PI-EX-NAM/TO-P

Ex-i NAMUR Isolation Amplifier
With Passive Transistor Output

INTERFACE

Data Sheet
102098_en_04

1 Description

The **PI-EX-NAM/TO-P** is a 3-way isolation amplifier. It is designed to operate proximity switches according to EN 60947-5-6 as well as switch contacts with open circuit and resistance circuit.

The signals from the Ex area are electrically isolated and transmitted to a control system located within the safe area via a transistor. At the output side, the isolation amplifier has a passive short-circuit-proof NPN transistor that is electrically isolated from the sensor and supply sides. The module itself is installed outside the Ex area or in zone 2.

NOTE: Devices manufactured in 2005 or later meet the requirements for SIL 2 (see device labeling: CE mark in conjunction with the date). Please refer to the instructions in Section 9.

The PI-EX-NAM/TO-P features line fault detection (LFD, see page 7), which can be switched on/off via a switch depending on the application.

If a line fault is detected or a supply voltage failure occurs, the module switches to the OFF state, i.e., the transistor output is blocking.

As an option, the PI-EX-NAM/TO-P can also be operated in the inverted direction. A switch is also used to switch between normal and inverse mode. Both switches are located on the front of the device and can be operated after opening the transparent cover.

1.1 Properties

- Single-channel
- Input for NAMUR proximity sensor or switch, [Ex ia] IIC
- Transistor output (passive)
- Installation in zone 2
- 20 V DC ... 30 V DC supply
- Option of phase reversal
- Line fault detection (LFD)
- 3-way electrical isolation
- SIL 2 according to IEC 61508

WARNING: Explosion hazard
The device is an associated item of equipment. It is designed for use in zone 2, if the specific conditions are observed.
When installing and operating the device, the applicable safety directives (including national safety directives), accident prevention regulations, as well as general technical regulations, must be observed.

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

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

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

Table of Contents

2 Ordering Data

NAMUR Isolation Amplifier

Description	Type	Order No.	Pcs./Pck.
Ex-i NAMUR isolation amplifier with passive transistor output	PI-EX-NAM/TO-P	2865117	1

Accessories

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

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

3 Technical Data

Input	
Input	Intrinsically safe, designed for protection type "i" [Ex i]
Available input sources	– NAMUR proximity switches according to EN 60947-5-6 – Switch contacts with open circuit **(not for safety-related applications, SIL 2)** – Switch contacts with resistance circuit (series resistance 1 kΩ ±10%, parallel resistance 10 kΩ ±10%)

Control Circuit	
Non-load voltage	8.2 V DC ±10%
Switching points according to EN 60947-5-6	
Blocking Conductive	I < 1.2 mA I > 2.1 mA
Switching hysteresis	150 µA, approximately
Line fault detection	Activated/deactivated via switch
Cable break detection	I < 0.05 mA
Short-circuit detection: Operating range R (according to EN 60947-5-6)	100 Ω ... 360 Ω

Output	
Transistor (terminal block 3, 4)	Passive transistor switching output (NPN transistor) with electrical isolation from sensor and supply sides
Maximum output current	100 mA (short-circuit-proof)
External switching voltage U/ΔU	10 V DC ... 30 V DC/1.5 V
Switching behavior	Can be inverted via switch (not with SIL)
Switching frequency	DC, 2 kHz, maximum (with pulse-duty factor of < 4:1)

General Data	
Supply voltage range	20 V DC ... 30 V DC
Nominal operating voltage	24 V DC
Current consumption	25 mA
Power dissipation	0.6 W, maximum (at 24 V)
Supply voltage type	External
Electrical isolation	
Input/output Input/supply	375 V (peak value according to EN 50020) 375 V (peak value according to EN 50020)
Test voltage (input/output and input/supply)	1.5 kV AC, 50 Hz, 1 minute
Housing material	PBT and polyamide PA, non-reinforced
Inflammability class according to UL 94	V0
Degree of protection	IP20
Color	Green
Dimensions	
Without basic terminal block (width x height) With basic terminal block (width x height x length)	12.4 mm x 108.6 mm 12.4 mm x 147 mm x 145 mm
NAMUR recommendation	NE 21

Ambient Conditions	
Ambient temperature (operation)	-20°C ... +55°C (perpendicular mounting of DIN rail) -20°C ... +60°C (horizontal mounting of DIN rail)
Average temperature according to IEC 61508	≤ +40°C
Ambient temperature (storage/transport)	-40°C … +80°C
Permissible humidity (operation and storage/transport)	10% ... 95% (relative humidity, no condensation)
Vibration	2g (according to DIN EN 60068-2-26)
Shock	15g (according to DIN EN 60068-2-27)

Ambient Conditions (Continued)

Height (installation location)	2000 m above sea level, maximum
Height (storage location)	3500 m above sea level, maximum
Protection against water and dust	IP20

Indicators

Status indicator	Green LED (supply voltage) Yellow LED (switching state of the transistor output) Red LED (line fault on the sensor cable, transistor blocking)

When using the PI-EX-NAM/TO-P in safety-related applications, observe the technical data on page 12, as the requirements differ for safety-related functions.

EC Conformance

EMC directive 89/336/EEC	Yes
Ex directive (ATEX)	Yes

Safety Data According to ATEX for Intrinsically Safe Circuits

Maximum output voltage U_o	10.6 V		
Maximum output current I_o	33 mA		
Maximum output power P_o	86 mW		
Gas group	II A	II B	II C
Maximum external inductance L_o Maximum external capacitance C_o	230 mH 72.0 µF	110 mH 16.2 µF	30 mH 2.3 µF
U_m	250 V AC		

Approvals

ATEX	Ⓔx II (1) GD [Ex ia] IIC, KEMA 00 ATEX 1126 Ⓔx II 3G Ex nA II T4X
UL/CUL	In preparation

4 Safety Regulations and Installation Notes

4.1 Installation and Operation

Follow the installation instructions.

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

When installing and operating the device, the applicable safety directives (including national safety directives), accident prevention regulations, as well as general technical regulations, must be observed.

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

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

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

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

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

4.2 Safety Regulations for Installation in Potentially Explosive Areas

Regulations for Intrinsically Safe Circuits

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

Only use devices approved for use in intrinsically safe circuits.

WARNING: Explosion hazard
If the **device has been used in non-intrinsically safe circuits,** it must **not** be used again in intrinsically safe circuits.

The module must be clearly labeled as non-intrinsically safe.

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

Installation in Zone 2

WARNING: Explosion hazard
The device is an associated item of equipment with "intrinsically safe" explosion protection and is designed for installation in zone 2, if the Ex symbol is printed on the block.

Observe the specified conditions for use in potentially explosive areas.

WARNING: Explosion hazard
Install the device in suitable **housing that meets IP54 protection, minimum**.
Observe the requirements of IEC 60079-14/EN 60079-14, e.g., steel housing with a wall thickness of 3 mm.

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

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

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

Installation in Areas With a Danger of Dust Explosions

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

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

4.3 Use in Safety-Related Applications (SIL 2)

When using the PI-EX-NAM/TO-P in safety-related applications, observe the instructions in Section 9, as the requirements differ for safety-related functions.

5 Structure

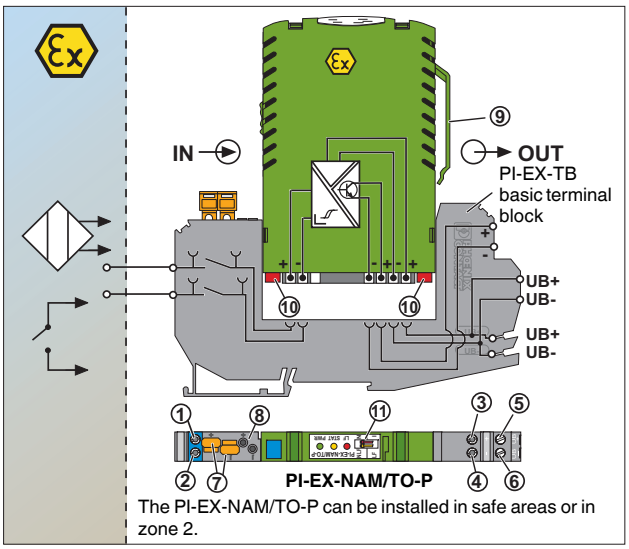

Figure 1 Structure

① Input "+"
② Input "–"
③ Output "+"
④ Output "–"
① - ④ Terminal screw with integrated test socket
⑤ Voltage supply "+", UB+
⑥ Voltage supply "–", UB–
⑦ Isolating connectors
⑧ Test socket
⑨ Locking clip
⑩ Keying pin
⑪ Switch (LF/NLF and N/I)

Dimensions

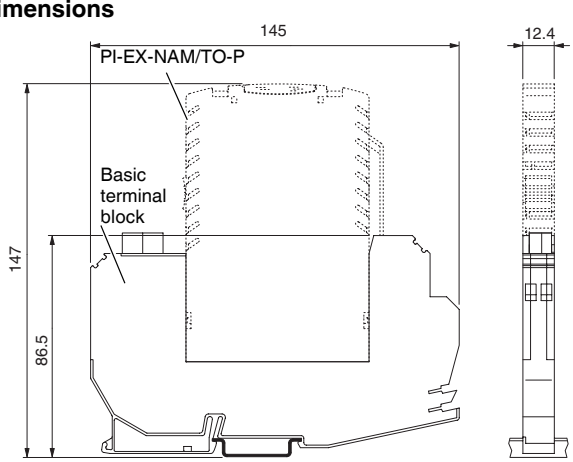

Figure 2 Dimensions (in mm)

6 Installation

NOTE: Electrostatic discharge

The device contains components that can be damaged or destroyed by electrostatic discharge. When handling the device, observe the necessary safety precautions against electrostatic discharge (ESD) according to EN 61340-5-1 and EN 61340-5-2.

WARNING: Explosion hazard

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

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

6.1 Base Elements

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

WARNING: Explosion hazard

If the **device has been used in non-intrinsically safe circuits,** it must **not** be used again in intrinsically safe circuits.

The module must be clearly labeled as non-intrinsically safe.

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

6.2 Automatic Keying of Electronic Modules

The base element is not keyed by default upon delivery. The user-friendly keying is located in the electronic module and consists of four plastic parts, which are joined together. When the electronic module is first removed, the lower part of the keying pins (⑩ in Figure 1 on page 6) remains in the base element. In this way, it is automatically keyed to the relevant electronic module.

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

Automatic keying	Electronic module		Base element	
	View from below (locking clip to the right)		View from above (isolating connector to the left)	
	Input	Output	Input	Output
PI-EX-NAM/TO-P	◁	▽	◁	△

7 Configuration

LF = Line fault detection enabled
NLF = Line fault detection disabled **(not permitted for safety-related applications, SIL 2)**
N = Normal function
I = Inverse function
PWR = Supply voltage
STAT = Transistor output switching status
LF = Line fault on the sensor cable

Figure 3 Configuration

By default upon delivery, line fault detection is disabled and the normal phase function is enabled.

7.1 Line Fault Detection (LF/NLF Switch)

Line fault detection is enabled or disabled using a switch (see Figure 3, disabling is not permitted for safety-related applications, SIL 2). When line fault detection is enabled, the transistor blocks so that the output is set to the safe, non-conductive state. The red LED (LF) lights up.

Operating range for the cable break alarm: 50 µA > I > 350 µA

Operating range for the short-circuit alarm: 100 Ω > R > 360 Ω

NOTE: For **switch contacts with open circuit** (Figure 4) line fault detection (LF) must be disabled or the corresponding resistance circuit must be provided directly at the switch contact (Figure 5, e.g., UKK 5-2R/NAMUR (Order No. 2941662) with D-UKK 3/5 (Order No. 2770024)).

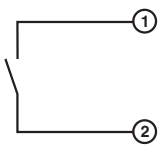

Figure 4 Switch contact with open circuit (not permitted for safety-related applications (SIL 2))

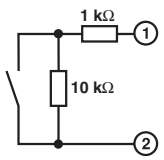

Figure 5 Switch contact with resistance circuit

7.2 Phase Reversal

The phase reversal function is enabled or disabled using a switch (see Figure 3).

Normal Phase	Inverted Phase
Output transistor conductive, if I > 2.1 mA	Output transistor blocking, if I > 2.1 mA
Output transistor blocking, if I < 1.2 mA	Output transistor conductive, if I < 1.2 mA

7.3 Truth Table for Non-Safety-Related Applications

NOTE: This truth table does **not** apply to safety-related applications according to IEC 61508 (SIL 2).
For the truth table for SIL 2 applications, please refer to page 10.

Sensor in Input			Input	Switch				Output	ST LED	LF LED
Switch										
Open Circuit	Resistance Circuit	NAMUR		N	I	NLF	LF	Transistor	Yellow	Red
Open	Open	Blocking	OK	X		X		Non-conductive		
Closed	Closed	Conductive	OK	X		X		Conductive	X	
Any	Any	Any	Open circuit	X		X		Non-conductive		
Any	Any	Any	Short circuit	X		X		Conductive	X	
Open	Open	Blocking	OK		X	X		Conductive	X	
Closed	Closed	Conductive	OK		X	X		Non-conductive		
Any	Any	Any	Open circuit		X	X		Conductive	X	
Any	Any	Any	Short circuit		X	X		Non-conductive		
	Open	Blocking	OK	X			X	Non-conductive		
	Closed	Conductive	OK	X			X	Conductive	X	
	Any	Any	Open circuit	X			X	Non-conductive		X
	Any	Any	Short circuit	X			X	Non-conductive		X
	Open	Blocking	OK		X		X	Conductive	X	
	Closed	Conductive	OK		X		X	Non-conductive		
	Any	Any	Open circuit		X		X	Non-conductive		X
	Any	Any	Short circuit		X		X	Non-conductive		X

8 Comparison of Safety Data

WARNING: Explosion hazard
Compare the safety data before connecting a device located in the Ex-i area to the PI-EX-NAM/TO-P.

Safety data of:

Field devices:	U_i, I_i, P_i, L_i, C_i
NAMUR isolation amplifiers:	U_o, I_o, P_o, L_o, C_o

For the values for U_o, I_o, P_o, L_o, and C_o, please refer to "Safety Data According to ATEX for Intrinsically Safe Circuits" on page 4.

Ex i Requirements:

$U_i \geq U_o$
$I_i \geq I_o$
$P_i \geq P_o$
$L_i + L_c \leq L_o$ (L_c and C_c depend on the cables/lines used)
$C_i + C_c \leq C_o$

9 Safety-Related Applications (SIL 2)

9.1 Installation

Use one of the following base elements:

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

9.2 Wiring

Input

Permitted for safety-related applications:

– NAMUR sensor (according to EN 60947-5-6)
– Switch contact with resistance circuit (1 kΩ serial and 10 kΩ parallel (tolerance ±10%))
(Note: The resistance circuit regulates the behavior of a NAMUR sensor)

WARNING: Switch contacts without resistance circuit are **not permitted** for safety-related applications.

Output

The safety-related function at the output depends on the "N/I" switch position.

N =	Normal function	In the event of a 0 signal (NAMUR sensor high resistance, therefore lower current in the input circuit), the output (transistor) switches to the "non-conductive" state.
I =	Inverse function	In the event of a 1 signal at the input, the output switches to the "non-conductive" state.

9.3 Diagnostic Function of the "LF/NLF" Switch

For safety applications, line fault detection is enabled, i.e., the slide switch is in the "LF" position.

WARNING: The "NLF" switch position is **not permitted** for safety-related applications.

When line fault detection is enabled, the red LED indicates any faults that occur. If a line fault is detected, the output is disabled ("non-conductive"). This behavior is independent of the position of the "N/I" switch.

9.4 Safe State

The "safe state" means that the output is in a non-conductive state, i.e., the transistor is blocking.

9.5 Truth Table for Safety-Related Applications (SIL 2)

WARNING: Only the "**LF**" switch position is **permitted** for safety-related applications.

WARNING: Only switch contacts with resistance circuit are **permitted** at the input for safety-related applications (see Figure 5 on page 7).

	Sensor in Input		Input	Switch				Output	ST LED	LF LED	Permitted for Safety-Related Applications
	Switch Resistance Circuit	NAMUR		N	I	NLF	LF	Relay	Yellow	Red	
	Open	Blocking	OK	X			X	Non-conductive			Yes
	Closed	Conductive	OK	X			X	Conductive	X		Yes
	Any	Any	Open circuit	X			X	Non-conductive		X	Yes
	Any	Any	Short circuit	X			X	Non-conductive		X	Yes
	Open	Blocking	OK		X		X	Conductive	X		Yes
	Closed	Conductive	OK		X		X	Non-conductive			Yes
	Any	Any	Open circuit		X		X	Non-conductive		X	Yes
	Any	Any	Short circuit		X		X	Non-conductive		X	Yes

LF = Line fault detection enabled

NLF = Line fault detection disabled **(not permitted for safety-related applications, SIL 2)**

N = Normal function

I = Inverse function

PWR LED = Supply voltage

STAT LED = Switching state of the relay output

LF LED = Line fault on the sensor cable

9.6 Response Times

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

9.7 Operating Mode of the Safety Function

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

9.8 Failure Behavior and Required Response

1. The safe state is entered in the event that a line fault is detected or the supply voltage fails (see Section 9.4).
2. The safe state is reached by removing the device from the base element.

Startup and Restart

Behavior	Description
Startup or restart of the device	The output enters the state without oscillation (according to the truth table on page 10). A reset is not required.
What happens when a line fault is detected and what must the user do?	The fault is indicated by the red LED and the output enters the "non-conductive" state regardless of the input signal and the operating mode (normal or inverse mode). The user must remove the line fault (short circuit or break in the sensor cable). The device output is not blocked when fault detection is triggered (no lock or reset). Undefined line states that occur during repairs can switch the output. This must be prevented by the user by disconnecting the supply voltage or by removing the device. Other options that have the same result and do not present an additional hazard are permitted.
The line fault is removed.	The user must ensure that a defined state is entered using the truth table on page 10. The device is restarted as with initial startup. The device then behaves as described under "Startup or restart of the device".

9.9 Safety Integrity Requirements

Error Rates

– Type A device (according to IEC 61508-2)
– Safety Integrity Level (SIL) 1 and 2

λ_{sd}	λ_{su}[1]	λ_{dd}	λ_{du}	SFF[2]	DC_S[3]	DC_D[3]
6 FIT[4]	183 FIT	8 FIT	37 FIT	84%	3%	17%

[1] The SU (**S**afe **U**ndetected) category includes failures that do not cause a spurious trip.

[2] SFF = **S**afe **F**ailure **F**raction

[3] DC = **D**iagnostic **C**overage (safe or dangerous)

[4] FIT = **F**ailure **i**n **T**ime (1 FIT = 1 failure/10^9 h)

PFD_{AVG} Values

T[PROOF] =	1 year	5 years	10 years
PFD_{AVG}[1] =	1,62E-04	8,08E-04	1,62E-03

[1] PFD = **P**robability of **F**ailure on **D**emand

The box marked in white means that the calculated PFD_{AVG} values are within the permitted range for SIL 2 according to table 2 of IEC 61508-1, but do not meet the requirement to not claim more than 10% of this range, i.e., to not be better than or equal to 1,00E-03.

The boxes marked in gray mean that the calculated PFD_{AVG} values are within the permitted range for SIL 2 according to table 2 of IEC 61508-1, but do meet the requirement to not claim more than 10% of this range, i.e., to be better than or equal to 1,00E-03.

Failure Limit

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

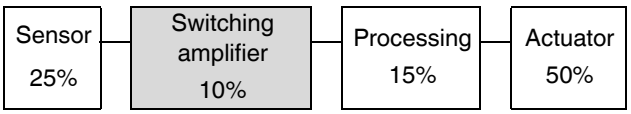

Figure 6 Safety loop

Conditions

– Line fault detection is active.
– The failure rates of the components used remain constant throughout the period of use.
– Propagation of errors by the device in the system is not taken into consideration.
– The repair time (= replacement) should take eight hours.
– The failure rates of the external power supply are not taken into consideration.
– The average temperature at which the device is to be used is +40°C. This is based on standard industrial conditions.
– At an average temperature of +60°C, the error rates should by multiplied by 2.5 (guide value).
– A multiplier must also be used in the event of frequently fluctuating temperatures.

9.10 Proof Test

1. Carry out the appropriate steps to prevent incorrect use.
2. An appropriate signal is applied at the input of the PI-EX-NAM/TO-P NAMUR switching amplifier in order to obtain the non-conductive state at the output. Check whether the output is non-conductive.
3. Restore the full functions of the safety circuit.
4. Restore normal mode.

With this test around 99% of possible "du" ("**d**angerous **u**ndetected") errors are uncovered in the NAMUR isolation amplifier.

10 Appendix

Exida Assessment Summary (3 pages)

Failure Modes, Effects and Diagnostic Analysis

Project:

NAMUR Switching Amplifiers
PI-Ex-NAM/RNO-NE and PI-Ex-NAM/TO-P

Customer:

PHOENIX CONTACT GmbH & Co. KG
Blomberg
Germany

Contract No.: Phoenix Contact 05/10-12
Report No.: Phoenix Contact 05/10-12 R002
Version V1, Revision R1.1, March 2006
Stephan Aschenbrenner

Management summary

This report summarizes the results of the hardware assessment carried out on the NAMUR switching amplifiers PI-Ex-NAM/RNO-NE (relay output) and PI-Ex-NAM/TO-P (transistor output).

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

For safety applications only the described outputs have been considered. All other possible output variants or electronics are not covered by this report.

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

According to table 2 of IEC 61508-1 the average PFD for systems operating in low demand mode has to be $\geq 10^{-3}$ to $< 10^{-2}$ for SIL 2 safety functions. However, as the modules under consideration are only one part of an entire safety function they should not claim more than 10% of this range, i.e. they should be better than or equal to 1,00E-03.

The NAMUR switching amplifiers PI-Ex-NAM/RNO-NE and PI-Ex-NAM/TO-P are considered to be Type A[1] components with a hardware fault tolerance of 0.

For Type A components the SFF has to be between 60% to < 90% according to table 2 of IEC 61508-2 for SIL 2 (sub-) systems with a hardware fault tolerance of 0.

The following tables show how the above stated requirements are fulfilled.

Table 1: Summary PI-Ex-NAM/RNO-NE – Failure rates

λ_{sd}	λ_{su} [2]	λ_{dd}	λ_{du}	SFF	DC_S [3]	DC_D [3]
6 FIT	194 FIT	8 FIT	74 FIT	73%	3%	9%

Table 2: Summary PI-Ex-NAM/RNO-NE – PFD_{AVG} values

T[Proof] = 1 year	T[Proof] = 5 years	T[Proof] = 10 years
PFD_{AVG} = 3,25E-04	PFD_{AVG} = 1,62E-03	PFD_{AVG} = 3,25E-03

Table 3: Summary PI-Ex-NAM/TO-P – Failure rates

λ_{sd}	λ_{su} [2]	λ_{dd}	λ_{du}	SFF	DC_S [3]	DC_D [3]
6 FIT	183 FIT	8 FIT	37 FIT	84%	3%	17%

Table 4: Summary PI-Ex-NAM/TO-P – PFD_{AVG} values

T[Proof] = 1 year	T[Proof] = 5 years	T[Proof] = 10 years
PFD_{AVG} = 1,62E-04	PFD_{AVG} = 8,08E-04	PFD_{AVG} = 1,62E-03

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

[2] Note that the SU category includes failures that do not cause a spurious trip

[3] DC means the diagnostic coverage (safe or dangerous).

The boxes marked in yellow ( ) mean that the calculated PFD_{AVG} values are within the allowed range for SIL 2 according to table 2 of IEC 61508-1 but do not fulfill the requirement to not claim more than 10% of this range, i.e. to be better than or equal to 1,00E-03. The boxes marked in green ( ) mean that the calculated PFD_{AVG} values are within the allowed range for SIL 2 according to table 2 of IEC 61508-1 and do fulfill the requirement to not claim more than 10% of this range, i.e. to be better than or equal to 1,00E-03.

Because the Safe Failure Fraction (SFF) is above 60%, also the architectural constraints requirements of table 2 of IEC 61508-2 for Type A subsystems with a Hardware Fault Tolerance (HFT) of 0 are fulfilled.

The listed failure rates are valid for operating stress conditions typical of an industrial field environment similar to IEC 60654-1 class C (sheltered location) with an average temperature over a long period of time of 40ºC. For a higher average temperature of 60°C, the failure rates should be multiplied with an experience based factor of 2,5. A similar multiplier should be used if frequent temperature fluctuation must be assumed.

A user of the NAMUR switching amplifiers PI-Ex-NAM/RNO-NE and PI-Ex-NAM/TO-P can utilize these failure rates in a probabilistic model of a safety instrumented function (SIF) to determine suitability in part for safety instrumented system (SIS) usage in a particular safety integrity level (SIL). A full table of failure rates is presented in sections 5.1 and 5.2 along with all assumptions.

It is important to realize that the “no effect” and “annunciation undetected” failures are included in the “safe undetected” failure category according to IEC 61508. Note that these failures on its own will not affect system reliability or safety, and should not be included in spurious trip calculations.

The failure rates are valid for the useful life of the NAMUR switching amplifiers PI-Ex-NAM/RNO-NE and PI-Ex-NAM/TO-P, which is estimated to be between 8 to 12 years (see Appendix 2).

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