FY01035K/09/EN/02.21-00
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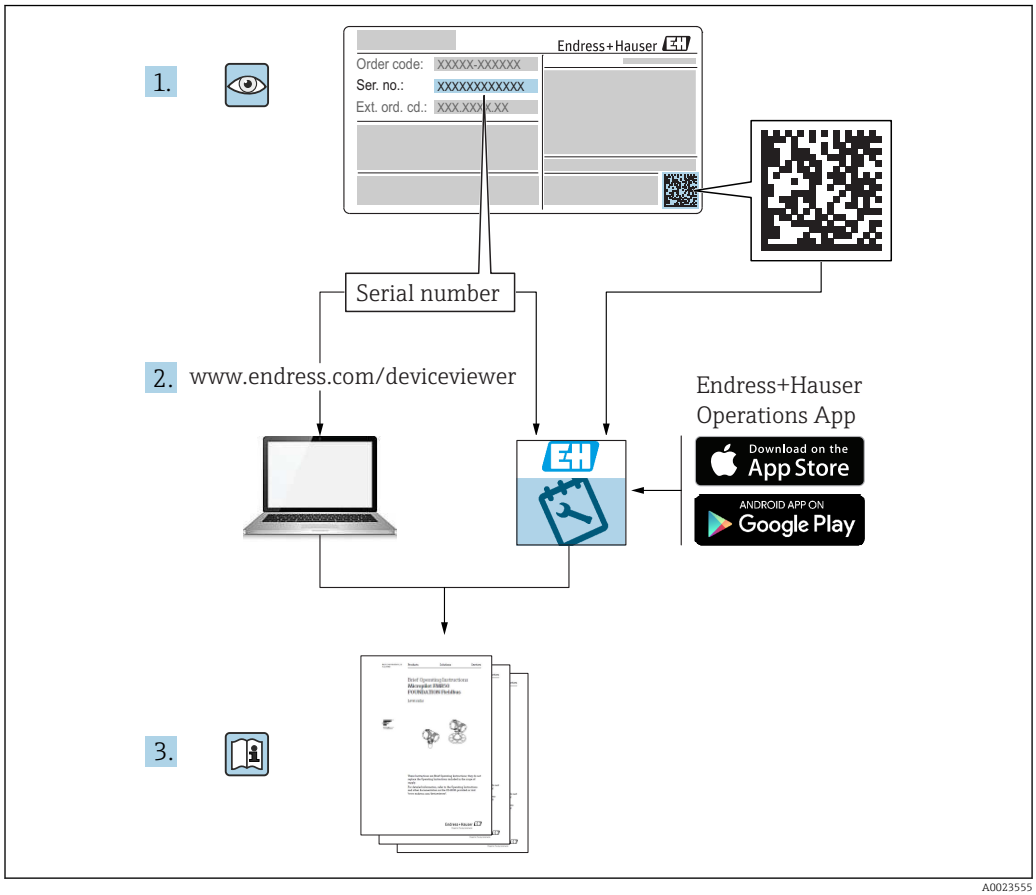
2021-11-30

Functional Safety Manual
RLN22, RLN42

NAMUR isolating amplifier with relay signal output

Endress+Hauser
People for Process Automation


1.
Endress+Hauser
Order code: XXXXX-XXXXXX
Ser. no.: XXXXXXXXXXX
Ext. ord. cd.: XXX XXX XX XX
Serial number
2. www.endress.com/deviceviewer
Endress+Hauser
Operations App
Download on the App Store
ANDROID APP ON Google Play
3.
A0023555

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1 Manufacturer's declaration

SIL_00467_01.21

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Manufacturer Declaration

Functional Safety according to IEC 61508:2010
Supplement 1 / NE130 Form B.1

Endress+Hauser Wetzer GmbH+Co. KG Obere Wank 1, 87484 Nesselwang

declares as a manufacturer, that the following NAMUR signal conditioner with relay output

RLN22-SIL and RLN42-SIL

is suitable for use in safety relevant applications up to SIL2 according to IEC 61508:2010.

In safety relevant applications according to IEC 61508, the instructions of the Safety Manual have to be followed.

Nesselwang, 27.07.2021
Endress+Hauser Wetzer GmbH+Co. KG

Harald Hertweck
Managing Director

i.V. Robert Zeller
Head of Department R&D-Components

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1.1 Safety-related characteristic values

SIL_00467_01.21

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General			
Device designation and permissible types	RLN22, RLN42 (Order code for "Additional approval": Option LA "SIL")		
Safety-related output signal	relay		
Fault current	energy-free state of the relay coil		
Process variable/function	NAMUR signal		
Safety function(s)	NAMUR switch normal- and inverter function		
Device type acc. to IEC 61508-2	☑ Type A	☐ Type B	
Operating mode	☑ Low Demand Mode	☑ High Demand	☐ Continuous Mode
Valid Hardware-Version	Rev. 01 or higher		
Valid Software-Version			
Safety manual	FY01035K/09		
Type of evaluation (check only one box)	☐ Complete HW/SW evaluation parallel to development incl. FMEDA and change request acc. to IEC 61508-2, 3		
	☐ Evaluation of "Proven-in-use" performance for HW/SW incl. FMEDA and change request acc. to IEC 61508-2, 3		
	☐ Evaluation of HW/SW field data to verify „prior use" acc. to IEC 61511		
	☑ Evaluation by FMEDA acc. to IEC61508-2 for devices w/o software		
Evaluation through / certificate no.			
Test documents	development documents, test reports, data sheets		

SIL - Integrity			
Systematic safety integrity		☑ SIL 2 capable	☐ SIL 3 capable
Hardware safety integrity	Single channel use (HFT = 0)	☑ SIL 2 capable	☐ SIL 3 capable
	Multi-channel use (HFT ≥ 1)	☑ SIL 2 capable	☐ SIL 3 capable

FMEDA RLN22 1-channel non-inverted operation	Function C1	Function C2	Function C5	Function C6
Safety function	N/O contact	N/O contact	N/C contact	N/C contact
λ_{DU} [1) 2)]	55 FIT	90 FIT	65 FIT	110 FIT
λ_{DD} [1) 2)]	7 FIT	7 FIT	7 FIT	7 FIT
λ_{SD} [1) 2)]	6 FIT	6 FIT	6 FIT	6 FIT
λ_{SU} [1) 2)]	165 FIT	230 FIT	155 FIT	210 FIT
SFF - Safe Failure Fraction	76 %	72 %	72 %	67 %
PFD_{avg} T1 = 1 year [2)] (single channel architecture)	$2{,}39 \cdot 10^{-4}$	$3{,}92 \cdot 10^{-4}$	$2{,}83 \cdot 10^{-4}$	$4{,}82 \cdot 10^{-4}$
PFD_{avg} T1 = 5 years [2)] (single channel architecture)	$4{,}78 \cdot 10^{-4}$	$7{,}84 \cdot 10^{-4}$	$5{,}66 \cdot 10^{-4}$	$9{,}64 \cdot 10^{-4}$
PFH	$5{,}46 \cdot 10^{-8}$	$8{,}96 \cdot 10^{-8}$	$6{,}46 \cdot 10^{-8}$	$1{,}1 \cdot 10^{-7}$
PTC [3)]	95 %			
MTBF [4)]	287 years	229 years	287 years	229 years
Fault reaction time [5)]	≤ 40 ms			

FMEDA RLN22 1-channel inverted operation	Function C3	Function C4	Function C7	Function C8
Safety function	N/O contact	N/O contact	N/C contact	N/C contact
λ_{DU} [1) 2)]	55 FIT	90 FIT	65 FIT	110 FIT
λ_{DD} [1) 2)]	6 FIT	6 FIT	6 FIT	6 FIT
λ_{SD} [1) 2)]	7 FIT	7 FIT	7 FIT	7 FIT
λ_{SU} [1) 2)]	168 FIT	233 FIT	158 FIT	213 FIT
SFF - Safe Failure Fraction	76 %	73 %	73 %	67 %
PFD_{avg} T1 = 1 year [2)] (single channel architecture)	$2{,}39 \cdot 10^{-4}$	$3{,}92 \cdot 10^{-4}$	$2{,}83 \cdot 10^{-4}$	$4{,}82 \cdot 10^{-4}$
PFD_{avg} T1 = 5 years [2)] (single channel architecture)	$4{,}78 \cdot 10^{-4}$	$7{,}84 \cdot 10^{-4}$	$5{,}66 \cdot 10^{-4}$	$9{,}64 \cdot 10^{-4}$
PFH	$5{,}46 \cdot 10^{-8}$	$8{,}96 \cdot 10^{-8}$	$6{,}46 \cdot 10^{-8}$	$1{,}1 \cdot 10^{-7}$
PTC [3)]	95 %			

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MTBF [4]	286 years	229 years	287 years	229 years
Fault reaction time [5]	≤ 40 ms			
FMEDA RLN22 2-channel	Function C1	Function C2	Function C3 inv	Function C4 inv
Safety function	N/O contact	N/O contact	N/O contact	N/O contact
λ_{DU} [1) 2)]	55 FIT	90 FIT	55 FIT	90 FIT
λ_{DD} [1) 2)]	7 FIT	7 FIT	6 FIT	6 FIT
λ_{SD} [1) 2)]	6 FIT	6 FIT	7 FIT	7 FIT
λ_{SU} [1) 2)]	165 FIT	230 FIT	168 FIT	233 FIT
SFF - Safe Failure Fraction	76 %	72 %	76 %	72 %
PFD_{avg} T1 = 1 year [2)] (single channel architecture)	$2{,}39 \cdot 10^{-4}$	$3{,}92 \cdot 10^{-4}$	$2{,}39 \cdot 10^{-4}$	$3{,}92 \cdot 10^{-4}$
PFD_{avg} T1 = 5 years [2)] (single channel architecture)	$4{,}78 \cdot 10^{-4}$	$7{,}84 \cdot 10^{-4}$	$4{,}78 \cdot 10^{-4}$	$7{,}84 \cdot 10^{-4}$
PFH	$5{,}46 \cdot 10^{-8}$	$8{,}96 \cdot 10^{-8}$	$5{,}46 \cdot 10^{-8}$	$8{,}96 \cdot 10^{-8}$
PTC [3)]	95 %			
MTBF [4)]	287 years	229 years	286 years	229 years
Fault reaction time [5)]	≤ 40 ms			
FMEDA RLN42 2-channel non-inverted operation	Function C1	Function C2	Function C5	Function C6
Safety function	N/O contact	N/O contact	N/C contact	N/C contact
λ_{DU} [1) 2)]	48 FIT	83 FIT	58 FIT	103 FIT
λ_{DD} [1) 2)]	6 FIT	6 FIT	6 FIT	6 FIT
λ_{S} [1) 2)]	187 FIT	252 FIT	177 FIT	232 FIT
SFF - Safe Failure Fraction	80 %	76 %	76 %	70 %
PFD_{avg} T1 = 1 year [2)] (single channel architecture)	$2{,}1 \cdot 10^{-4}$	$3{,}63 \cdot 10^{-4}$	$2{,}54 \cdot 10^{-4}$	$4{,}51 \cdot 10^{-4}$
PFD_{avg} T1 = 5 years [2)] (single channel architecture)	$4{,}2 \cdot 10^{-4}$	$7{,}26 \cdot 10^{-4}$	$5{,}08 \cdot 10^{-4}$	$9{,}02 \cdot 10^{-4}$
PFH	$4{,}79 \cdot 10^{-8}$	$8{,}29 \cdot 10^{-8}$	$5{,}79 \cdot 10^{-8}$	$1{,}03 \cdot 10^{-7}$
PTC [3)]	99 %			
MTBF [4)]	227 years	189 years	227 years	189 years
Fault reaction time [5)]	≤ 40 ms			
FMEDA RLN42 2-channel inverted operation	Function C3	Function C4	Function C7	Function C8
Safety function	N/O contact	N/O contact	N/C contact	N/C contact
λ_{DU} [1) 2)]	51 FIT	86 FIT	61 FIT	106 FIT
λ_{DD} [1) 2)]	6 FIT	5 FIT	6 FIT	6 FIT
λ_{S} [1) 2)]	189 FIT	254 FIT	179 FIT	234 FIT
SFF - Safe Failure Fraction	79 %	75 %	75 %	69 %
PFD_{avg} T1 = 1 year [2)] (single channel architecture)	$2{,}22 \cdot 10^{-4}$	$3{,}75 \cdot 10^{-4}$	$2{,}65 \cdot 10^{-4}$	$4{,}64 \cdot 10^{-4}$
PFD_{avg} T1 = 5 years [2)] (single channel architecture)	$4{,}44 \cdot 10^{-4}$	$7{,}5 \cdot 10^{-4}$	$5{,}3 \cdot 10^{-4}$	$9{,}28 \cdot 10^{-4}$
PFH	$5{,}06 \cdot 10^{-8}$	$8{,}56 \cdot 10^{-8}$	$6{,}06 \cdot 10^{-8}$	$1{,}06 \cdot 10^{-7}$
PTC [3)]	99 %			
MTBF [4)]	227 years	189 years	227 years	189 years
Fault reaction time [5)]	≤ 40 ms			
Declaration				
☑	Our internal company quality management system ensures information on safety-related systematic faults which become evident in the future			

[1)] FIT = Failure In Time, Number of failures per 10^9 h
[2)] Valid for average ambient temperature up to +40 °C (+104 °F)
For continuous operation at ambient temperature close to +60 °C (+140 °F), a factor of 2,5 should be applied
[3)] PTC = Proof Test Coverage
[4)] MTBF = Mean time between failures, this value takes into account all failure types of the electronic components according to Siemens SN29500
[5)] Maximum time between error recognition and error response

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2 About this document

2.1 Document function

This supplementary Safety Manual applies in addition to the Operating Instructions, Technical Information and ATEX Safety Instructions. The supplementary device

documentation must be observed during installation, commissioning and operation. The requirements specific to the protection function are described in this Safety Manual.

General information on functional safety (SIL) is available at:
- www.endress.com/SIL
- CP01008Z, Brochure "Functional Safety – SIL, Safety Instrumented Systems in the Process Industry"

2.2 Symbols used

2.2.1 Safety symbols

DANGER
This symbol alerts you to a dangerous situation. Failure to avoid this situation will result in serious or fatal injury.

WARNING
This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in serious or fatal injury.

CAUTION
This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in minor or medium injury.

NOTICE
This symbol contains information on procedures and other facts which do not result in personal injury.

2.2.2 Symbols for certain types of information and graphics

Tip
Indicates additional information

Reference to documentation

Reference to graphic

▶
Notice or individual step to be observed

1., 2., 3.
Series of steps

Result of a step

1, 2, 3, ...
Item numbers

A, B, C, ...
Views

2.3 Supplementary device documentation

For an overview of the scope of the associated Technical Documentation, refer to the following:
- *W@M Device Viewer* (www.endress.com/deviceviewer): Enter the serial number from nameplate
- *Endress+Hauser Operations App*: Enter the serial number from the nameplate or scan the 2D matrix code (QR code) on the nameplate

The following documentation types are available in the Downloads section of the Endress+Hauser website (www.endress.com/downloads):

2.3.1 Further applicable documents

TI

- RLN22: TI01560K
- RLN42: TI01565K

BA

- RLN22: BA02042K
- RLN42: BA02065K

KA

- RLN22: KA01458K
- RLN42: KA01482K

XA

- RLN22: XA02122K
- RLN42: XA02473K

2.3.2 Technical Information (TI)

Planning aid
The document contains all the technical data on the device and provides an overview of the accessories and other products that can be ordered for the device.

2.3.3 Brief Operating Instructions (KA)

Guide that takes you quickly to the 1st measured value
The Brief Operating Instructions contain all the essential information from incoming acceptance to initial commissioning.

2.3.4 Operating Instructions (BA)

Your reference guide
These Operating Instructions contain all the information that is required in various phases of the life cycle of the device: from product identification, incoming acceptance and storage, to mounting, connection, operation and commissioning through to troubleshooting, maintenance and disposal.

2.3.5 Safety Instructions (XA)

Safety Instructions (XA) are supplied with the device, depending on the approval. They are an integral part of the Operating Instructions.

The nameplate indicates which Safety Instructions (XA) apply to the device in question.

3 Design

3.1 Permitted device types

The details pertaining to functional safety in this manual relate to the device versions listed below and are valid as of the specified firmware and hardware versions.

Unless otherwise specified, all subsequent versions can also be used for safety functions.

A modification process according to IEC 61508 is applied for any device modifications.

Any exemptions from possible combinations of features are saved in the Endress +Hauser ordering system.

Valid device versions for safety-related use:

3.1.1 Order codes

RLN22 (1-/2-channel)

Feature: 010 "Approval"
Version: all

Feature: 020 "Channel"
Version: all

Feature: 030 "Electrical connection"
Version: all

Feature: 590 "Additional approval"
Version: LA
Version **"LA"** must be selected for use as a safety instrumented function as per IEC 61508.

Feature: 620 "Accessory enclosed"
Version: all

Feature: 895 "Marking"
Version: all

RLN42 (2-channel)

Feature: 010 "Approval"
Version: all

Feature: 020 "Channel"
Version: all

Feature: 030 "Electrical connection"
Version: all

Feature: 590 "Additional approval"
Version: LA
Version **"LA"** must be selected for use as a safety instrumented function as per IEC 61508.

Feature: 620 "Accessory enclosed"
Version: all

Feature: 895 "Marking"
Version: all

3.2 Identification marking

SIL-certified devices are marked with the SIL logo Ⓢ on the nameplate.

3.3 Safety instrumented function

The safety instrumented functions of the NAMUR isolating amplifier are:
- Normal function:
  When a 0 signal is present (high-impedance NAMUR sensor means low current in the input circuit), the relay output switches to the "non-conductive" or "open" state (NO contact) and "conductive" or "closed" state (NC contact for devices with changeover contact).
- Inverse function:
  When a 1 signal is present at the input, the relay output switches to the "non-conductive" or "open" state (NO contact) and "conductive" or "closed" state (NC contact for devices with changeover contact).

3.3.1 Safety-related output signal

The output state follows the input state, i.e. the safety-oriented function at the output depends on the position of the DIP 1 switch for channel 1 and DIP 3 for channel 2 (option) (set direction of action).

NOTICE

In an alarm condition

▶ Ensure that the equipment under control achieves or maintains a safe state.

3.3.2 Safety-related input signal

Permitted for safety-oriented applications:

- NAMUR sensor (as per EN 60947-5-6)
- Switching contact with resistor circuit (1 kΩ serial and 10 kΩ; tolerance < 10%)

Switching contacts without resistor circuit are not permitted for safety-oriented applications.

3.3.3 Response times

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

3.3.4 Failsafe mode and required response

The safe state is assumed if a line fault is detected or the supply voltage fails. The safe state is achieved by removing the terminals, with the exception of the NC contact in the output.

3.3.5 Safety integrity requirements (safety characteristics)

RLN22: 24V_{DC}, 1-channel changeover contact

Safety characteristics as per IEC 61508 Edition 2 (2010)
- Device type A
- Safety integrity level (SIL) 2
- Systematic capability (SC) 2
- HFT 0
- 1oo1 architecture
- Low demand mode oder high demand mode
- MTTR 24 h
- Mission time 10 years
- Ambient temperature 40 °C
- Proof test coverage (PTC) 95 %

List of observed configurations

Configuration	Operation	Relay contact	Relay load
C1	not inverted	NC contact	Load field IV, up to 250 V AC / 2 A or 30 V DC / 2 A resistive or slightly inductive load (cos φ > 0.95)
C2	not inverted	NC contact	Load field II, up to 120 V AC / 0.2 A resistive or slightly inductive load (cos φ > 0.95)
C3	inverted	NC contact	Load field IV, up to 250 V AC / 2 A or 30 V DC / 2 A resistive or slightly inductive load (cos φ > 0.95)
C4	inverted	NC contact	Load field II, up to 120 V AC / 0.2 A resistive or slightly inductive load (cos φ > 0.95)
C5	not inverted	NO contact	Load field IV, up to 250 V AC / 2 A or 30 V DC / 2 A resistive or slightly inductive load (cos φ > 0.95)
C6	not inverted	NO contact	Load field II, up to 120 V AC / 0.2 A resistive or slightly inductive load (cos φ > 0.95)
C7	inverted	NO contact	Load field IV, up to 250 V AC / 2 A or 30 V DC / 2 A resistive or slightly inductive load (cos φ > 0.95)
C8	inverted	NO contact	Load field II, up to 120 V AC / 0.2 A resistive or slightly inductive load (cos φ > 0.95)

3.3.6 Safety integrity requirements (safety characteristics)

RLN22: 24V DC, 2-channel NO contact

Safety characteristics as per IEC 61508 Edition 2 (2010)

- Device type A
- Safety integrity level (SIL) 2
- Systematic capability (SC) 2
- HFT 0
- 1oo1 architecture
- Low demand mode or high demand mode
- MTTR 24 h
- Mission time 15 years
- Ambient temperature 40 °C
- Proof test coverage (PTC) 95 %

RLN42: 24V DC, wide-range AC/DC, 2-channel changeover contact

- Device type A
- Safety integrity level (SIL) 2
- Systematic capability (SC) 2
- HFT 0
- 1oo1 architecture
- Low demand mode or high demand mode
- MTTR 24 h
- Mission time 10 years
- Ambient temperature 40 °C
- Proof test coverage (PTC) 99 %

List of observed configurations

Configuration	Operation	Relay contact	Relay load
C1	not inverted	NC contact	Load field IV, up to 250 V AC / 2 A or 30 V DC / 2 A resistive or slightly inductive load (cos φ > 0.95)
C2	not inverted	NC contact	Load field II, up to 120 V AC / 0.2 A resistive or slightly inductive load (cos φ > 0.95)
C3	inverted	NC contact	Load field IV, up to 250 V AC / 2 A or 30 V DC / 2 A resistive or slightly inductive load (cos φ > 0.95)
C4	inverted	NC contact	Load field II, up to 120 V AC / 0.2 A resistive or slightly inductive load (cos φ > 0.95)
C5	not inverted	NO contact	Load field IV, up to 250 V AC / 2 A or 30 V DC / 2 A resistive or slightly inductive load (cos φ > 0.95)
C6	not inverted	NO contact	Load field II, up to 120 V AC / 0.2 A resistive or slightly inductive load (cos φ > 0.95)
C7	inverted	NO contact	Load field IV, up to 250 V AC / 2 A or 30 V DC / 2 A resistive or slightly inductive load (cos φ > 0.95)
C8	inverted	NO contact	Load field II, up to 120 V AC / 0.2 A resistive or slightly inductive load (cos φ > 0.95)

3.3.7 Failure rates

Failure rates RLN22: 24V DC, 1-channel changeover contact

Non-inverting operation

Failure rates, safety characteristics

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	DC_{avg}	MTBF	Function
6 FIT	165 FIT	7 FIT	55 FIT	76 %	9 %	287 years	NO contact (RNO) C1
6 FIT	230 FIT	7 FIT	90 FIT	72 %	7 %	229 years	NO contact (RNO) C2
6 FIT	155 FIT	7 FIT	65 FIT	72 %	9 %	287 years	NC contact (RNC) C5
6 FIT	210 FIT	7 FIT	110 FIT	67 %	6 %	229 years	NC contact (RNC) C6

Low demand mode

T[PROOF]=	1 year	2 years	3 years	4 years	Function
PFD_{avg}=	$2.39 * 10^{-4}$	$4.78 * 10^{-4}$	$9.56 * 10^{-4}$	$1.19 * 10^{-3}$	NO contact (RNO) C1
PFD_{avg}=	$3.92 * 10^{-4}$	$7.84 * 10^{-4}$			NO contact (RNO) C2
PFD_{avg}=	$2.83 * 10^{-4}$	$5.66 * 10^{-4}$	$1.13 * 10^{-3}$		NC contact (RNC) C5
PFD_{avg}=	$4.82 * 10^{-4}$	$9.64 * 10^{-4}$			NC contact (RNC) C6

The values for 1 and 2 years mean that the PFD_{avg} values calculated are within the permitted range for SIL 2 as per Table 2 of IEC/EN 61508-1. They meet the requirement of covering no more than 10% of the safety circuit or are better than or equal to $1.00 * 10^{-3}$.

Inverting operation

Failure rates, safety characteristics

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	DC_{avg}	MTBF	Function
7 FIT	168 FIT	6 FIT	55 FIT	76 %	9 %	286 years	NO contact (RNO) C3
7 FIT	233 FIT	6 FIT	90 FIT	73 %	6 %	229 years	NO contact (RNO) C4
7 FIT	158 FIT	6 FIT	65 FIT	72 %	9 %	287 years	NC contact (RNC) C7
7 FIT	213 FIT	6 FIT	110 FIT	67 %	5 %	229 years	NC contact (RNC) C8

Low demand mode

T[PROOF]=	1 year	2 years	3 years	4 years	Function
PFD_{avg}=	$2.39 * 10^{-4}$	$4.78 * 10^{-4}$	$9.56 * 10^{-4}$	$1.19 * 10^{-3}$	NO contact (RNO) C1
PFD_{avg}=	$3.92 * 10^{-4}$	$7.84 * 10^{-4}$			NO contact (RNO) C2
PFD_{avg}=	$2.83 * 10^{-4}$	$5.66 * 10^{-4}$	$1.13 * 10^{-3}$		NC contact (RNC) C5
PFD_{avg}=	$4.82 * 10^{-4}$	$9.64 * 10^{-4}$			NC contact (RNC) C6

The PFD_{avg} values for 1, 2, 3 and 4 years are within the permitted range for SIL 2 as per Table 2 of IEC/EN 61508-1. They meet the requirement of covering no more than 10% of the safety circuit or are better than or equal to $1.00 * 10^{-3}$.

The PFD_{avg} value for 5 years is within the permitted range for SIL 2 as per Table 2 of IEC/EN 61508-1. However, it does not meet the requirement of covering no more than 10% of the safety circuit or is not better than or equal to $1.00 * 10^{-3}$.

Target failure measure

This is based on the low demand mode. The device's share of the PFH/PFD of the entire safety loop is less than 10 %.

Safety circuit as per IEC / EN 61508-1

Sensor	Device	Processing	Actuator
25 %	< 10 %	15 %	50 %

High demand mode

	250 V AC / 2 A	120 V AC / 0.2 A	24 V AC / 2 A	Function
PFH	$5.46 * 10^{-8}$	$8.96 * 10^{-8}$	$5.46 * 10^{-8}$	NO contact (RNO)
PFH	$6.46 * 10^{-8}$	$1.1 * 10^{-7}$	$6.46 * 10^{-8}$	NC contact (RNC)
Cycles/year	1000	100	1000	

The switching frequency must be taken into account in the service life of the relays.

Due to the line inductance, slightly resistive inductive loads are permitted (cos phi > 0.95).

Assumption: switching frequency of 1000 cycles/year

Permitted switching frequency: 6/min

Failure rates RLN22: 24V DC, 2-channel NO contact

Non-inverting operation

Failure rates, safety characteristics

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	DC_{avg}	MTBF	Function
6 FIT	165 FIT	7 FIT	55 FIT	76 %	9 %	287 years	NO contact (RNO) C1
6 FIT	230 FIT	7 FIT	90 FIT	72 %	7 %	229 years	NO contact (RNO) C2

Low demand mode

T[PROOF]=	1 year	2 years	4 years	5 years	Function
PFD_{avg}=	$2.39 * 10^{-4}$	$4.78 * 10^{-4}$	$9.56 * 10^{-4}$	$1.19 * 10^{-3}$	NO contact (RNO) C1
PFD_{avg}=	$3.92 * 10^{-4}$	$7.84 * 10^{-4}$			NO contact (RNO) C2

The PFD_{avg} values calculated for 1, 2, 3 and 4 years are within the permitted range for SIL 2 as per Table 2 of IEC/EN 61508-1. They meet the requirement of covering no more than 10% of the safety circuit or are better than or equal to $1.00 * 10^{-3}$.

The PFD_{avg} values calculated for 1, 2, 3 and 4 years are within the permitted range for SIL 2 as per Table 2 of IEC/EN 61508-1. They meet the requirement of covering no more than 10% of the safety circuit or are better than or equal to $1.00 * 10^{-3}$.

Inverting operation

Failure rates, safety characteristics

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	DC_{avg}	MTBF	Function
7 FIT	168 FIT	6 FIT	55 FIT	76 %	9 %	286 years	NO contact (RNO) C3
7 FIT	233 FIT	6 FIT	90 FIT	73 %	6 %	229 years	NO contact (RNO) C4

Low demand mode

T[PROOF]=	1 year	2 years	3 years	4 years	Function
PFD_{avg}=	2.39 * 10^{-4}	4.78 * 10^{-4}	9.56 * 10^{-4}	1.19 * 10^{-3}	NO contact (RNO) C3
PFD_{avg}=	3.92 * 10^{-4}	7.84 * 10^{-4}			NO contact (RNO) C4

The PFD_{avg} values for 1, 2, 3 and 4 years are within the permitted range for SIL 2 as per Table 2 of IEC/EN 61508-1. They meet the requirement of covering no more than 10% of the safety circuit or are better than or equal to 1.00 * 10^{-3}.

The PFD_{avg} value for 5 years is within the permitted range for SIL 2 as per Table 2 of IEC/EN 61508-1. However, it does not meet the requirement of covering no more than 10% of the safety circuit or is not better than or equal to 1.00 * 10^{-3}.

Target failure measure

This is based on the low demand mode. The device's share of the PFH/PFD of the entire safety loop is less than 10 %.

Safety circuit as per IEC / EN 61508-1

Sensor	Device	Processing	Actuator
25 %	< 10 %	15 %	50 %

High demand mode

	250 V AC / 2 A	120 V AC / 0.2 A	24 V AC / 2 A
PFH	5.46 * 10^{-8}	8.96 * 10^{-8}	5.46 * 10^{-8}
Cycles/year	1000	100	1000

The switching frequency must be taken into account in the service life of the relays.

Due to the line inductance, slightly resistive inductive loads are permitted (cos phi > 0.95).

Assumption: switching frequency of 1000 cycles/year

Permitted switching frequency: 6/min

Failure rates RLN42 wide-range AC/DC, 2-channel changeover contact:

Non-inverting operation

λ_S	λ_{DD}	λ_{DU}	SFF	DC_{avg}	MTBF	Function
187 FIT	6 FIT	48 FIT	80 %	9 %	227 years	NO contact (RNO) C1
252 FIT	6 FIT	83 FIT	76 %	7 %	189 years	NO contact (RNO) C2
177 FIT	6 FIT	58 FIT	76 %	9 %	227 years	NC contact (RNC) C5
232 FIT	6 FIT	103 FIT	70 %	6 %	189 years	NC contact (RNC) C6

Inverting operation

λ_S	λ_{DD}	λ_{DU}	SFF	DC_{avg}	MTBF	Function
189 FIT	6 FIT	51 FIT	79.4 %	9 %	227 years	NO contact (RNO) C3
254 FIT	5 FIT	86 FIT	75.2 %	5 %	189 years	NO contact (RNO) C4
179 FIT	6 FIT	61 FIT	75.3 %	9 %	227 years	NC contact (RNC) C7
234 FIT	6 FIT	106 FIT	69.4 %	5 %	189 years	NC contact (RNC) C8

Low demand mode

T[PROOF]=	1 year	2 years	3 years	4 years	5 years	Function
PFD_{avg}=	$2.1 * 10^{-4}$	$4.20 * 10^{-4}$	$6.30 * 10^{-4}$	$8.40 * 10^{-4}$	$1.05 * 10^{-3}$	NO contact (RNO) C1
PFD_{avg}=	$3.63 * 10^{-4}$	$7.26 * 10^{-4}$				NO contact (RNO) C2
PFD_{avg}=	$2.22 * 10^{-4}$	$4.44 * 10^{-4}$	$6.66 * 10^{-3}$	$8.88 * 10^{-4}$	$1.11 * 10^{-3}$	NO contact (RNO) C3
PFD_{avg}=	$3.75 * 10^{-4}$	$7.50 * 10^{-4}$				NO contact (RNO) C4
PFD_{avg}=	$2.54 * 10^{-4}$	$5.08 * 10^{-4}$	$7.62 * 10^{-4}$	$1.16 * 10^{-3}$		NC contact (RNC) C5
PFD_{avg}=	$4.51 * 10^{-4}$	$9.02 * 10^{-4}$				NC contact (RNC) C6
PFD_{avg}=	$2.65 * 10^{-4}$	$5.30 * 10^{-4}$	$7.95 * 10^{-4}$	$1.60 * 10^{-3}$		NC contact (RNC) C7
PFD_{avg}=	$4.64 * 10^{-4}$	$9.28 * 10^{-4}$				NC contact (RNC) C8

The PFD_{avg} values for 1, 2 and 3 years are within the permitted range for SIL 2 as per Table 2 of IEC/EN 61508-1. They meet the requirement of covering no more than 10% of the safety circuit or are better than or equal to $1.00 * 10^{-3}$.

The PFD_{avg} value for 4 and 5 years is within the permitted range for SIL 2 as per Table 2 of IEC/EN 61508-1. However, it does not meet the requirement of covering no more than 10% of the safety circuit or is not better than or equal to $1.00 * 10^{-3}$.

Safety circuit as per IEC / EN 61508-1

Sensor	Device	Processing	Actuator
25 %	< 10 %	15 %	50 %

High demand mode

	C1	C2	C3	C4	C5	C6	C7	C8
PFH	$4.79 * 10^{-8}$	$8.29 * 10^{-8}$	$5.06 * 10^{-8}$	$8.56 * 10^{-8}$	$5.79 * 10^{-8}$	$1.03 * 10^{-7}$	$6.06 * 10^{-8}$	$1.06 * 10^{-7}$
Cycles/year	1000	100	1000	100	1000	100	1000	100

The switching frequency must be taken into account in the service life of the relays.

Due to the line inductance, slightly resistive inductive loads are permitted (cos phi > 0.95).

Assumption: switching frequency of 1000 cycles/year

Permitted switching frequency: 6/min

3.4 Basic conditions for use in safety-related applications

The measuring system must be used correctly for the specific application, taking into account the medium properties and ambient conditions. Carefully follow instructions pertaining to critical process situations and installation conditions from the Operating Instructions. The application-specific limits must be observed. The specifications in the Operating Instructions and the Technical Information must not be exceeded.

3.4.1

- Connect an external 4 A (T) fuse on the contact side of the relay to prevent impermissible currents.
- When installed, external temperature monitoring must be present.
- The device must be installed in a cabinet with a keylock and at least IP54.
- The power supply used must compensate for short interruptions (≤ 20 ms).

3.5 Dangerous undetected failures in this scenario

An incorrect output signal that deviates from the value specified in this manual but is still in the range of 4 to 20 mA, is considered a "dangerous, undetected failure".

3.6 Safety measured error

The accuracy specified for SIL is <= 2 % of the full scale value.

3.7 Useful lifetime of electric components

The established failure rates of electrical components apply within the useful lifetime as per IEC 61508-2:2010 section 7.4.9.5 note 3.

According to DIN EN 61508-2:2011 section 7.4.9.5 (national footnote N3) appropriate measures taken by the operator can extend the useful lifetime.

4 Commissioning (installation and configuration)

4.1 Requirements for personnel

The personnel for installation, commissioning, diagnostics and maintenance must fulfill the following requirements:

- ▶ Trained, qualified specialists must have a relevant qualification for this specific function and task.
- ▶ Personnel must be authorized by the plant owner/operator.
- ▶ Be familiar with federal/national regulations.
- ▶ Before starting work: personnel must read and understand the instructions in the manual and supplementary documentation as well as the certificates (depending on the application).
- ▶ Personnel must follow instructions and comply with general policies.

The operating personnel must fulfill the following requirements:

- ▶ Personnel are instructed and authorized according to the requirements of the task by the facility's owner-operator.
- ▶ Personnel follow the instructions in this manual.

4.2 Installation

The mounting and wiring of the device and the permitted orientations are described in the Operating Instructions pertaining to the device.

4.3 Commissioning

The device can be commissioned using the commissioning wizard. The commissioning procedure is described in the Operating Instructions pertaining to the device.

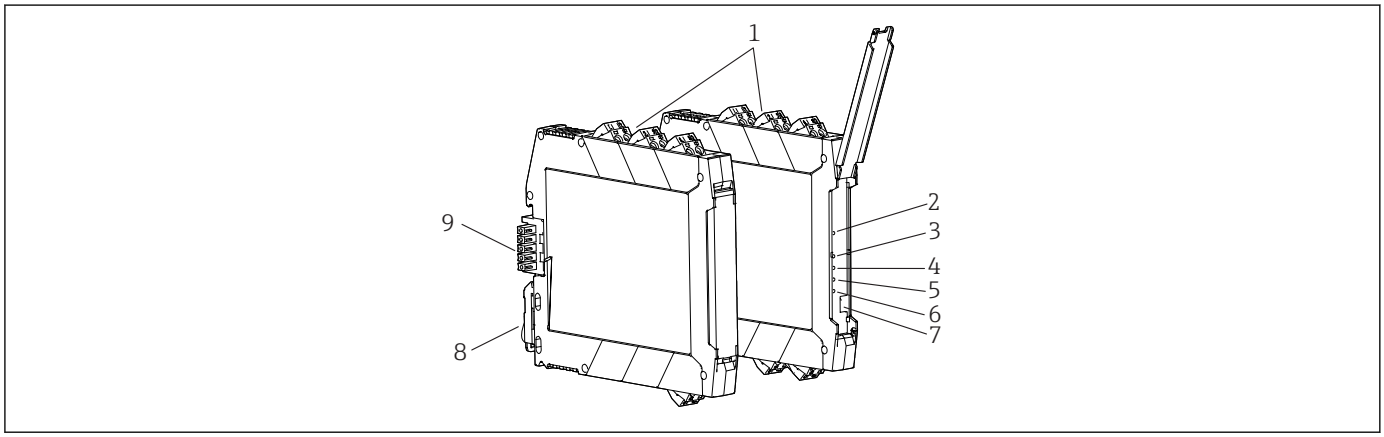
Prior to operating the device in a safety instrumented system, verification must be performed by carrying out a test sequence as described in **Section 6 Proof testing**.

4.4 Operation

The operation of the device is described in the Operating Instructions pertaining to the device.

4.5 Device configuration for safety-related applications

4.5.1



A0042251

In the order configuration, all DIP switches are in the "I" position.

NOTICE

Line fault detection must be switched on for safety-oriented applications.

- Only switch position "DIP 2 = II" or "DIP 2 / DIP 4 = II" is permitted for the two-channel device. For safety-oriented applications, only switching contacts with a resistor circuit are permitted at the input.
- Switch the DIP switches only when the device is de-energized.

Sensor in the input			Input circuit	DIP switch				Output	LED		Permitted for safety-oriented applications
				Channel 1		Channel 2		Relay contact			
Switch	Switching contacts with resistor circuit	NAMUR	State	1	2	3	4	NO contact	OUT	LF	
-	Open	Blocking	OK	I	II	I	II	Open			Yes
-	Closed	Conductive	OK	I	II	I	II	Closed	X		Yes

Sensor in the input			Input circuit	DIP switch				Output	LED		Permitted for safety-oriented applications
				Channel 1		Channel 2		Relay contact			
-	Any	Any	Wire break	I	II	I	II	Open		X	Yes
-	Any	Any	Short-circuit	I	II	I	II	Open		X	Yes
-	Open	Blocking	OK	II	II	II	II	Closed			Yes
-	Closed	Conductive	OK	II	II	II	II	Open	X		Yes
-	Any	Any	Wire break	II	II	II	II	Open		X	Yes
-	Any	Any	Short-circuit	II	II	II	II	Open		X	Yes

Line fault detection LF (DIP 2 switch = channel 1, DIP 4 = channel 2)

Line fault detection is set by the DIP switch DIP 2 (for channel 1) and DIP 4 (for channel 2).

Line fault detection must be switched on for safety-oriented applications.

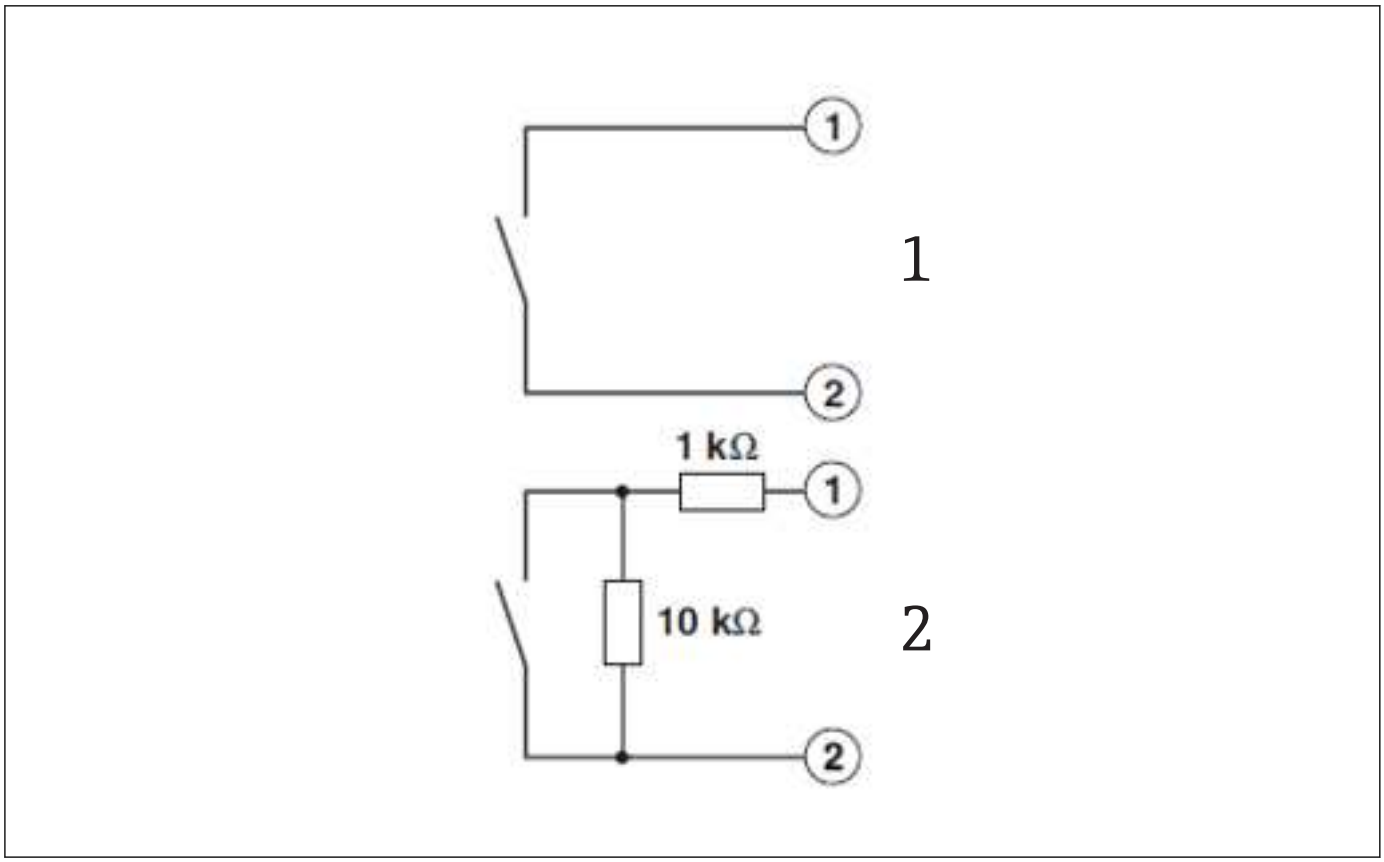
II = Line fault detection is switched on: If line fault detection is switched on, the relay drops out if the line to the sensor is interrupted or short-circuited, so that the output is changed to the safe, non-conductive state.

The red LED (LF) flashes (NAMUR NE 44). Response range as per EN 60947-5-6 for line fault indication:

Open circuit	0.05 mA < IIN < 0.35 mA
Short-circuit	100 Ω < RSensor < 360 Ω

If the module is connected to an MACX MCR-PTB(-SP) power supply module via a DIN rail bus connector, a group error message is also sent to the higher-level signal processing unit via a floating relay output.

For switching contacts with an open circuit, line fault detection (LF) must be disabled or the corresponding resistor circuit must be provided directly at the contact. The resistor coupling element is available as an accessory.



1 Switching contact with open circuit at sensor -> Safety-oriented application is not possible
2 Switching contact connected with resistor coupling element -> Safety-oriented application is possible

5 Operation

5.1 Device behavior during power-up

During normal operation, the green LED (PWR) is continuously lit. The yellow LEDs (OUT1/OUT2) indicate the switch status of the relay output.

5.2 Device behavior in demand mode of safety instrumented function

The red LED (LF) indicates errors that occur when line fault detection is switched on. The safe state is assumed after a line fault is detected or the supply voltage fails.

5.3 Start-up and restart

Switching on or restarting the device

The output enters the state without oscillating (as per the truth table – see Section 7 of the Operating Instructions - Operating options). A reset is not envisaged.

What happens after a line fault has been detected and what does the user need to do next?

The fault is indicated by the red LED and the output enters the "non-conductive" state regardless of the input signal and mode of operation (normal operation or inverse

operation). The user must eliminate the line fault (short-circuit or break in the sensor line). The device output is not locked after fault detection has been triggered (no lock or reset). Undefined line conditions that occur during repairs may cause the output to switch. The user must prevent this by switching off the supply voltage or removing the terminals. Other possibilities that produce the same result and not do present additional hazards are permitted.

The line fault is fixed

The user must ensure a defined state using the truth table. The device is recommissioned in the same way as with initial startup. The device then behaves as described under "Switching on or restarting the device".

5.4 Safe states

The "safe state" of the output is the de-energized state of the relay coil. This means that the NO contact is open and the NC contact (only with changeover contact) is closed. If the supply voltage fails or is switched off, or if line faults occur, the relay output enters the safe state.

5.5 Alarm and warning messages

The behavior of the device in the event of an alarm and warnings is described in the relevant Operating Instructions.

The red LED (LF) indicates errors that occur when line fault detection is switched on. The safe state is assumed after a line fault is detected or the supply voltage fails.

6 Proof test

The functional integrity of the device in the SIL mode must be verified during commissioning, when changes are made to safety-related parameters, as well as at appropriate time intervals. The operator must determine the time intervals.

⚠ CAUTION

The safety function is not guaranteed during a proof test.

- ▶ Suitable measures must be taken to guarantee process safety during the test.

- During the test, the safety-related output signal 4 to 20 mA must not be used for the safety instrumented system.
- The performance of a test must be documented. The template in the Appendix can be used for this purpose
- The operator specifies the testing interval and this must be taken into account when determining the probability of failure PFD_{avg} of the sensor system

If no operator-specific proof-testing requirements have been defined, the following is a possible alternative for testing the transmitter depending on the measured variable used for the safety function. The individual proof test coverages (PTC) that can be used for calculation are specified for the test sequences described below.

6.1 Test sequence

Proof-test procedure

- Apply a suitable signal to the input of the device to obtain the non-conductive state at the output.
- Check if the output is non-conductive.
- Check the conductive state in the same way.
- Restore the full function of the safety circuit.
- Restore normal operation.

This test covers more than 95 % of possible λ_{DU} (dangerous undetected) failures in the device.

If the function test is negative, the device must be taken out of operation and the process must be kept in a safe state using other measures.

6.2 Verification criterion

If one of the test criteria for the test sequences described above is not satisfied, the device may no longer be used as part of a safety instrumented system.

- The purpose of proof-testing is to detect dangerous undetected device failures (λ_{DU}).
- The impact of systematic failures on the safety instrumented function is not covered by this test and must be assessed separately.
- Systematic faults can be caused, for example, by process material properties, operating conditions, build-up or corrosion.

7 Repair and error handling

7.1 Repair

The devices are durable, are protected against malfunctions and are maintenance-free. If, however, a device still fails, return it immediately to Endress+Hauser, stating the type of malfunction the possible reason for the malfunction. When returning devices for repair or recalibration, use the original packaging or a suitable secure transport container. Repair means restoring functional integrity by replacing defective components.

Only original spare parts from Endress+Hauser may be used for this purpose.

We recommend documenting the repair and taking note of the following:

- Serial number of the device
- Date of the repair
- Type of repair
- Person who performed the repair

Components may be repaired/replaced by the customer's specialist staff if original E+H spare (which can be ordered by the end customer) are used, and if the relevant installation instructions are followed.

Installation Instructions are supplied with the original spare part and can also be accessed in the Download Area at www.endress.com

Send in replaced components to Endress+Hauser for fault analysis.

When returning the defective component, always enclose the "Declaration of Hazardous Material and Decontamination" with the note "Used as SIL device in a safety instrumented system.

Information on returns: http://www.endress.com/support/return-material

7.2 Modification

Modifications are changes to SIL devices that are already delivered or installed.

- Modifications to SIL devices can affect the functional safety of the device and must be carried out by staff authorized to perform such work by Endress+Hauser.
- Modifications to SIL devices onsite at the user's plant are possible by Endress+Hauser-authorized staff following approval. In this case, the modifications must be performed and documented by an Endress+Hauser service technician.
- **Modifications to SIL devices by the user are not permitted.**

7.3 Decommissioning

When decommissioning, the requirements according to IEC 61508-1:2010 section 7.17 must be observed.

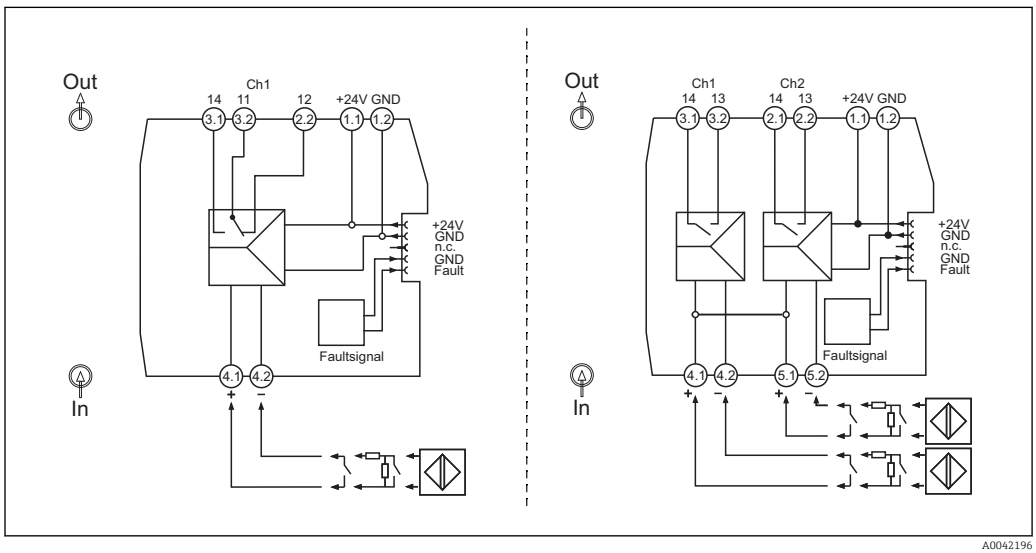
7.4 Disposal

If required by the Directive 2012/19/EU on waste electrical and electronic equipment (WEEE), the product is marked with the depicted symbol in order to minimize the disposal of WEEE as unsorted municipal waste. Do not dispose of products bearing this marking as unsorted municipal waste. Instead, return them to Endress+Hauser for disposal under the applicable conditions.

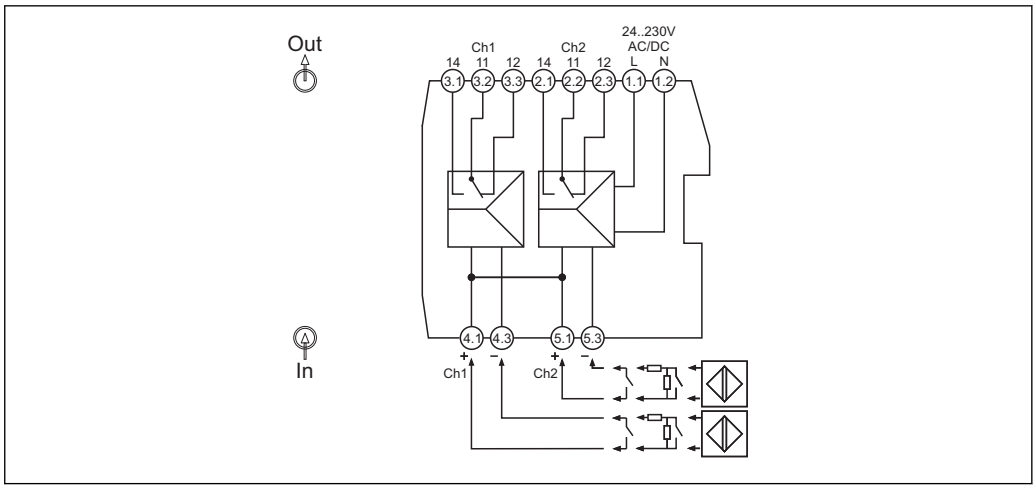
8 Appendix

8.1 Structure of the measuring system

8.1.1 System components



1 Schematic diagram RLN22: 1-channel version (on left), 2-channel version (on right)



2 Schematic diagram RLN42

8.2 Commissioning or proof test report

8.2.1 Test report – Page 1

Company / contact person	**/**
Tester	

Device information	
Facility	Measuring point/TAG no.:
Device type / order code	
Serial number	Hardware version

Verification information
Date/time
Performed by

Verification result		
Overall result	☐ Passed	☐ Failed

Comment:

Date	Signature of customer	Signature Tester

8.2.2 Test report – Page 2

Type of safety function
☐ Normal function ☐ Inverse function

Proof testing
☐ Test sequence

This report is based on the specifications in the Functional Safety Manual: FY01035K

Proof test report			
Test step	Target value	Actual value	Passed
1. Input: suitable signal for achieving non-conductive state at the output			☐ Passed ☐ Failed
2. Test output: output is non-conductive			☐ Passed ☐ Failed
3. Input: suitable signal for achieving conductive state at the output			☐ Passed ☐ Failed
4. Test output: output is conductive			☐ Passed ☐ Failed
5. Restore full function of safety circuit			☐ Passed ☐ Failed
6. Restore normal operation			☐ Passed ☐ Failed

Comment:

8.3 Version history

Version of manual	Changes	Valid from hardware version	Reference to NE53 customer information
FY01035K/09/EN/01.21	First version / changed safety-related characteristic values	01.00.zz	FY01035K/09/EN/01.21

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