**TURCK**

# IMX12-DI… | IM12-DI…
# Isolating Switching Amplifier

Safety Manual

# Contents

# Contents

# 1 About this document

This safety manual contains all information that is required by users to operate the device in functional safety systems. Read this manual carefully before using the device.

This document addresses only functional safety according IEC 61508. Other, e.g. intrinsic safety, is not considered.

All instructions must be followed in order to assure functional safety.

Always make sure that this is the latest version of the safety manual at www.turck.com.
The English version is considered the definitive document. Every care was taken in the production of the translations of this document. If there is any uncertainty in its interpretation, refer to the English version of the  safety manual or contact Turck directly.

# 2 Scope

This safety manual is valid for the following devices.

| Ident no. | Product Name | Number of Channels | Clamps | Power-Bridge | Intrinsic Safety |
|---|---|---|---|---|---|
| 7580000 | IMX12-DI03-1S-1NAM1R-0/24VDC | 1 | screw clamps | no | yes |
| 7580001 | IMX12-DI03-1S-1NAM1R-PR/24VDC | 1 | screw clamps | yes | yes |
| 7580002 | IMX12-DI03-1S-1NAM1R-0/24VDC/CC | 1 | spring type terminal | no | yes |
| 7580003 | IMX12-DI03-1S-1NAM1R-PR/24VDC/CC | 1 | spring type terminal | yes | yes |
| 7580004 | IMX12-DI03-1S-1NAM1T-0/24VDC | 1 | screw clamps | no | yes |
| 7580005 | IMX12-DI03-1S-1NAM1T-PR/24VDC | 1 | screw clamps | yes | yes |
| 7580006 | IMX12-DI03-1S-1NAM1T-0/24VDC/CC | 1 | spring type terminal | no | yes |
| 7580007 | IMX12-DI03-1S-1NAM1T-PR/24VDC/CC | 1 | spring type terminal | yes | yes |
| 7580008 | IMX12-DI03-1S-2R-S/24VDC | 1 | screw clamps | no | yes |
| 7580009 | IMX12-DI03-1S-2R-SPR/24VDC | 1 | screw clamps | yes | yes |
| 7580010 | IMX12-DI03-1S-2R-S/24VDC/CC | 1 | spring type terminal | no | yes |
| 7580011 | IMX12-DI03-1S-2R-SPR/24VDC/CC | 1 | spring type terminal | yes | yes |
| 7580012 | IMX12-DI03-1S-2T-S/24VDC | 1 | screw clamps | no | yes |
| 7580013 | IMX12-DI03-1S-2T-SPR/24VDC | 1 | screw clamps | yes | yes |
| 7580014 | IMX12-DI03-1S-2T-S/24VDC/CC | 1 | spring type terminal | no | yes |
| 7580015 | IMX12-DI03-1S-2T-SPR/24VDC/CC | 1 | spring type terminal | yes | yes |
| 7580016 | IMX12-DI01-2S-2R-0/24VDC | 2 | screw clamps | no | yes |
| 7580017 | IMX12-DI01-2S-2R-PR/24VDC | 2 | screw clamps | yes | yes |
| 7580018 | IMX12-DI01-2S-2R-0/24VDC/CC | 2 | spring type terminal | no | yes |
| 7580019 | IMX12-DI01-2S-2R-PR/24VDC/CC | 2 | spring type terminal | yes | yes |
| 7580020 | IMX12-DI01-2S-2T-0/24VDC | 2 | screw clamps | no | yes |
| 7580021 | IMX12-DI01-2S-2T-PR/24VDC | 2 | screw clamps | yes | yes |
| 7580022 | IMX12-DI01-2S-2T-0/24VDC/CC | 2 | spring type terminal | no | yes |
| 7580023 | IMX12-DI01-2S-2T-PR/24VDC/CC | 2 | spring type terminal | yes | yes |
| 7580024 | IMX12-DI01-2S-2PP-0/24VDC | 2 | screw clamps | no | yes |
| 7580025 | IMX12-DI01-2S-2PP-PR/24VDC | 2 | screw clamps | yes | yes |
| 7580026 | IMX12-DI01-2S-2PP-0/24VDC/CC | 2 | spring type terminal | no | yes |

| Ident no. | Product Name | Number of Channels | Clamps | Power-Bridge | Intrinsic Safety |
|---|---|---|---|---|---|
| 7580027 | IMX12-DI01-2S-2PP-PR/24VDC/CC | 2 | spring type terminal | yes | yes |
| 7580028 | IM12-DI03-1S-2R-S/24VDC | 1 | screw clamps | no | no |
| 7580029 | IM12-DI03-1S-2R-SPR/24VDC | 1 | screw clamps | yes | no |
| 7580030 | IM12-DI03-1S-2R-S/24VDC/CC | 1 | spring type terminal | no | no |
| 7580031 | IM12-DI03-1S-2R-SPR/24VDC/CC | 1 | spring type terminal | yes | no |
| 7580032 | IM12-DI03-1S-2T-S/24VDC | 1 | screw clamps | no | no |
| 7580033 | IM12-DI03-1S-2T-SPR/24VDC | 1 | screw clamps | yes | no |
| 7580034 | IM12-DI03-1S-2T-S/24VDC/CC | 1 | spring type terminal | no | no |
| 7580035 | IM12-DI03-1S-2T-SPR/24VDC/CC | 1 | spring type terminal | yes | no |
| 7580036 | IM12-DI01-2S-2R-0/24VDC | 2 | screw clamps | no | no |
| 7580037 | IM12-DI01-2S-2R-PR/24VDC | 2 | screw clamps | yes | no |
| 7580038 | IM12-DI01-2S-2R-0/24VDC/CC | 2 | spring type terminal | no | no |
| 7580039 | IM12-DI01-2S-2R-PR/24VDC/CC | 2 | spring type terminal | yes | no |
| 7580040 | IM12-DI01-2S-2T-0/24VDC | 2 | screw clamps | no | no |
| 7580041 | IM12-DI01-2S-2T-PR/24VDC | 2 | screw clamps | yes | no |
| 7580042 | IM12-DI01-2S-2T-0/24VDC/CC | 2 | spring type terminal | no | no |
| 7580043 | IM12-DI01-2S-2T-PR/24VDC/CC | 2 | spring type terminal | yes | no |
| 7580044 | IM12-DI01-2S-2PP-0/24VDC | 2 | screw clamps | no | no |
| 7580045 | IM12-DI01-2S-2PP-PR/24VDC | 2 | screw clamps | yes | no |
| 7580046 | IM12-DI01-2S-2PP-0/24VDC/CC | 2 | spring type terminal | no | no |
| 7580047 | IM12-DI01-2S-2PP-PR/24VDC/CC | 2 | spring type terminal | yes | no |
| 7580048 | IM12-DI03-1S-1NAM1R-0/24VDC | 1 | screw clamps | no | no |
| 7580049 | IM12-DI03-1S-1NAM1R-PR/24VDC | 1 | screw clamps | yes | no |
| 7580050 | IM12-DI03-1S-1NAM1R-0/24VDC/CC | 1 | spring type terminal | no | no |
| 7580051 | IM12-DI03-1S-1NAM1R-PR/24VDC/CC | 1 | spring type terminal | yes | no |
| 7580052 | IM12-DI03-1S-1NAM1T-0/24VDC | 1 | screw clamps | no | no |
| 7580053 | IM12-DI03-1S-1NAM1T-PR/24VDC | 1 | screw clamps | yes | no |
| 7580054 | IM12-DI03-1S-1NAM1T-0/24VDC/CC | 1 | spring type terminal | no | no |
| 7580055 | IM12-DI03-1S-1NAM1T-PR/24VDC/CC | 1 | spring type terminal | yes | no |

The following chapters cover the devices
- IMX12-DI03-1S-1NAM1R
- IM12-DI03-1S-1NAM1R
- IMX12-DI03-1S-1NAM1T
- IM12-DI03-1S-1NAM1T
- IMX12-DI03-1S-2R
- IM12-DI03-1S-2R
- IMX12-DI03-1S-2T
- IM12-DI03-1S-2T
- IMX12-DI01-2S-2R
- IM12-DI01-2S-2R
- IMX12-DI01-2S-2T
- IM12-DI01-2S-2T
- IMX12-DI01-2S-2PP
- IM12-DI01-2S-2PP

# 3 Safety Integrity Level

The devices are rated to a SIL of

| SIL2 |
| --- |

# 4 Product description

The isolating switching amplifiers are used for the galvanically isolated transmission of binary signals from sensors and mechanical contacts. Sensors acc. to EN 60947-5-6 (NAMUR) or mechanical contacts can be connected.

The output circuits are isolated from the input circuits and are either designed as relay outputs or potentially isolated transistor outputs, or NAMUR-outputs potential outputs.

## 4.1 Safety function

| | |
| --- | --- |
| **IMX12-DI01-2S-2R**<br>**IM12-DI01-2S-2R** | According to the input signal and the configuration (linemonitoring, effective direction, mapping of inputs and outputs) the relay output is within 20 ms de-energized. |
| **IMX12-DI01-2S-2T**<br>**IM12-DI01-2S-2T** | According to the input signal and the configuration (linemonitoring, effective direction, mapping of inputs and outputs) the transistor output is within 20 ms blocked. |
| **IMX12-DI03-1S-2R**<br>**IM12-DI03-1S-2R** | According to the input signal and the configuration (linemonitoring, effective direction, mapping of inputs and outputs) the relay output is within 20 ms de-energized. |
| **IMX12-DI03-1S-2T**<br>**IM12-DI03-1S-2T** | According to the input signal and the configuration (linemonitoring, effective direction, mapping of inputs and outputs) the transistor output is within 20 ms blocked. |
| **IMX12-DI01-2S-2PP**<br>**IM12-DI01-2S-2PP** | According to the input signal and the configuration (linemonitoring, effective direction, mapping of inputs and outputs) the output is within 20 ms < 1 V. |
| **IMX12-DI03-1S-1NAM1R**<br>**IM12-DI03-1S-1NAM1R** | According to the input signal and the configuration (linemonitoring, effective direction) the NAMUR output is within 20 ms 11 KΩ (± 5%).<br>According to the input signal and the configuration (linemonitoring, effective direction) the relais output is within 20 ms de-energized. |
| **IMX12-DI03-1S-1NAM1T**<br>**IM12-DI03-1S-1NAM1T** | According to the input signal and the configuration (linemonitoring, effective direction) the NAMUR output is within 20 ms 11 KΩ (± 5%).<br>According to the input signal and the configuration (linemonitoring, effective direction) the transistor output is within 20 ms blocked. |

Two devices must not be used for the same safety-function, e.g. to increase the hardware fault tolerance to achieve a higher SIL.

A 1oo2 architecture doesn´t achieve a SIL3.

The two channels are not used for the same safety function, e.g. to increase the hardware failure tolerance to achieve a higher SIL, as they contain common components.

Only one input and one output are part of the safety function. Signal doubling is not used.

The Power-Bridge is not part of the safety-function.

The LED is not part of the safety-function.

The common alarm output is not part of the safety-function.

## 4.2 Safe state

| | |
|---|---|
| **IMX12-DI-01-2S-2R**<br>**IM12-DI-01-2S-2R** | In the safe state the relay output is de-energized. |
| **IMX12-DI-01-2S-2T**<br>**IM12-DI-01-2S-2T** | In the safe state the transistor is blocked. |
| **IMX12-DI01-2S-2PP**<br>**IM12-DI01-2S-2PP** | In the safe state the output is < 1 V. |
| **IMX12-DI03-1S-2R**<br>**IM12-DI03-1S-2R** | In the safe state the relay output is de-energized. |
| **IMX12-DI03-1S-2T**<br>**IM12-DI03-1S-2T** | In the safe state the transistor is blocked. |
| **IMX12-DI03-1S-1NAM1R**<br>**IM12-DI03-1S-1NAM1R** | In the safe state the NAMUR output is >11 KΩ (± 5 %).<br>In the safe state the relay output is de-energized. |
| **IMX12-DI03-1S-1NAM1T**<br>**IM12-DI03-1S-1NAM1T** | In the safe state the NAMUR output is >11 KΩ (± 5 %)<br>In the safe state the transistor is blocked. |

Faults do not have to be acknowledged. If the fault is rectified, the device automatically resumes operation and leaves the safe state.

# 5 Safety-Planning

This chapter provides information for planning a safety-related loop.

The device is not specified for a certain application. Make sure that the data provided in this chapter is valid for your target application.

Special application-specific factors may cause the premature wear of the device and must be taken into consideration when planning systems; take special measures to compensate for a lack of experience based values, e.g. through implementation of shorter test intervals.

The suitability for specific applications must be assessed by considering the particular overall safety-related system with regard to the requirements of IEC 61508.

Safety-planning must only be carried out by trained and qualified personnel. In case of doubt contact Turck directly.

## 5.1    Architectural specifications

Due to architectural considerations the following characteristics are specified:

| Type | A |
|------|---|
| HFT  | 0 |

Experience has shown that the useful lifetime often lies within a range of 8 to 12 years. It can be significantly less if elements are operated near their specification limits. However, it can be extended by appropriate measures. For example, heavy temperature fluctuations could potentially decrease the useful lifetime, as constant temperature below 40 °C could potentially increase the useful lifetime.

For the relay outputs (cos phi = 1, I = 6 A AC) the useful liftetime is 8 to 12 years or 50.000 switching cycles.

## 5.2    Assumptions

- Failure rates are constant for 10 years, wear out mechanisms are not included
- Propagation of failures is not relevant
- External power supply failure rates are not included
- All components that are not part of the safety function and cannot influence the safety function (feedback immune) are excluded.
- Only one input and one output are part of the safety function
- The activations of line-monitoring can improve the results

## 5.3    FMEDA results

The following safety characteristic are the results of the FMEDA.
According to the configuration (inversion-mode, line-monitoring) the results of the FMEDA vary. In this case the worst-case configuration is regarded

|  | $\lambda SD$ | $\lambda SU$ | $\lambda DD$ | $\lambda DU$ | No effect | SFF | DC |
|---|---|---|---|---|---|---|---|
| IMX12-DI01-2S-2R<br>IM12-DI01-2S-2R | 0 FIT | 184 FIT | 3 FIT | 93 FIT | 256 FIT | 66% | 3% |
| IMX12-DI01-2S-2T<br>IM12-DI01-2S-2T | 0 FIT | 163 FIT | 3 FIT | 99 FIT | 246 FIT | 62% | 3% |
| IMX12-DI01-2S-2PP<br>IM12-DI01-2S-2PP | 0 FIT | 159 FIT | 3 FIT | 84 FIT | 246 FIT | 66% | 3% |
| IMX12-DI03-1S-2R<br>IM12-DI03-1S-2R | 0 FIT | 150 FIT | 3 FIT | 86 FIT | 239 FIT | 64% | 3% |
| IMX12-DI03-1S-2T<br>IM12-DI03-1S-2T | 0 FIT | 150 FIT | 3 FIT | 86 FIT | 239 FIT | 64% | 3% |
| IMX12-DI03-1S-1NAM1R<br>IM12-DI03-1S-1NAM1R | 0 FIT | 159 FIT | 3 FIT | 94 FIT | 238 FIT | 63% | 3% |
| IMX12-DI03-1S-1NAM1T<br>IM12-DI03-1S-1NAM1T | 0 FIT | 159 FIT | 3 FIT | 94 FIT | 238 FIT | 63% | 3% |

The stated SFF is for reference only. The complete subsystem will need to be evaluated to determine the overall Safe Failure Fraction.

The failure rates used in this analysis are the basic failure rates from the Siemens standard SN 29500 based on the average ambient temperature of components of 40 °C.

"No effect" is a failure mode of a component that plays part in implementing the safety function but is neither a safe nor a dangerous failure. According to IEC 62061, it would be possible to classify the "No effect" failures as "Safe Undetected" failures. Not doing so represents the worst-case.

## 5.4 Examples for using the results

### 5.4.1 Probability of dangerous failure per hour (High Demand mode)

The PFH values are based on a worst-case diagnostic test rate and a reaction time of 20ms. The ratio of the diagnostic test rate to the demand rate shall equal or exceed 100.

|  | PFH |
|---|---|
| IMX12-DI01-2S-2R<br>IM12-DI01-2S-2R | $9.30 * 10E{-}08$ 1/h |
| IMX12-DI01-2S-2T<br>IM12-DI01-2S-2T | $9.86 * 10E{-}08$ 1/h |
| IMX12-DI01-2S-2PP<br>IM12-DI01-2S-2PP | $8.36 * 10E{-}08$ 1/h |
| IMX12-DI03-1S-2R<br>IM12-DI03-1S-2R | $8.55 * 10E{-}08$ 1/h |
| IMX12-DI03-1S-2T<br>IM12-DI03-1S-2T | $8.55 * 10E{-}08$ 1/h |
| IMX12-DI03-1S-1NAM1R<br>IM12-DI03-1S-1NAM1R | $9.35 * 10E{-}08$ 1/h |
| IMX12-DI03-1S-1NAM1T<br>IM12-DI03-1S-1NAM1T | $9.35 * 10E{-}08$ 1/h |

### 5.4.2 Average probability of dangerous failure on demand (Low Demand mode)

With the FMEDA results and the values specified in the following table the average frequency of dangerous failure can be calculated exemplarily:

| $T_1$ | 8760 h |
|---|---|
| MTTR | 24h |

|  | $PFD_{avg}$ |
|---|---|
| IMX12-DI01-2S-2R<br>IM12-DI01-2S-2R | $4.80 * 10E{-}04$ |
| IMX12-DI01-2S-2T<br>IM12-DI01-2S-2T | $5.09 * 10E{-}04$ |
| IMX12-DI01-2S-2PP<br>IM12-DI01-2S-2PP | $4.31 * 10E{-}04$ |
| IMX12-DI03-1S-2R<br>IM12-DI03-1S-2R | $4.41 * 10E{-}04$ |
| IMX12-DI03-1S-2T<br>IM12-DI03-1S-2T | $4.41 * 10E{-}04$ |
| IMX12-DI03-1S-1NAM1R<br>IM12-DI03-1S-1NAM1R | $4.82 * 10E{-}04$ |
| IMX12-DI03-1S-1NAM1T<br>IM12-DI03-1S-1NAM1T | $4.82 * 10E{-}04$ |

# 6 Operating Instructions

## 6.1 General

➤ The device must be registered online: www.turck.com/SIL or with the supplied SIL registration card. This must be filled in with all required information upon receipt and sent to Turck.

➤ The device must only be carried out, fitted, installed, operated, commissioned and maintained by trained and qualified personnel.

➤ The device is not specified for a certain application. Make sure that application-specific aspects are considered.

➤ Data from other documents, e.g. data sheets, is not valid for functional safety operation. Devices must be used in cabinets in an typical industrial field environment only. The following restrictions describe the operation and storage conditions:

    ➤ Ensure that the environment complies with the following ratings

| | |
|---|---|
| Minimum ambient temperature | -25 °C |
| Maximum ambient temperature | 70 °C |
| Minimum storage temperature | -40 °C |
| Maximum storage temperature | 80 °C |
| Maximum air humidity | 95 % |
| Minimum air pressure | 80 kPa |
| Maximum air pressure | 110 kPa |

    ➤ The average temperature over a long period of time directly on the exterior sidewall of the housing must be maximum 40 °C.

    – The temperature on the exterior sidewall of the housing can deviate considerably from the temperature in the control cabinet.

    – The temperature on the exterior sidewall of the housing must be observed in a steady state.

    – In case the temperature on the exterior sidewall of the housing is higher, the failure rates from "5.3 FMEDA results" on page 10 must be adjusted:
For a higher average temperature of 60 °C on the exterior sidewall of the housing, the failure rates are multiplied by an experience factor of 2.5.

    ➤ Ensure that sufficient heat dissipation is provided.

    ➤ Protect the device from radiated heat and severe temperature fluctuations.

    ➤ Protect the device from dust, dirt, moisture, shock, vibration, chemical stress, increased radiation and other environmental influences.

    ➤ Ensure a degree of protection of at least IP20 according to IEC 60529 at the mounting location.

    ➤ Ensure that the electromagnetic stress does not increase the requirements of IEC 61326-3.1.

➤ If there is a visible error, e.g. defective housing the device must not be used.

➤ During operation of the device, surface temperatures may occur that could lead to burns if touched.

➤ The device must not be repaired. If problems occur with regard to functional safety, Turck must be notified immediately and the device must be returned immediately to:

Hans Turck GmbH & Co. KG
Witzlebenstraße 7
45472 Mülheim an der Ruhr
Germany

## 6.2 Before Operation

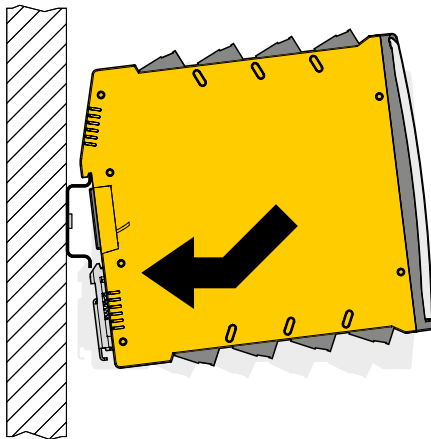➤ Fasten the device to a rail according EN 60715 (TH35) as follows:



Fig. 1: Fasten the device

➤ Connect cables according to the wiring diagrams in **"7 Appendix: Connection and wiring diagrams" on page 19**
➤ Use cables with Terminal cross section
  — rigid: 0.2 mm$^2$ to 2.5 mm$^2$ or
  — flexible 0.2 mm$^2$ to 2.5 mm$^2$
➤ When wiring with stranded wires: Fix the wiring ends with ferrules.

Connection via screw terminals:

➤ Insert the stripped cable ends (7 mm) in the guides of the cable glands.
➤ Fasten the screws with a screwdriver (max. tightening torque 0.5 Nm) to affix the cable ends.
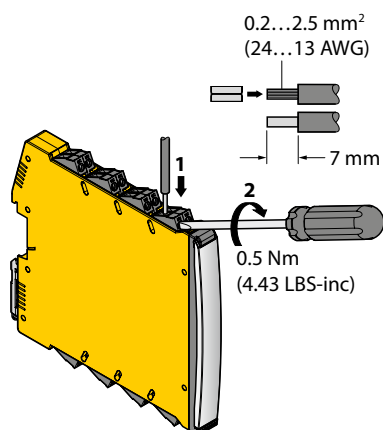


Fig. 2: Connection with screw terminals

Connection with spring-type terminals

➤ Push the opening lever with a suitable screwdriver.
➤ Insert the stripped cable ends (7 mm) in the guides of the spring-type terminals.
➤ Pull the screwdriver to fix the cable ends.
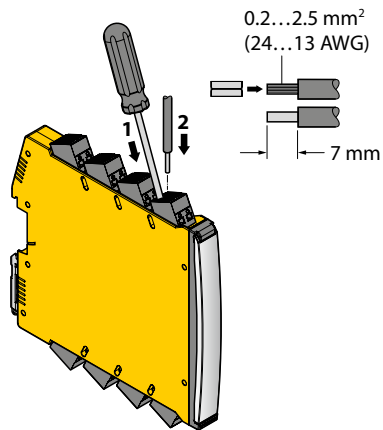


Fig. 3:     Connection with spring-type terminals

➤ Make sure that only suitable equipment, e.g. sensors, are connected to the device (see **"7 Appendix: Connection and wiring diagrams" on page 19**).
➤ Make sure that a suitable power supply with the following characteristic is used:

| Minimum voltage | 10 VDC |
| --- | --- |
| Maximum voltage | 30 VDC |
| Minimum Power | 4 W |

The relay outputs shall be protected by a fuse that limits the current to 2 A to avoid contact welding.

## 6.2.1    Parameterization

### Parameterization IMX12-DI01-2S-2X

| Product Name |
| --- |
| IMX12-DI01-2S-2R |
| IM12-DI01-2S-2R |
| IMX12-DI01-2S-2T |
| IM12-DI01-2S-2T |
| IMX12-DI01-2S-2PP |
| IM12-DI01-2S-2PP |

The safety function depends on the parameterization via DIP switches. The following switches are available:
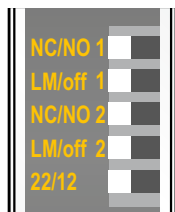


| Switch | Description |
| --- | --- |
| NC / NO | "Normally closed" (NC) or "Normally open" (NO) operation. See table below for details. |
| LM / off | Line monitoring for wire break and short circuit activated (LM) or deactivated (off). See table below for details. |
| 22 / 12 | This switch must always be set to 22. |

The numbers after "NC / NO" and "LM / off" represent the channel. 1 controls the function of input E1 to A1. 2 controls the function of input E2 to A2.

The following table describes the cases for the execution of the safety function
■ "IMX12-DI01-2S-2R: The relay output is within 20 ms de-energized"
■ "IM12-DI01-2S-2R: The relay output is within 20 ms de-energized"
■ "IMX12-DI01-2S-2R: The transistor output is within 20 ms blocked"
■ "IM12-DI01-2S-2R: The transistor output is within 20 ms blocked"
■ "IMX12-DI01-2S-2PP:The output is within 20 ms < 1 V"
■ "IM12-DI01-2S-2PP:The output is within 20 ms < 1 V"
depending on the input signal and the parameterizsation:

| input signal (sensor state) according IEC 60947-5-6 | LM / off | NC / NO |
| --- | --- | --- |
| wire break | off | NO |
| | LM | NC or NO |
| short circuit | off | NC |
| | LM | NC or NO |
| open | LM or off | NO |
| closed | LM or off | NC |

## Parameterization IMX12-DI03-1S-2X

| Product Name |
| --- |
| IMX12-DI03-1S-2R |
| IM12-DI03-1S-2R |
| IMX12-DI03-1S-2T |
| IM12-DI03-1S-2T |

The safety function depends on the parameterization via DIP switches. The following switches are available:



| Switch | Description |
| --- | --- |
| NC / NO | "Normally closed" (NC) or "Normally open" (NO) operation. See tables below for details. |
| LM / off | Line monitoring for wire break and short circuit activated (LM) or deactivated (off). See tables below for details. |
| 121 / 12 | Selects between splitter function (12) and separate alarm output (121). See tables below for details. |

The following table describes the cases for the execution of the safety function
- "IMX12-DI03-1S-2R: The relay output is within 20 ms de-energized"
- "IM12-DI03-1S-2R: The relay output is within 20 ms de-energized"
- "IMX12-DI03-1S-2T: The transistor output is within 20 ms blocked"
- "IM12-DI03-1S-2T: The transistor output is within 20 ms blocked"
depending on the input signal and the parameterization:

### A1 or A2 in splitter function

| input signal (sensor state) according IEC 60947-5-6 | LM / off | NC / NO |
| --- | --- | --- |
| wire break | off | NO |
| | LM | NC or NO |
| short circuit | off | NC |
| | LM | NC or NO |
| open | LM or off | NO |
| closed | LM or off | NC |

### A2 as alarm output

| input signal (sensor state) according IEC 60947-5-6 | LM / off | NC / NO |
| --- | --- | --- |
| wire break | LM | NC or NO |
| short circuit | LM | NC or NO |

## Parameterization IMX12-DI03-1S-1NAM1X

| Product Name |
| --- |
| IMX12-DI03-1S-1NAM1R |
| IM12-DI03-1S-1NAM1R |
| IMX12-DI03-1S-1NAM1T |
| IM12-DI03-1S-1NAM1T |

The safety function depends on the parameterization via DIP switches. The following switches are available:
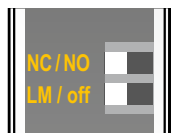
NC / NO
LM / off

| Switch | Description |
| --- | --- |
| NC / NO | "Normally closed" (NC) or "Normally open" (NO) operation. See table below for details. |
| LM / off | Line monitoring for wire break and short circuit activated (LM) or deactivated (off). See table below for details. |

### A1 – NAMUR output
The following table describes the cases for the execution of the safety function
■ "The NAMUR output is within 20 ms 11 K$\Omega$ ($\pm$ 5 %)"
depending on the input signal and the parameterization:

| input signal (sensor state) according IEC 60947-5-6 | LM / off | NC / NO |
| --- | --- | --- |
| wire break | off | NO |
| short circuit | off | NC |
| open | LM or off | NO |
| closed | LM or off | NC |

### A2 - Relais/transistor output:
The following table describes the cases for the execution of the safety function
■ "IMX12-DI03-1S-1NAM1R: The relay output is within 20 ms de-energized"
■ "IM12-DI03-1S-1NAM1R: The relay output is within 20 ms de-energized"
■ "IMX12-DI03-1S-1NAM1T: The transistor output is within 20 ms blocked"
■ "IM12-DI03-1S-1NAM1T: The transistor output is within 20 ms blocked"
depending on the input signal and the parameterization

| input signal (sensor state) according IEC 60947-5-6 | LM / off | NC / NO |
| --- | --- | --- |
| wire break | off | NO |
| | LM | NC or NO |
| short circuit | off | NC |
| | LM | NC or NO |
| open | LM or off | NO |
| closed | LM or off | NC |

## 6.3    Operation

➤ If the device is used in low demand mode, proof tests shall be executed executed periodically according to T1 (see **"9 Appendix: Proof tests" on page 27**).

➤ Ensure that the plug connections and cables are always in good condition.

➤ The device must be replaced immediately if the terminals are faulty or the device has any visible faults.

➤ If cleaning is required, do not use any liquid or statically charging cleaning agent. Perform proof tests after each cleaning (see **"9 Appendix: Proof tests" on page 27**).

➤ The proof test (see **"9 Appendix: Proof tests" on page 27**) shall be executed each time after installation and parameterization in order to check the requested function.

➤ The DIP switches shall not be modified during operation. The device shall be locked against unintended operation/modification.

## 6.4    After Operation

➤ Undo the terminal connection on the device.

➤ Remove the device from its rail fixing as shown in the figure:
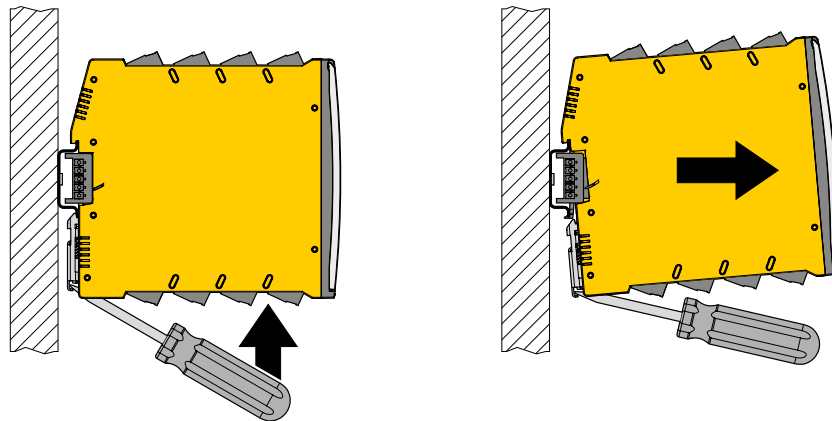


Fig. 4:      Remove device

➤ Ensure the proper disposal of the device.

# 7 Appendix: Connection and wiring diagrams

The pin number assignment can be found at the front label.

## 7.1 Output Relay

**Output relay – Load curve**
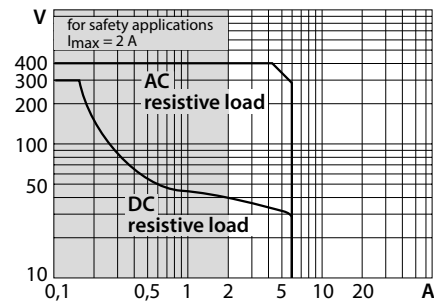


Fig. 5:     Output relay load curve

### 7.1.1 IMX12-DI01-2S-2R
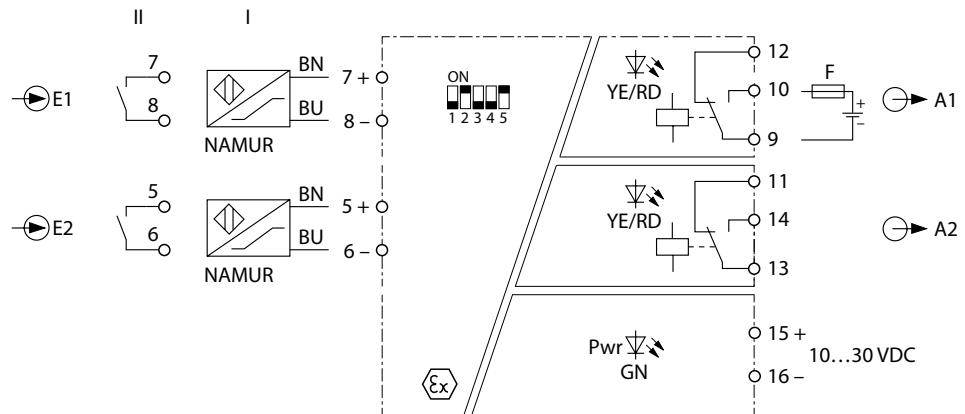


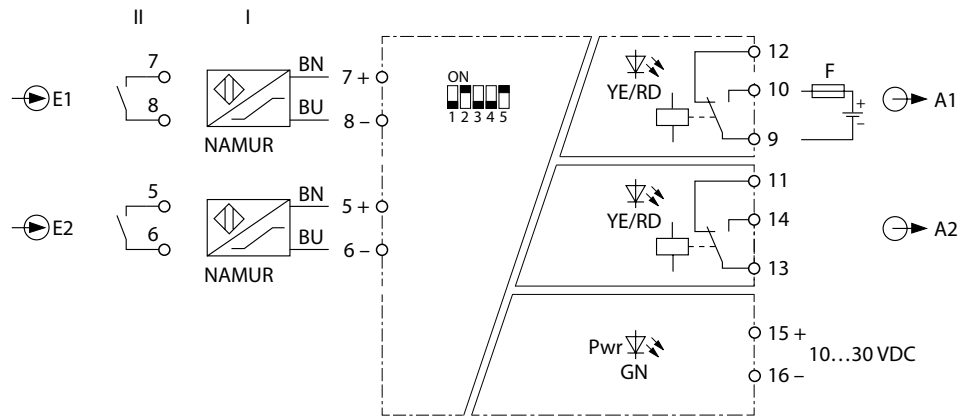Fig. 6:     Block diagram IMX12-DI01-2S-2R

### 7.1.2    IM12-DI01-2S-2R



Fig. 7:     Block diagram IMX12-DI01-2S-2R
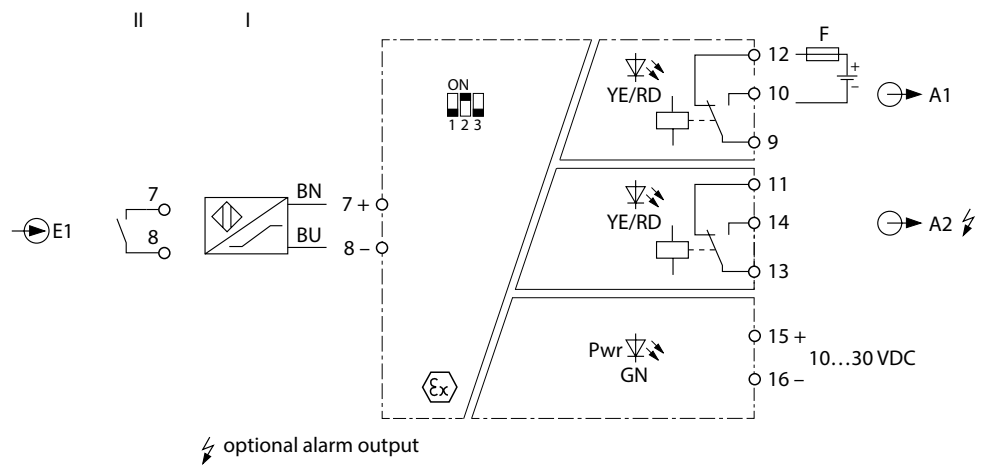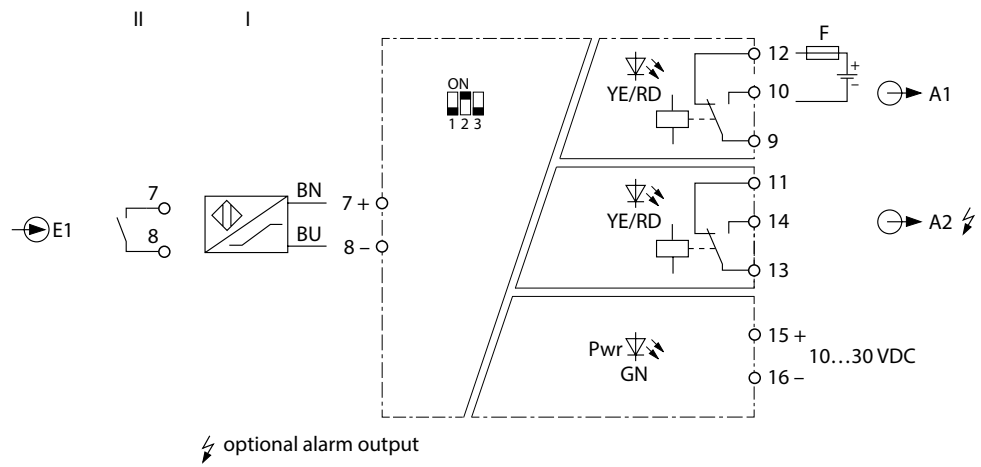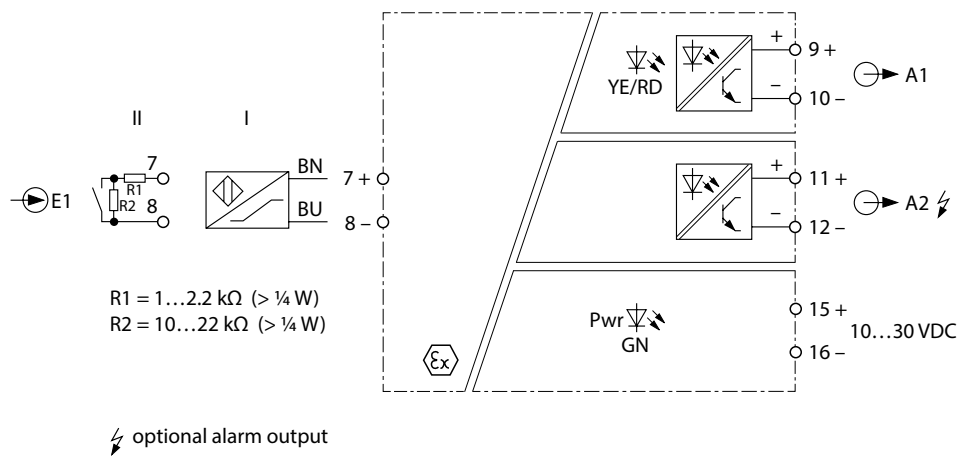
### 7.1.3    IMX12-DI03-1S-2R



optional alarm output

Fig. 8:     Block diagram IMX12-DI03-1S-2R

### 7.1.4 IM12-DI03-1S-2R



⚡ optional alarm output

Fig. 9: Block diagram IM12-DI03-1S-2R

## 7.2 Output Transistor

**Semiconductor output (A1, A2) ratings:**
Switching voltage: ≤ 30 V
Switching current: ≤ 100 mA

### 7.2.1 IMX12-DI01-2S-2T



R1 = 1…2.2 kΩ  (> ¼ W)
R2 = 10…22 kΩ  (> ¼ W)
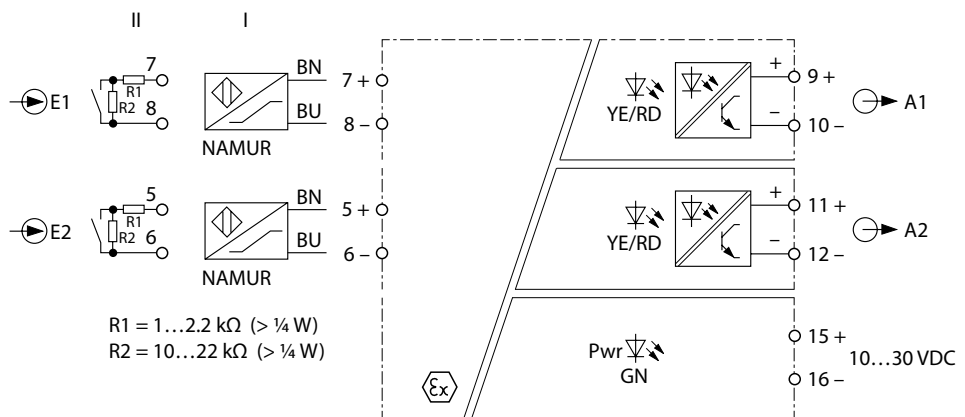
Fig. 10: Block diagram IMX12-DI01-2S-2T

## 7.2.2    IM12-DI01-2S-2T
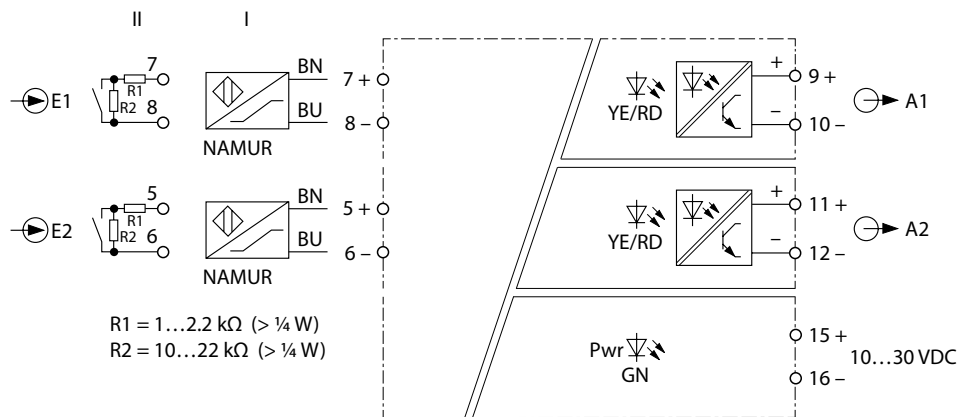


Fig. 11:    Block diagram IM12-DI01-2S-2T

## 7.2.3    IMX12-DI03-1S-2T



Fig. 12:    Block diagram IMX12-DI03-1S-2T

## 7.2.4    IM12-DI03-1S-2T
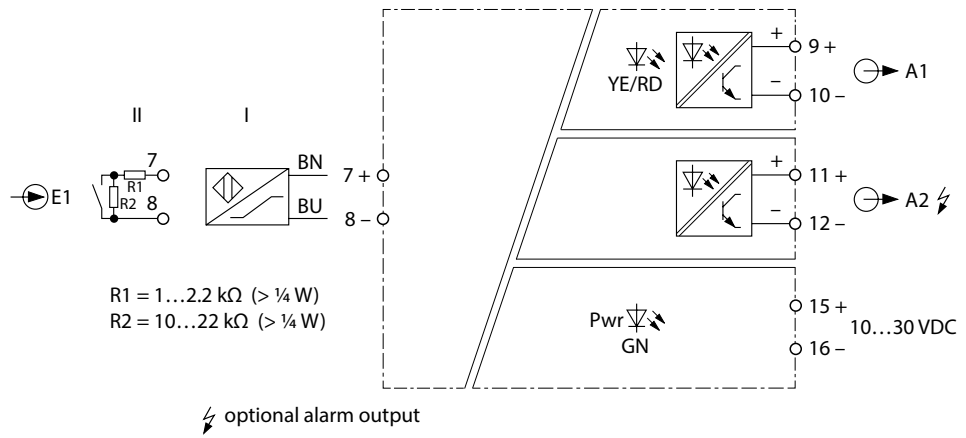


Fig. 13:    Block diagram IM12-DI03-1S-2T

# 7.3    Output Push-Pull

**Semiconductor output (A1, A2) ratings:**
Output voltage high: 28.5 V…30.5 V
Output voltage low: < 1 V
Switching current: ≤ 10 mA
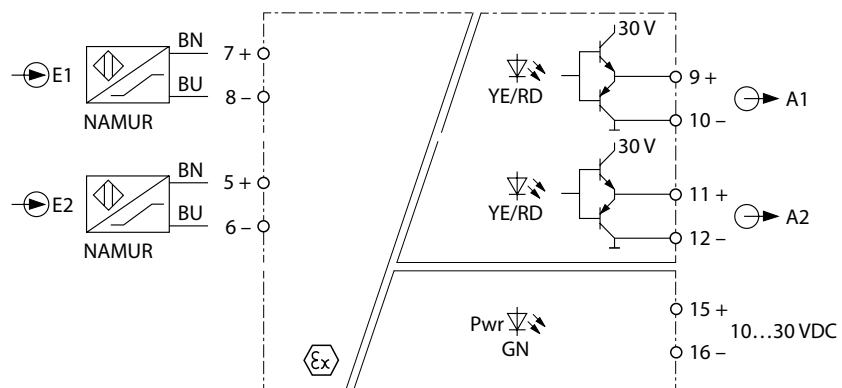
## 7.3.1    IMX12-DI01-2S-2PP



Fig. 14:    Block diagram IMX12-DI01-2S-2PP
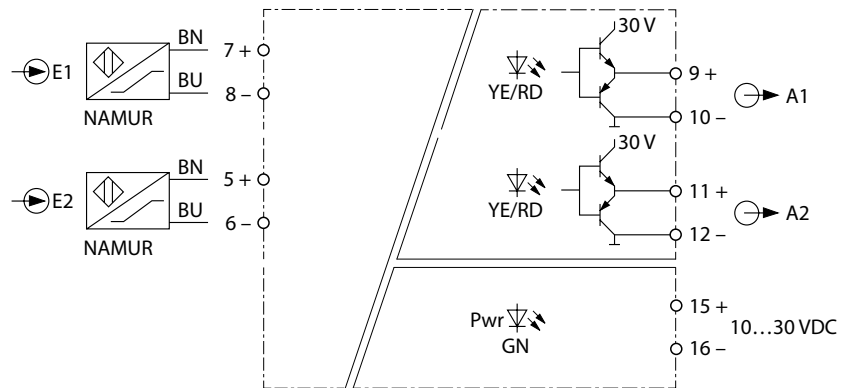
### 7.3.2 IM12-DI01-2S-2PP



Fig. 15: Block diagram IM12-DI01-2S-2PP

## 7.4 Output NAMUR

### 7.4.1 IMX12-DI03-1S-1NAM1R

Output A1 according to NAMUR EN 60947-5-6
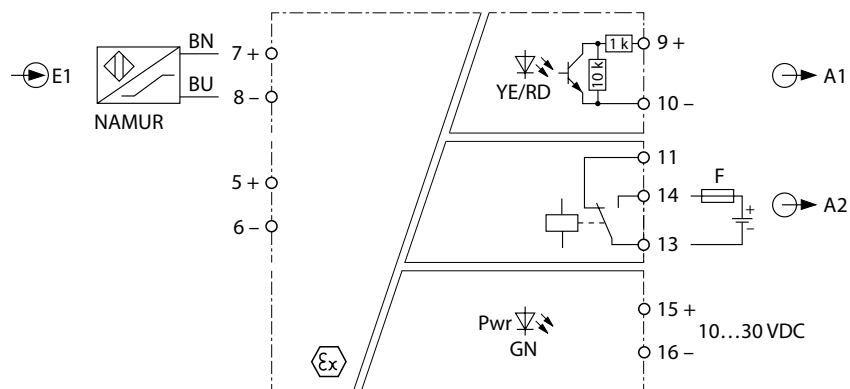Output A2 Relay (**"7.1 Output Relay" on page 19**)



Fig. 16: Block diagram IMX12-DI03-1S-1NAMR

### 7.4.2 IM12-DI03-1S-1NAM1R

Output A1 according to NAMUR EN 60947-5-6
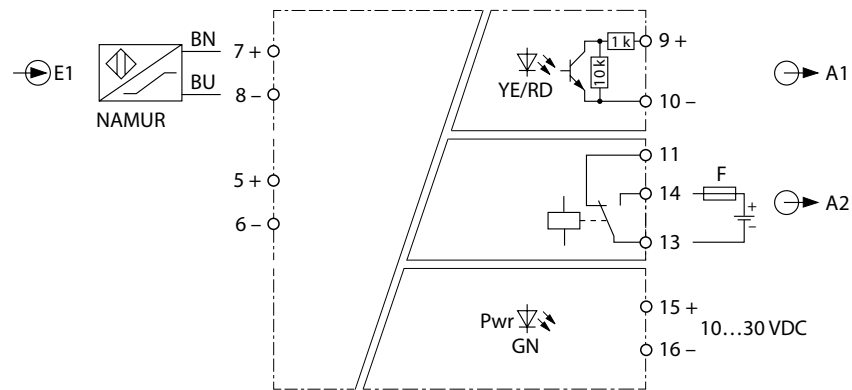Output A2 Relay (**"7.1 Output Relay" on page 19**)



Fig. 17: Block diagram IM12-DI03-1S-1NAMR

### 7.4.3 IMX12-DI03-1S-1NAM1T

Output A1 according to NAMUR EN 60947-5-6
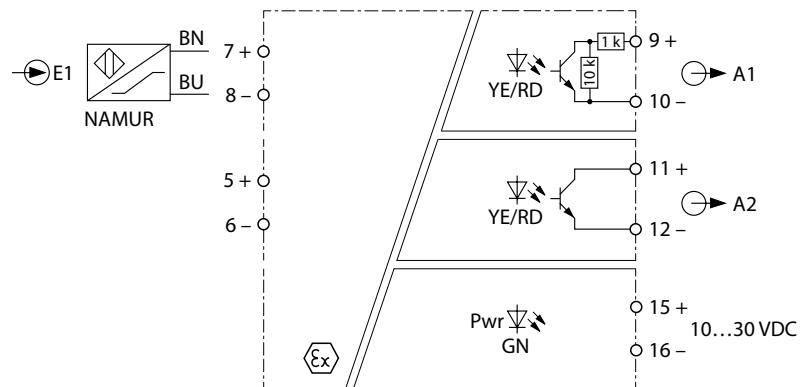Output A2 Transistor (**"7.2 Output Transistor" on page 21**)



Fig. 18: Block diagram IMX12-DI03-1S-1NAMT

### 7.4.4 IM12-DI03-1S-1NAM1T

Output A1 according to NAMUR EN 60947-5-6
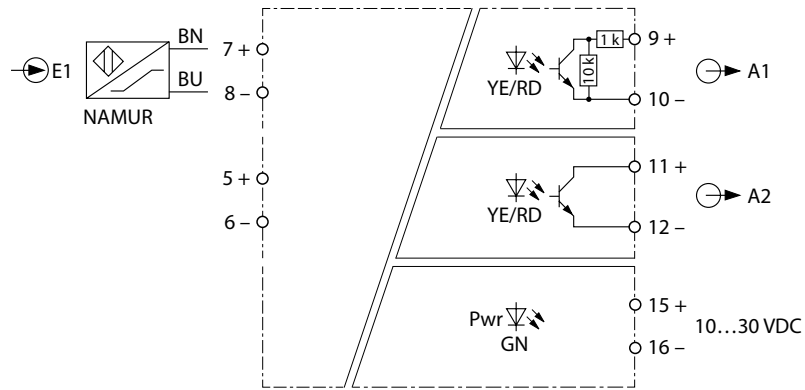Output A2 Transistor (**"7.2 Output Transistor" on page 21**)

Fig. 19: Block diagram IM12-DI03-1S-1NAMT

# 8 Appendix: Terms and abbreviations

| | |
|---|---|
| **DC** | Diagnostic Coverage |
| **FIT** | 1 FIT is 1 failure per 10E09 hours |
| **FMEDA** | Failure Modes, Effects and Diagnostic Analysis |
| **HFT** | Hardware failure tolerance |
| **λAU** | Undetected Annunciation failure rate (per hour) Annunciation failures do not directly impact safety but impact the ability to detect a future fault (such as a fault in diagnostic circuit). |
| **λDD** | Detected dangerous failure rate (per hour) |
| **λDU** | Undetected dangerous failure rate (per hour) |
| **λSD** | Detected safe failure rate (per hour) |
| **λSU** | Undetected safe failure rate (per hour) |
| **MTTR** | Mean time to restoration (hour) |
| **PFDavg** | Average probability of failure on demand |
| **PFH** | Probability of dangerous failure per hour |
| **SFF** | Safe Failure Fraction |
| **SIL** | Safety Integrity Level |
| **T1** | Proof test interval (hour) |
| **Type A** | "Non-complex" element (all failure modes are well defined); for details see 7.4.4.1.2 of IEC 61508-2 |
| **Type B** | "Complex" element (using micro controlllers or programmable logic); for details see 7.4.4.1.3 of IEC 61508-2 |

# 9 Appendix: Proof tests

Proof tests shall be undertaken to reveal dangerous faults which are undected by diagnostic tests. This means that it is necessary to specify how dangerous undetected faults which have been noted during the FMEDA can be detected during proof testing.
Ensure that the proof test is only carried out by qualified personnel.
A suggested proof test consists of the following steps:

| Step | Action |
| --- | --- |
| 1. | Bypass the safety functions and take appropriate action to avoid a false trip. |
| 2. | Provide appropriate input-/control signals to the interface modules and verify the expected signal input/output conditions for the interfaces. |
| 3. | Verify if internal fault detection is working in case it is activated. |
| 4. | Provide appropriate input-/control signals to the interface modules and verify that the safety function is carried out correctly. |
| 5. | Remove the bypass and otherwise restore normal operation. |

This test will detect 98 % of possible dangerous undetected failures. Once the test has been completed, document and archive the results.

# 10 Appendix: Document history

| Document Version | Date | Modifications |
| --- | --- | --- |
| 1.0 | 2015-06-10 | Initial version |
| 2.0 | 2018-02-05 | – Variants IMX12-DI03-1S-2R, IMX12-DI03-1S-2T, IMX12-DI01-2S-2R, IMX12-DI01-2S-2T, IMX12-DI01-2S-2PP added<br>– Useful lifetime updated<br>– 7 mm cable ends |
| 3.0 | 2018-07-16 | More detailed explanation of temperature conditions |
| 4.0 | 2019-04-05 | – IM (non-X) devices added<br>– headings high-/low-demand updated<br>– note for 61326-3-1 modified: exceed (not increase)<br>– note for safety-function: power-rail not part, LED not part<br>– wiring diagrams added and updated<br>– safety function: HFT 1 via connection in parallel is not possible<br>– language/spelling errors (improvement with help of native speaker)<br>– safe state<br>– frequency<br>– power rail renamed in power bridge<br>– cage clamps renamed  in spring type terminal renamed<br>– in chapter 2 Intrinsic Safety added |

# 11 Appendix: Certificate

The certificate can be found on the internet at **www.turck.com**.

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