMC class A). It may cause EMC problems if used in residential areas.
– The products must be installed according to all relevant standards for electrical systems in potentially explosive areas.
– Only use copper cables as connecting cables.

2.2 Intrinsic safety

– The device is approved for intrinsically safe (Ex i) electrical circuits up to Zone 0 (gas) and Zone 20 (dust) of the Ex area. The safety technology values for intrinsically safe equipment and the connecting lines must be observed for the hook-up process (EN 60079-14) and the values specified in this installation note and/or the EU examination certificate must be observed.
– During measurements on the intrinsically safe side, make sure to observe the valid conditions relevant to the interconnection of intrinsically safe equipment. Only use the approved measuring devices in intrinsically safe electrical circuits.
– If the device has been used in non-intrinsically safe electrical circuits, using it again in intrinsically safe electrical circuits is prohibited! Clearly mark the device as not intrinsically safe.

2 Safety requirements and installation instructions

2.3 Installation in zone 2

– Adhere to the specified conditions for use in potentially explosive areas. Install the device in a suitable approved housing with at least IP54 protection that meets the requirements of EN 60079-15, Section 1.
  Also observe the requirements of EN 60079-14.
– In potentially explosive areas, connecting and disconnecting cables and connectors in non-intrinsically safe electrical circuits or actuating DIP switches is only permitted in a de-energized state or if no potentially explosive atmosphere is present.
– The device must be taken out of operation and removed from the Ex area immediately if it is damaged, has been improperly stressed or stored, or malfunctions.
– Temporary malfunctions (transients) must not exceed the value 497 V (355 V x 1.4).

2.4 Areas that are potentially explosive due to dust

– The device is not designed for installation in Zone 22.
– If you nevertheless want to use the device in Zone 22, you have to install it in a housing according to EN 60079-31. In doing so, observe the maximum surface temperatures. Adhere to the requirements of EN 60079-14.
– Only carry out interconnection with the intrinsically safe electrical circuit in areas that are potentially explosive due to dust (Zones 20, 21, or 22) if the equipment connected to this electrical circuit is approved for this zone (e.g. category 1D, 2D, or 3D).

2.5 Safety-related applications (SIL)

When using the device in safety-related applications, observe the instructions in the chapter "Safety-related applications", as the requirements for the safety-related function vary.

⇨ chapter 5 "Safety-related applications", Page 19

2.6 Safety data according to ATEX

Repeater power supply amplifier operation

Max. output voltage U_o	25.2 V
Max. output current I_o	93 mA
Max. output power P_o	587 mW
Max. external inductance L_o, max. external capacitance C_o	Simple electrical circuit IIB: 4 mH/820 nF Simple electrical circuit IIC: 2 mH/107 nF
Safety-related maximum voltage U_m	
Supply terminals	AC/DC 253 V
Output terminals	AC 253 V, DC 125 V

Input isolating amplifier operation

Max. voltage U_i	≤ 30 V
Max. current I_i	≤ 150 mA
Max. internal inductance L_i	Negligible
Max. internal capacitance C_i	Negligible
Safety-related maximum voltage U_m:	
Supply terminals	AC/DC 253 V
Output terminals	AC 253 V

2.7 UL note

The safety requirements resulting from the UL approval are included in the "Control Drawing". The "Control Drawing" is part of the package leaflet.

2 Safety requirements and installation instructions

3.1 Connection instructions

WARNING!

Electrical dangers due to improper installation

Observe the following connection information to ensure safe installation according to EN/UL 61010-1:

- In the device installation, separating devices and auxiliary flow circuit protection devices must be provided with suitable AC or DC values.
- The device is intended for installation in a control cabinet or in a comparable housing. The device must only be operated when installed. The control cabinet must correspond to the requirements of a fire protection housing of the safety standard UL/IEC 61010-1 and provide adequate protection against electric shock or burns.
- Provide a switch/power switch close to a device that is marked as the disconnecting device for this device (or the entire control cabinet).
- Provide an **overcurrent protection device** (I ≤ 16 A) in the installation.
- Install the device in an appropriate **housing** with a suitable protection type according to IEC/EN 60529 in order to protect against mechanical or electrical damage.
- Disconnect the device from all effective energy sources if it is not a SELV or PELV electric circuit when carrying out **repair or maintenance work**.
- If the device is not used according to the documentation, the intended protection may be impaired.
- Settings must only be made on the device using the DIP switch when it is in a de-energized state.
- The device has basic insulation of 300 V_{eff} to adjacent devices due to its housing. Note this when installing multiple devices next to one another and install additional insulation if necessary. If the adjacent device has basic insulation, no additional insulation is required.
- The voltages present at the input, output, and supply are extra-low voltages (ELV). The switching voltage at the relay output may be a voltage that is dangerous to the touch (> AC 30 V / > DC 60 V) depending on the application. In this case, safe, galvanic isolation to the other connections must be available.

WARNING!

Explosion hazard

If you have used the device in non-intrinsically safe electrical circuits, you can then no longer use it in intrinsically safe electrical circuits. Clearly mark the device as not intrinsically safe.

3.2 Electrostatic discharge

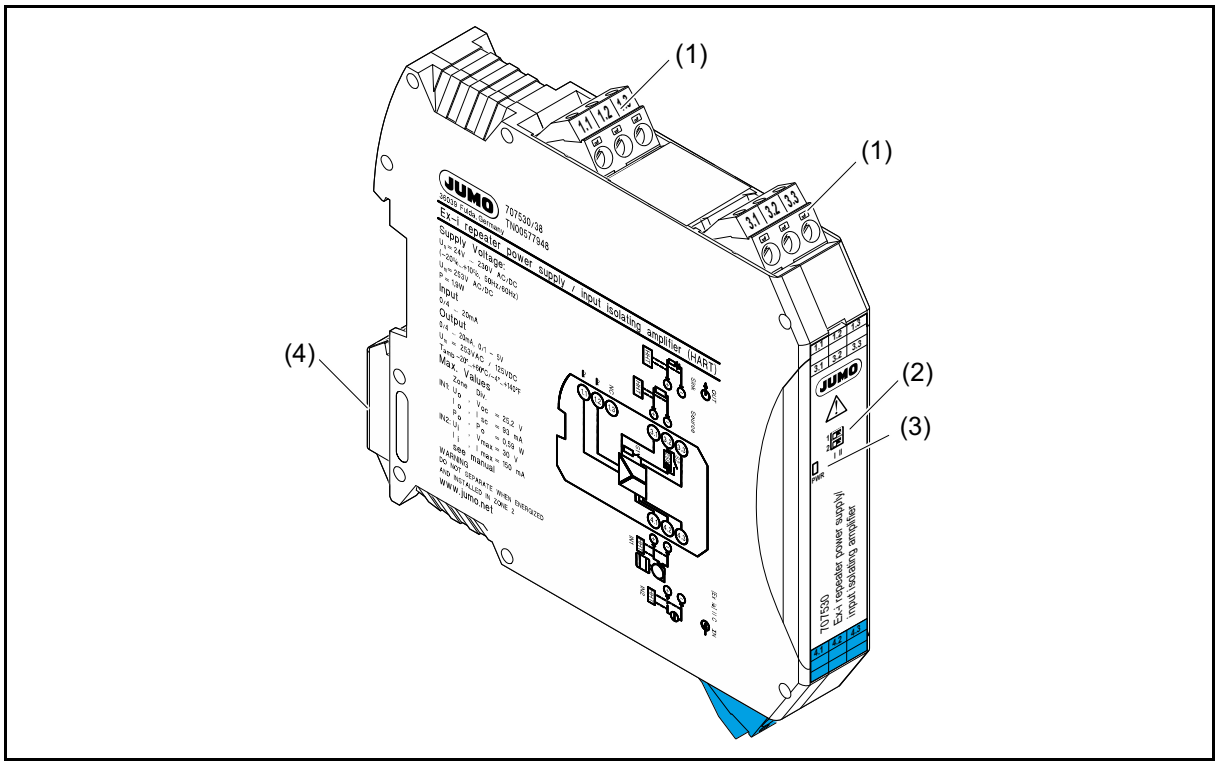
CAUTION!

Electrostatic discharge!

The device contains elements that may be damaged or destroyed by electrostatic discharge. When dealing with the device, observe the necessary safety measures against electrostatic discharge (ESD) according to EN 61340-5-1 and IEC 61340-5-1.

3 Installation

3.3 Design



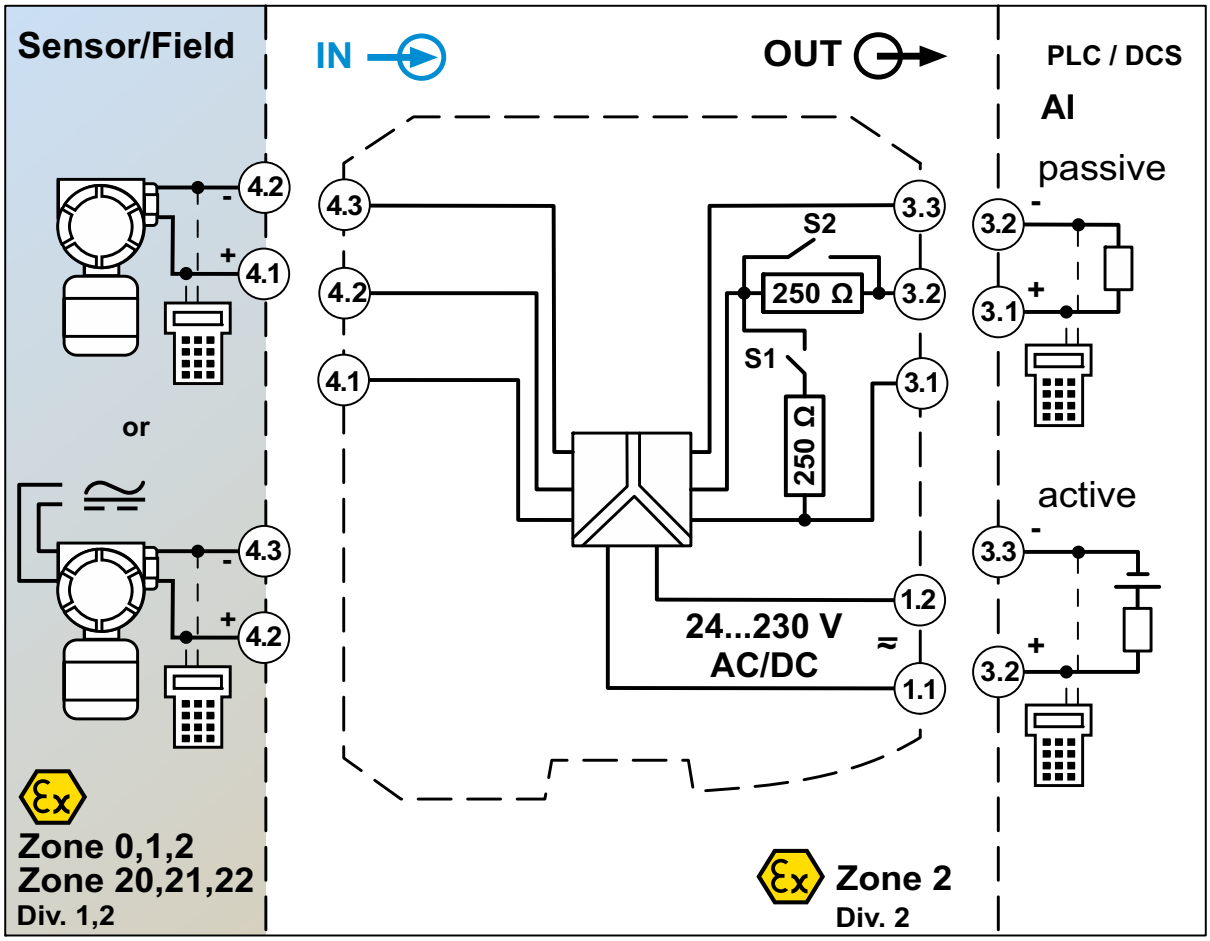
(1) Pluggable screw connection terminal block with integrated test socket

(2) DIP switch (S1: toggling current/voltage output; S2: resistance in the output circuit to increase HART impedance)

(3) Green LED: “PWR” voltage supply

(4) Snap-on foot for mounting rail installation

3.4 Schematic diagram



3.5 Inputs (intrinsically safe)

- Repeater power supply operation (feeding input for 2-conductor transmitter or 2-conductor measuring transducer) on terminal 4.1 (+) and 4.2 (-)
- Input isolating amplifier operation (non-feeding input for four-wire transmitter/power sources) at terminals 4.2 (+) and 4.3 (-)

3.6 Output of current without HART communication

Connection for	Terminals	DIP-switch position[a]	
		S1	S2
Source (passiv input card)	3.1 (+) and 3.2 (-)	I	II
Sink (active input card)	3.2 (+) and 3.3 (-)	I	II

[a] The two DIP-switches are located at the front of the device. Settings made to the device with DIP-switches must occur in a voltage-free state.

3 Installation

3.7 Output of current with HART communication

Connection for	Electrical circuit impedance	Connection		DIP-switch position[a]	
		of the input card at terminal	of the HART communicator	S1	S2
Source (passiv input card)	≥ 250 Ω	3.1 (+) and 3.2 (-)	3.1 and 3.2	I	II
	< 250 Ω	3.1 (+) and 3.2 (-)	3.2 and 3.3	I	I
Sink (active input card)	≥ 250 Ω	3.2 (+) and 3.3 (-)	3.2 and 3.3	I	II
	< 250 Ω	3.2 (+) and 3.3 (-)	-	I	II

[a] The two DIP-switches are located at the front of the device. Settings made to the device with DIP-switches must occur in a voltage-free state.

3.8 HART® communication

HART communicators (HHT) can be connected as shown in the basic circuit diagram. Test sockets (diameter 2.3 mm) are integrated in the screw connection terminal blocks for this purpose.

3.9 Output Voltage

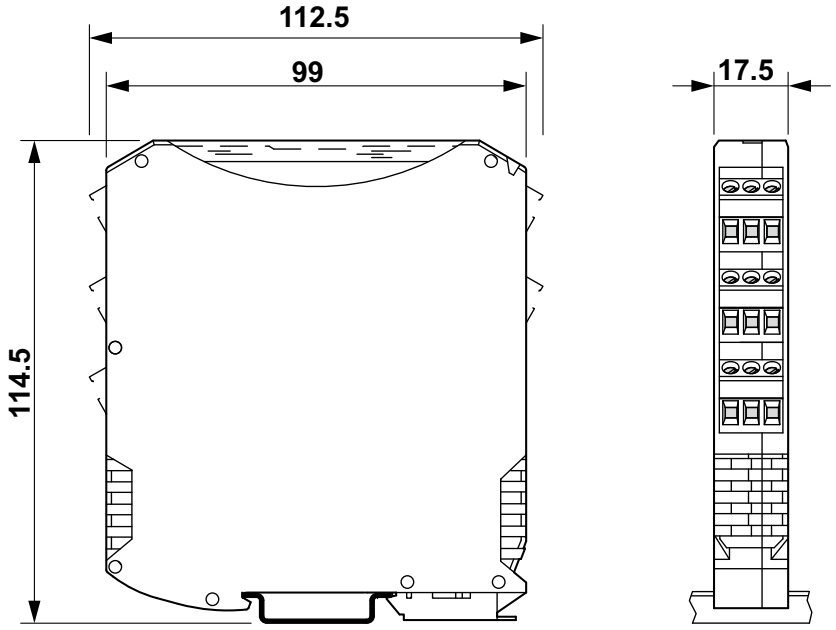
Connection for	Connection of the input card at the terminal	DIP-switch position[a]	
		S1	S2
Source – passive input card	3.1 (+) and 3.2 (-)	II	II

[a] The two DIP-switches are located at the front of the device. Settings made to the device with DIP-switches must occur in a voltage-free state.

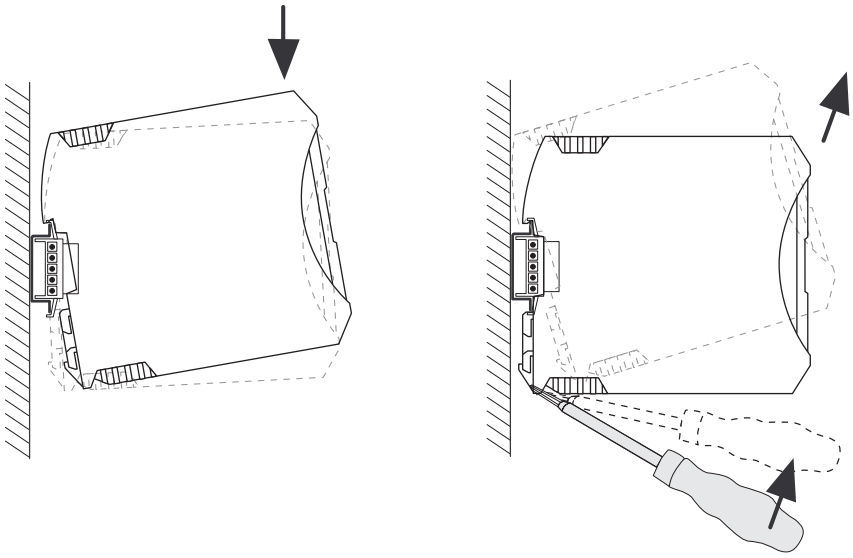
3.10 Voltage supply

The voltage supply is fed in via the connection terminals 1.1 (+) und 1.2 (-) (DC/AC 24 to 230 V).

3.11 Dimensions



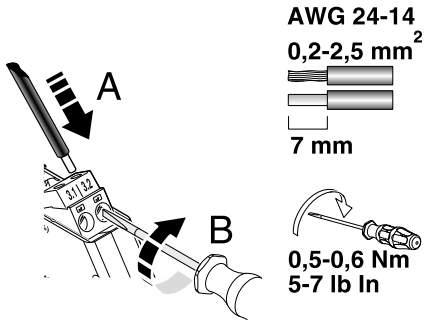
3.12 Mounting



1. Mount the module on a 35 mm mounting rail according to EN 60715.
2. Install the module in a suitable housing in order to meet the requirements for the protection rating.

3.13 Connecting the lines

Screw connection



Admissible conductor cross section: 0.2 mm^2 to 2.5 mm^2

1. Strip 7 mm of the wire and provide it with ferrules.
2. Insert the wire into the relevant connection terminal.
3. Tighten the screw in the opening above the connection terminal using a screwdriver.
   Connection torque: 0.6 Nm

3.14 Startup

1. Before startup, check the device is working correctly and is wired properly, in particular the wiring and identification marking of the intrinsically safe electrical circuits.

3.15 Level conversion

Level conversion between the input and output is not provided for.

4 to 20 mA input signals therefore become 4 to 20 mA output signals.

In the same manner, active input signals of 0 to 20 mA become galvanically isolated 0 to 20 mA output signals.

WARNING!

Explosion hazard

Compare the safety data before you connect a module located in the Ex-i area to the JUMO Ex-i isolating switch amplifier.

Provide proof of intrinsic safety according to standard EN 60079-14 and other national standards and installation specifications, if applicable.

Safety data of the

Field devices: U_i, I_i, P_i, L_i, C_i

Ex-i repeater power supply and input isolating amplifier: U_o, I_o, P_o, L_o, C_o

You can find the values for U_o, I_o, P_o, L_o, C_o in chapter 2.6 "Safety data according to ATEX", Page 9.

Example for proof of intrinsic safety (simple electrical circuit):

Data	Conditions
$U_i \geq U_o$	-
$I_i \geq I_o$	-
$P_i \geq P_o$	-
$L_i + L_c \leq L_o$	$L_i < 1$ % 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 or $C_i \geq 1$ % of C_o
$C_i + C_c \leq 0.5\ C_o$	

L_c and C_c depend on the cables/lines used.

Proof of intrinsic safety (simple intrinsically safe electrical circuit)

In a simple intrinsically safe electrical circuit without external concentrated capacitances (C_i) and without external concentrated inductances (L_i), the full values of C_0nd L_0 can be used.

⇨ chapter 2.6 "Safety data according to ATEX", Page 9

Proof of intrinsic safety (mixed intrinsically safe electrical circuit)

Condition for the mixed intrinsically safe electrical circuit with external concentrated capacitances (C_i) and/or external concentrated inductances (L_i):

- $L_i < 1$ % of L_0 **or** $C_i < 1$ % of C_0

The full values of C_0 and L_0 can also be used here.

⇨ chapter 2.6 "Safety data according to ATEX", Page 9

- $L_i \geq 1$ % of L_0 **and** $C_i \geq 1$ % of C_0

The values of C_0 and L_0 that have been reduced by 50 % must be used here:

- $C_i + C_c \leq 0.5\ C_0$
- $L_i + L_c \leq 0.5\ L_0$

In order to be able to realize larger line lengths, you can also use certified value pairs alternatively to the values reduced by 50 %.

⇨ chapter 2.6 "Safety data according to ATEX", Page 9

4 Comparison of the safety data

The following information applies for the device:

Designation	Part no.
JUMO Ex-i repeater power supply and input isolating amplifier	00577948

The safety-oriented repeater power supply and input isolating amplifier mentioned above is certified for compliance with DIN EN 61508 and IEC 62061.

Test certificate: ZP/C006/21

5.1 Safety function and safety requirements

The safety function of the device consists of galvanically isolated transmission of a standard signal of 4 to 20 mA with a max. deviation of 2 %.

Output values outside the range of 3.6 to 21 mA are considered a safe operating state, which is detected by the downstream control system.

Safe faults in the device are therefore those where the device delivers an output signal that does not deviate more than 2 % from the input signal.

Hazardous, unidentifiable faults are those where the device does not follow a change in the input signal or deviates by more than 2 % from the input signal and is not outside the range.

Hazardous, identifiable faults are those that deliver a signal outside of the range (< 3.6 mA/> 21 mA).

5.2 1-channel operation as a repeater power supply and input isolating amplifier for SIL2 (1oo1) applications

5.2.1 Safety/integrity requirements

Fault rates

- Type A device (according to IEC/EN 61508-2)
- Safety integrity level (SIL) 2 (1oo1 structure)
- Systematic capability (SC) 3 (1oo2 structure)
- HFT 0
- MTTR 24 h
- MTR 8 h
- Mission time 10 years
- Safety response time 2 s
- Ambient temperature 40 °C
- Proof test coverage (PTC) 97 %
- Process safety time 500 ms
- Switch-on duration 2 s

Safety characteristics according to IEC 61508 Edition 2

λ_{SU}	λ_{SD}	λ_{DU}	λ_{DD}	SFF	DC_D
251	0	62.1	0	80.17 %	0 %

The entire failure rate is 558 FIT.

The MTBF is therefore 205 years.

The fault rates are used to calculate the average probability of failure of the designed function in the event of a request for the operating type "low demand" and the probability of a hazardous failure per hour for the operating type "continuous demand".

Low-demand mode

The following PFD_{avg} values (low demand rate) result from the fault rates.

T [PROOF]	1 year	2 years	3 years	4 years	5 years
PFD_{avg}	2.73×10^{-4}	5.45×10^{-4}	8.17×10^{-4}	1.09×10^{-3}	1.37×10^{-3}

T [PROOF]	6 years	7 years	8 years	10 years
PFD_{avg}	1.64×10^{-3}	1.91×10^{-3}	2.18×10^{-3}	2.73×10^{-3}

High-demand mode

The following PFH value (high demand rate) results from the fault rates:

PFH = 6.21×10^{-8}/h

The requirements when it comes to the PFH value for a SIL2 system are therefore met.

The values for 1, 2, and 3 years mean that the calculated PFD_{avg} values are within the permissible range for SIL2 according to table 2 from IEC/EN 61508-1. They meet the requirement of not covering more than 10 % of the safety circuit or are better than or equal to 1.00×10^{-3}.

The values for 4, 5, 6, 7, 8, and 10 years mean that the calculated PFD_{avg} values are within the permissible range for SIL2 according to table 2 from IEC/EN 61508-1. However, they do not meet the requirement of not covering more than 10 % of the safety circuit/are not better than or equal to 1.00×10^{-3}.

Failure limit value

The operating mode with a low-demand rate is taken as the basis. The proportion of the device at PFH/PFD of the entire safety loop is less than 10 %.

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

5.3 2-channel operation as a repeater power supply and input isolating amplifier for SIL3 (1oo2) applications

5.3.1 Safety/integrity requirements

Fault rates

- Type A device (according to IEC/EN 61508-2)
- Safety integrity level (SIL) 3 (1oo2 structure)
- Systematic capability (SC) 3 (1oo2 structure)
- HFT 1
- MTTR 24 h
- MTR 8 h
- Mission time 10 years
- Safety response time 2 s
- Ambient temperature 40 °C
- Proof test coverage (PTC) 97 %
- Process safety time 500 ms
- Switch-on duration 2 s
- ß factor 2 % (Beta D)

Two devices have to be used to achieve a SIL3 level. The two outputs of the devices to the control side must be connected to the same evaluation unit (PLC/PLS). The evaluation unit must compare the two values with the max. permissible deviation of 2 % of the input signal.

The supply voltage must be monitored externally for undervoltage (< 19.2 V), the ambient temperature monitored externally at the installation site (max. <+ 60 °C, mean + 40 °C), and the detection of short circuits and interruptions in the output line with interlock must also be used.

Safety characteristics according to IEC 61508 Edition 2

λ_{SU}	λ_{SD}	λ_{DU}	λ_{DD}	SFF	DC_D
5.03	0	1.27	0	79.76 %	0 %

The entire failure rate is 558 FIT.

The MTBF is therefore 205 years.

The fault rates are used to calculate the average probability of failure of the designed function in the event of a request for the operating type "low demand" and the probability of a hazardous failure per hour for the operating type "continuous demand".

Low-demand mode

The following PFD_{avg} values (low demand rate) result from the fault rates.

T [PROOF]	1 year	2 years	3 years	4 years	5 years
PFD_{avg}	5.54×10^{-6}	1.13×10^{-5}	1.72×10^{-5}	2.33×10^{-5}	2.96×10^{-5}

T [PROOF]	6 years	7 years	8 years	10 years
PFD_{avg}	3.61×10^{-5}	4.27×10^{-5}	4.96×10^{-5}	6.93×10^{-5}

High-demand mode

The following PFH value (high demand rate) results from the fault rates:

$PFH = 1.27 \times 10^{-9}/h$

The requirements when it comes to the PFH value for a SIL3 system are therefore met.

The values for 1, 2, 3, 4, 5, 6, 7, 8, and 10 years mean that the calculated PFD_{avg} values are within the permissible range for SIL3 according to table 2 from IEC/EN 61508-1. They meet the requirement of not covering more than 10 % of the safety circuit or are better than or equal to 1.00×10^{-4}.

5.4 Conditions

- The failure rates of the components used are constant over the period of use.
- The spread of faults through the device in the system is not considered.
- The failure rates of the external power supply are not taken into account.
- The specified fault rates relate to an ambient temperature of 40 °C. For an ambient temperature of 60 °C, you have to multiply the fault rates by a factor of 2.5. The factor of 2.5 is based on empirical values.

5 Safety-related applications

5.5 Installation and startup

NOTICE!

Installation, operation, and maintenance must be carried out by qualified personnel.

Please note the package leaflet during installation:

Designation
Installation instructions for the electrical installer
EU declaration of conformity

The package leaflet is part of the device's scope of delivery. The documents are available as PDF files and can be downloaded from the manufacturer's website.

A lockable housing with protection type IP54 is recommended for device installation.

- Connect the device according to the installation instructions.
- Ensure that the connected sensor and transmitter corresponds to the intended configuration.
- Check the functionality of the device with a connected transmitter and sensor for correct functioning.
- A calibrated sensor simulator and a calibrated digital multimeter may be required to test the device with a connected transmitter
- Put the safety circuit into operation and check it for correct functioning.

5.6 Notes for operation

In standard operation, the green LED (PWR) lights up continuously.

If a malfunction occurs during operation, then the output signal is usually set to a value outside the "normal" signal range of 3.6 to 21 mA. The connected SIS should therefore check the loaded signal values for validity and initiate corresponding measures if they deviate from the normal values.

Make sure that the connected measuring transmitters respond to line faults at the sensors.

After switching off and switching back on, the required voltages are established in the device. Signal transmission then occurs without any further measures.

5.7 Regular tests

Regularly test the function of the entire safety loop according to IEC/EN 61508 and EN 61511.

The intervals for the inspection are specified by the intervals for the individual devices in the safety loop.

It is the responsibility of the operator to select the type of inspection and the intervals in the specified period of time.

The test must be carried out so that the correct function of the safety device can be demonstrated in conjunction with all components.

In SIL applications, the devices have to be checked after the maximum maintenance/test interval at the latest if they make up a proportion of the entire safety circuit that is not more than 10 %.

Possible behavior for the recurring tests in order to detect dangerous and undetected device faults

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

1. Carry out the appropriate steps in order to prevent misuse.
2. Disconnect the safety circuit from further processing steps.
3. Connect the current simulator to the input of the repeater power supply and input isolating amplifier or connect the sensor simulator to the input of the transmitter.
4. Connect the digital multimeters to the input and output of the repeater power supply and input isolating amplifier respectively.
5. Set a signal in the range of 4 to 20 mA at the input of the device or set a suitable signal at the input of the connected transmitter with the sensor simulator.
6. Measure the current in the repeater power supply and input isolating amplifier. The output must adjust to the same value.
7. You can verify that subsequent processing steps can detect and accordingly evaluate signals outside of the range by applying a setting of ≤ 3.6 mA/> 21 mA. If the output value deviates by more than 3x the specified class accuracy from the input value, the device should be inspected. Replace the device with an equivalent device in the event of a fault.
8. Establish the full function of the safety circuit.
9. Establish normal operation again.

5.8 Repairs

The devices have a long life cycle, are protected against malfunctions, and are maintenance-free.

If a device fails despite this, send it back to JUMO GmbH & Co. KG. Specify the type of malfunction and the possible reason for the malfunction when doing so.

Use the original package or a suitably secure transport container to send back devices for repair.

Download the "Supplementary sheet for product returns" from our website, please fill it out, and send it together with the faulty device to:

JUMO GmbH & Co. KG
Moritz-Juchheim-Straße 1
36039 Fulda

GERMANY

5 Safety-related applications

5.9 Standards

The devices are developed and approved 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

5.10 Abbreviations

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: the ability of a functional unit to continue performing a required function in cases in which fault or deviations exist
λ_D	Rate of dangerous failures	Rate of dangerous failures per hour
λ_{DD}	Rate of dangerous detected failures	Rate of dangerous detected failures per hour
λ_{DU}	Rate of dangerous undetected failures	Rate of dangerous undetected failures per hour
λ_S	Rate of safe failures	Rate of safe failures per hour
λ_{SD}	Rate of safe detectable failures	Rate of safe detectable failures per hour
λ_{SU}	Rate of safe undetectable failures	Rate of safe undetectable failures per hour
MTBF	Mean time between failures	Mean time between two failures
PDF_{avg}	Average probability of failure on demand	Average probability of dangerous failures of a safety function on demand
PFH_D	Probability of a dangerous failure per hour	Probability per hour of a failure for the safety function
SFF	Safe failure fraction	Fraction of safe failures: fraction of failures that do not have the potential of putting the safety-related system into a dangerous or inadmissible functional state
SIL	Safety integrity level	The international IEC 61508 standard defines four discrete safety integrity levels (SIL 1 to SIL 4). Each level corresponds to a probability range for the failure of a safety function. The higher the safety integrity level of the safety-related systems is, the lower the probability of the systems failing to perform the required safety functions is.

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