

IL SAFE

The safety-related segment circuit

Application note

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1 Description

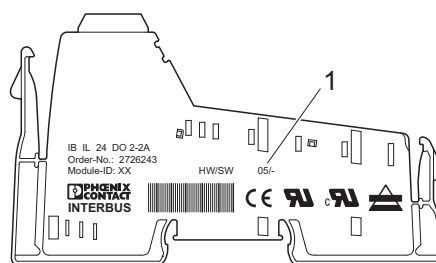
This application note describes the measures that must be observed when using Inline terminals in an application which should meet the functional safety requirements (hereinafter referred to as safety application).

The structure of the safety-related segment circuit in the Inline system is such that actuators/controlled devices, which are connected to output terminals, can be switched separately via the bus system and can be switched off safely on a safety demand to the upstream safety terminal.

The safety-related segment circuit starts at a safety module (see “Safety modules which open a safety-related segment circuit (with Inline ECO terminals)” on page 3). The safety-related segment circuit finishes at the last Inline terminal before another feed-in or at the end of the station.

Only Inline terminals that are specifically designed for the safety-related segment circuit may be used. They are listed under “Inline terminals that are approved for the safety-related segment circuit” on page 3.

Inline terminals of a specific hardware version and later are approved for the safety-related segment circuit. The hardware version is printed on the side of the housing of every Inline terminal (1 in Figure 1).



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Figure 1 Printing on an Inline terminal



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

In addition to this application note, please also refer to the following documentation:

- Data sheet or user manual for the Inline terminal used
- “Automation terminals of the Inline product range” user manual

(see “Ordering data” on page 3).



This document is valid for all products listed in “Ordering data” on page 3.

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2 Ordering data

2.1 Safety modules which open a safety-related segment circuit

Description	Type	Order No.	Transmission speed
Safety-oriented decentral relay output module, IP20 degree of protection, for the INTERBUS-Safety and the PROFIsafe system. This module has four safe digital relay outputs, each having two contacts.	IB IL 24 PSDOR 4-PAC	2985864	500 kbps 2 Mbps
Safety-related distributed relay output module, IP20 protection, for the PROFIsafe system. The module has 4 safe digital relay outputs, each with two contacts. The output states are mirrored for diagnostic purposes.	IB IL 24 PSDOR 4-F-PAC	2700563	500 kbps 2 Mbps

2.2 Safety modules which open a safety-related segment circuit with Inline ECO terminals

Description	Type	Order No.	Transmission speed
Inline ECO, Safety module, digital inputs: 4 (for 2 sensor circuits (1- or 2-channel, non-equivalent/equivalent)), for safety-related shutdown of the segment voltage by means of potential routing, transmission speed in the local bus 500 kbps, degree of protection IP20, including Inline connectors and marking fields	IB IL 24 SAFE 2-ECO	2702446	500 kbps

2.3 Inline terminals that are approved for the safety-related segment circuit

Description	Type	Order No.	As of hardware version
500 kbps (approved for the safety modules listed under 2.1)			
Inline, digital output terminal, digital outputs: 2, 24 V DC, 2 A, connection technology: 4-wire, transmission speed in the local bus 500 kbps, degree of protection IP20, including Inline connector and labeling field	IB IL 24 DO 2-2A-PAC	2861263	06
Inline, digital output terminal, digital outputs: 8, 24 V DC, 500 mA, connection technology: 4-wire, transmission speed in the local bus 500 kbps, degree of protection IP20, including Inline connectors and marking fields	IB IL 24 DO 8-PAC	2861289	05
Inline, digital output terminal, digital outputs: 8, 24 V DC, 500 mA, connection technology: 4-wire, transmission speed in the local bus 500 kbps, degree of protection IP20, including Inline connectors and marking fields, connectors numbered individually	IB IL 24 DO 8-PAC/SN	2862945	07
Inline, digital output terminal, digital outputs: 8, 24 V DC, 2 A, connection technology: 4-wire, transmission speed in the local bus 500 kbps, degree of protection IP20, including Inline connectors and marking fields	IB IL 24 DO 8-2A-PAC	2861603	03
Inline, digital output terminal, digital outputs: 4, 24 V DC, 500 mA, connection technology: 3-conductor, transmission speed in the local bus 500 kbps, degree of protection IP20, including Inline connector and labeling field	IB IL 24 DO 4/EF-PAC	2701009	00
Inline power-level terminals, electromechanical direct starter, up to 3.7 kW/400 V AC	IB IL 400 MLR 1-8A	2727365	07

Description	Type	Order No.	As of hardware version
500 kbps, Inline ECO (approved for the safety modules listed under 2.1 and 2.2)			
Inline ECO, digital output terminal, digital outputs: 4, 24 V DC, 500 mA, connection technology: 3-conductor, transmission speed in the local bus 500 kbps, degree of protection IP20, including Inline connector	IB IL 24 DO 4/EF-ECO	2702825	00
2 Mbps (approved for the safety modules listed under 2.1)			
Inline, digital output terminal, digital outputs: 2, 24 V DC, 2 A, connection technology: 4-wire, transmission speed in the local bus 2 Mbps, degree of protection IP20, including Inline connector and labeling field	IB IL 24 DO 2-2A-2MBD-PAC	2861700	03
Inline, digital output terminal, digital outputs: 8, 24 V DC, 500 mA, connection technology: 4-wire, transmission speed in the local bus 2 Mbps, degree of protection IP20, including Inline connectors and marking fields	IB IL 24 DO 8-2MBD-PAC	2861687	04
Einspeiseklemme (approved for the safety modules listed under 2.1 and 2.2)			
Inline feed-in terminal, without accessories, 24 V DC	IB IL 24 PWR IN	2726311	09
Inline feed-in terminal, complete with accessories (connector and marking field), 24 V DC, without fuse	IB IL 24 PWR IN-PAC	2861331	10

2.4 Documentation

Description	Type
User manual "Automation terminals of the Inline product range"	IL SYS INST UM E
Application note "Creating a safe segment circuit using the feed-in terminal"	AH EN IB IL 24 PWR IN APPL



Please refer to the corresponding documentation for the listed safety and Inline terminals. It can be downloaded at phoenixcontact.net/products.

3 Explanation of symbols and abbreviations used

3.1 Labeling of warning notes



This symbol indicates hazards that could lead to personal injury. There are three signal words indicating the severity of a potential injury.

DANGER

Indicates a hazard with a high risk level. If this hazardous situation is not avoided, it will result in death or serious injury.

WARNING

Indicates a hazard with a medium risk level. If this hazardous situation is not avoided, it could result in death or serious injury.

CAUTION

Indicates a hazard with a low risk level. If this hazardous situation is not avoided, it could result in minor or moderate injury.



This symbol together with the **NOTE** signal word alerts the reader to a situation which may cause damage or malfunction to the device, hardware/software, or surrounding property.



Here you will find additional information or detailed sources of information.

3.2 Abbreviations used

Kat.	Category
PL	Performance level
MTTFd	Mean time to failure dangerous

4 Safety notes

The machine/system manufacturer and the operator are solely responsible for validating the safety of the machine or system and the implemented application in which the machine or system is used. The Machinery Directive must be observed.



WARNING: Loss of safety function

Use the safety terminals and the Inline terminals in the safety-related segment circuit correctly.

In the event of noncompliance, the safety of personnel and equipment can no longer be assured.

The following organizational points must be observed:

- When working on safety terminals, on Inline terminals in the safety-related segment circuit, and/or on the system, the latest version of the data sheets for the Inline terminals and other product documentation must always be at hand and referred to.
 - It is prohibited for unqualified personnel to work on safety terminals, on Inline terminals in the safety-related segment circuit, on the system, or in their vicinity.
 - Only qualified personnel who are familiar with the applicable regulations governing occupational safety and accident prevention are permitted to install and start up the safety terminals and the Inline terminals in a safety-related segment circuit while observing the information provided in the data sheets for the Inline terminals used. Electrical work may only be carried out by qualified electricians.
 - Observe all applicable regulations, especially those regarding protective measures.
 - Repairs to the Inline terminals including the safety terminals, especially if the housing must be opened, may only be carried out by the manufacturer or authorized persons.
 - The manufacturers and users of machines or systems in which the Inline terminals are used in the safety-related segment circuit are solely responsible for agreeing on and observing all applicable safety directives and regulations and all applicable standards with the appropriate authorities.
- Observe the following additional points during installation:**
- Observe the safety notes in the “Automation terminals of the Inline product range” user manual.
 - The instructions given in this document must be followed during installation and startup.
 - Mount the Inline terminals in housing protected from dust and humidity (IP54 or higher); dust and humidity can lead to malfunctions.
 - Take measures to prevent the mismatching, polarity reversal, and manipulation of connections.
 - Disconnecting an output via the bus system does not guarantee the safety-related function of the system (e.g., emergency stop, safety door). This is only achieved if the supply voltage of the output groups is disconnected via the safety relay module.
 - The process notes and circuit details presented in this document should be understood in a general sense and the relevant application should be examined to see if they apply. Phoenix Contact cannot guarantee the suitability of the procedures described or the circuit suggestions for the relevant application made in this document.

5 Requirements for the terminal wiring in the safety-related segment circuit



WARNING: Loss of safety function in the event of feedback

When wiring Inline terminals in safety applications, ensure that errors are prevented in terms of feedback for:

- All connected cables that supply the Inline terminal with actuator voltage
- The connecting cables of the actuators

Please also take all connected loads into consideration. This means, for example, that separate sheathed cables must be used for the cabling.

Observe the respective applicable DIN and VDE regulations that are required for error prevention.

Feedback is when voltages are fed into a cable (caused, for example, by generator effects of the connected load, by an insulation fault or by feed-in from a connected load due to an internal insulation fault).

5.1 Requirements for the power supply



WARNING: Loss of safety function when using unsuitable power supplies

Inline terminals are designed exclusively for protective extra-low voltage (PELV) operation according to EN 60204-1. Only protective extra-low voltages according to the defined standard may be used for supply purposes.

The following applies to networks (INTERBUS, PROFIBUS, etc.) and the IO devices used in them:

Only use power supply units that meet EN 61204 with safe isolation and PELV according to EN 50178/VDE 0160 (PELV). This prevents short circuits between primary and secondary sides.

Also make sure that the output voltage of the power supply does not exceed 32 V even in the event of an error.

Make sure that the GND connection to PE on the power supply unit complies with the applicable VDE regulations and is executed in such a way that errors are prevented if the connection is lost (interrupted).

If you cannot ensure that errors will be prevented, the application can be used up to PL c (Cat. 2) maximum depending on the safe switching device connected upstream.

5.2 Requirements for the connection between DIN rail and PE



WARNING: Loss of safety function when the connection from the DIN rail to PE is interrupted

When connecting the DIN rail to PE, make sure that errors are prevented if the connection is lost (interrupted).

If you cannot ensure that errors will be prevented, establish an additional, separate connection from the DIN rail to PE.

Observe the respective applicable DIN and VDE regulations that are required for error prevention.

5.3 Requirements for DO terminals

- Only use the Inline terminals that are listed under “Inline terminals that are approved for the safety-related segment circuit” on page 3 in the safety-related segment circuit.



WARNING: Loss of safety function due to parasitic voltages

The ground connection of the connected load must only be connected to the ground connection of the Inline terminal. This means, for example, that single-conductor connection is not permitted.

5.4 Requirements for controlled devices/actuators

- Dimension the controlled device used such that a leakage current of 2 mA does not cause a hazardous system state.
This also means that the controlled devices must switch from the operating state to the idle state at a current of 2 mA.
This requirement is met if the connected loads are adapted to the outputs since the outputs of the Inline terminals meet the requirements of EN 61131-2.
- Only use controlled devices that definitely maintain a voltage of 5 V in the idle state.
This also means that the controlled devices must switch from the operating state to the idle state at a voltage of 5 V.
- Only use loads that have an isolated structure. I.e.:
 - Make sure there is no electrically conductive connection between the control connections and the equipotential bonding.
 - Make sure there is no electrically conductive connection between GND and PE/FE at the load.
 - Make sure that, even in the event of an error, no external voltage is led via the load to the outputs of the Inline terminals (no feedback).
- Only use appropriately qualified actuators.
- Use reliable components. These include, for example:
 - Control contactors according to EN 60947-4-1
 - Power contactors
 - Relays with force-guided contacts according to DIN EN 50205
- Use relays or contactors with force-guided N/C contacts to safely monitor the state (pick-up, dropout).

6 Use of the Inline terminals in systems according to EN ISO 13849-1

In accordance with the installation guidelines, these Inline terminals may be used in systems up to Cat. 4/PL e (see connection examples in the documents for the safety terminals and feed-in terminals listed in Section 2.1). The category and PL that can be achieved are specified for each connection example.

To achieve the required Cat./PL, implement the measures described in Sections 4, 5, and 7.

The Inline terminals are PL-neutral. This means that they do not perform any safety functions and do not have any influence on the safety function.

An infinite MTTFd may be assumed for the Inline terminals. Please note that these Inline terminals do not have diagnostic coverage (DC = 0). Make sure that the application (e.g., safety relay modules) provides the diagnostic coverage required for the safety function.

The Inline terminals have an unlimited duration of use.

7 Measures required to achieve a specific category



Please also observe the information in EN ISO 13849.

Cat. 2

- Use proven and basic safety principles according to EN ISO 13849.
- Use appropriately qualified actuators (see “Requirements for controlled devices/actuators” on page 8).
- Please note that mechanical failure of the switching device can result in the loss of the safety function.
- Prevent the welding of contacts on the connected contactors or safety relays with appropriate protection against overcurrent and surge voltage.
- Please note that **a single** error can result in the loss of the safety function between tests.
- Make sure that the external wiring is tested by the machine control system on machine startup and at suitable intervals. This test must detect the loss of the safety function.
- Make sure that in the event of an error the application shuts down the machine or system safely or generates a warning (optical and/or audible).

Cat. 3

- Use proven and basic safety principles according to EN ISO 13849.
- Use appropriately qualified actuators (see “Requirements for controlled devices/actuators” on page 8).
- Please note that mechanical failure of the switching device can result in the loss of the safety function.
- Prevent the welding of contacts on the connected contactors or safety relays with appropriate protection against overcurrent and surge voltage.
- All errors that cannot be detected can result in the loss of the safety function. Take appropriate measures to prevent such errors. Suitable measures include, for example, protected cable installation or double insulation.
- Please take into consideration errors with a common cause.
- Ensure that **a single** error does not result in the loss of the safety function.
- Test the shutdown capability of the actuators at regular intervals.

Cat. 4

- Use proven and basic safety principles according to EN ISO 13849.
- Use appropriately qualified actuators (see “Requirements for controlled devices/actuators” on page 8).
- Please note that mechanical failure of the switching device can result in the loss of the safety function.
- Prevent the welding of contacts on the connected contactors or safety relays with appropriate protection against overcurrent and surge voltage.
- An accumulation of errors must not result in the loss of the safety function. Following the third error, evaluation can be aborted if the probability of further errors occurring is low.
- All errors that cannot be detected can result in the loss of the safety function. Take appropriate measures to prevent such errors. Suitable measures include, for example, protected cable installation or double insulation.
- Please take into consideration errors with a common cause.
- Test the shutdown capability of the actuators at regular intervals.

8 Connection examples



For connection examples for the safety-related segment circuit, please refer to the documentation for the safety terminal used (data sheet/user manual).



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