KENDRION

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INDUSTRIAL CONTROL SYSTEMS

# User Guide

Original Operating Instructions
Version 1.3

Kuhnke FIO Safety SDI4 / SDO2
694 430 00
FIO System Safety Terminal

E 818 GB 15. Nov 2022 / Document Number 10235625


Safety over EtherCAT®



KUHNKE

# Table of Contents

# 1 Legal Notice

## 1.1 Contact Details

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## 1.2 Version Details

### 1.2.1 Manual

| Modification history | |
|---|---|
| **Date** | **Comments / modifications** |
| **21. July 2016** | Original manual version 1.0 - for module release V1.0 |
| **07. Nov 2016** | Object dictionary revised - 8.1 Object Dictionary |
| **30. Jan 2017** | Revision of 7.7 Connecting Two Parallel Actuators to One Safe Output |
| **23. Feb 2017** | Tüv Certificate added - 8.3.2 TÜV Certificate |
| **26. Apr 2017** | Corrections in chapter 6.5.7 Error Codes (hex-codes) and 8.1.10 Err.code 2007h for µC1 and 2017h for µC2 has been supplemented by two entries (0x0296, 0x02A0) |
| **21. June 2017** | Corrections in the description of the inputs and outputs in the table of the safety related ratings 4.6 and 4.7. No changes in the ratings. |
| **04. Sep 2017** | Footnote in chapter 6.3.2 FSoE Parameters inserted |
| **19. Mar 2018** | Note added to the ERRATA_Sheet_Safety<br>Additionally: unique date format selected |
| **14. May 2018** | Note inserted for single-channel applications. "Consideration of the parameterization" |
| **18. May 2018** | Note inserted for two-channel applications added. See chapter 6.2.7 and 7.5 |
| **11 Dec 2018** | Several Hazard and Other Warnings adapted. See chapter 6.3.4 and 7 |
| **26 Mar 2019** | Change in chapter 6.2.7 Sensor Connection, “A high signal is sent from both inputs when the Safety Mat is stepped on” |
| **15 Nov 2022** | Maximum output switching frequency added in chapter 4.5.4 Safe Digital Outputs. |

### 1.2.2 FIO Safety SDI4 / SDO2 Order Number 694 430 00

The table below summarises the module releases, manual versions, production dates and the changes to the functionality.

| Modul release | | | |
|---|---|---|---|
| **Version** | **Manual** | **Date** | **Comments / modifications** |
| **V1.00** | **V1.0** | **From 21. July 2016** | **Applies to module release V1.00 → software version 1.0; hardware version V2.1** |
| **V1.01** | **V1.1** | **From 19. Mar 2018** | **Applies to module release V1.01 → software version 1.0; hardware version V2.1** |
| **V1.02** | **From V1.2** | **From 10 Sep 2018** | **Applies to module release V1.02 → software version 1.0; hardware version V2.1** |

# 2 Preface

## 2.1 About this User Guide

This document is the original user guide to Kuhnke's FIO Safety I/O Module, order number 694 430 00. Your module work should always be based on the correct user guide version → 1.2 Version Details.

This document is primarily directed to system designers, project engineers and device developers. It does not contain any availability information. We reserve the rights for errors, omissions and modifications. Pictures are similar.

Note, information

Please also note the ERRATA_Sheet_Safety for currently relevant safety warnings.
The current version can be found in our product finder Link.

### 2.1.1 Limitation of Liability

Specifications are for description only and are not to be understood as guaranteed product properties in a legal sense. Exact properties and characteristics shall be agreed in the specific contract. Claims for damages against us - on whatever grounds - are excluded, except in instances of deliberate intent or gross negligence on our part.

### 2.1.2 Terms of Delivery

The general conditions of sales and service of Kendrion Kuhnke Automation GmbH shall apply.

### 2.1.3 Copyright



### 2.1.4 Warranty

Warranty is subject to the provisions of the conditions of sale of Kendrion Kuhnke Automation GmbH or any contractual agreements between the parties.

The warranty will be voided by:

- improper assembly and use
- repairs or inadmissible servicing
- modifications or rendering the serial number illegible or removing it

# 2.2 Reliability, Safety

## 2.2.1 Applicability

This user guide contains all information necessary for the use of the described product (control device, control terminal, software, etc.) according to instructions.

## 2.2.2 Target Group

The user guide is written for design, project planning, servicing and commissioning experts. For proper understanding and error-free application of technical descriptions, instructions for use and particularly of notes of danger and warning, extensive knowledge of automation technology and functional safety is compulsory.

## 2.2.3 Reliability

Reliability of Kuhnke products is brought to the highest possible standards by extensive and cost-effective means in their design and manufacture.

These include:

- selecting high-quality components,
- quality agreements with our suppliers,
- actions to avoid static charges when handling MOS circuits,
- worst case planning and design of all circuits,
- visual inspections at various stages of fabrication,
- computer-aided tests of all assemblies and their interaction in the circuit,
- statistical assessment of the quality of fabrication and of all returned goods for the immediate taking of appropriate corrective actions.
- standardised returns handling process
- ISO 9001:2015 certification

## 2.2.4 Hazard and Other Warnings

Despite the actions described in section 2.2.3Reliability , the occurrence of faults or errors in electronic control units - even if most highly improbable - must be taken into consideration.

Please pay particular attention to the additional notices which we have marked by symbols throughout this user guide. While some of these notices make you aware of possible dangers, others are intended as a means of orientation. They are described further down below in descending order of importance.

Every alert and hazard warning is made up as follows:

***Type and source of risk***

*Potential consequences of non-observance*

⇨ Preventive measures

| | |
|---|---|
|  | ***DANGER*** |
| | ***A DANGER warning makes you aware of an immediately hazardous situation which WILL cause a serious or fatal accident if not observed.*** |

| | |
|---|---|
|  | ***WARNING*** |
| | ***A WARNING makes you aware of a potentially hazardous situation which MAY cause a serious or fatal accident or damage to this or other devices if not observed.*** |

| | |
|---|---|
|  | ***CAUTION*** |
| | ***A CAUTION alert makes you aware of a potentially hazardous situation which MAY cause an accident or damage to this or other devices if not observed.*** |

| | |
|---|---|
|  | ***ATTENTION*** |
| | ***An ATTENTION notice makes you aware of a potentially hazardous situation which MAY cause damage to this or other devices if not observed.*** |

## 2.2.5 Other Notices

| | |
|---|---|
|  | ***Note, information*** |
| | ***This symbol draws your attention to additional information concerning the use of the described product. This may include cross references to information found elsewhere (e.g. in other manuals).*** |

## 2.2.6 Safety

Our products normally become part of larger systems or installations. The information below is intended to help you integrate the product into its environment without dangers to humans or material/equipment.

| | |
|---|---|
|  | ***DANGER*** |
| | ***Non-compliance with the user guide***<br>*Measures for the prevention of dangerous faults or errors may be rendered ineffective or new hazard sources created.*<br>• *Carefully read the user guide*<br>• *Take particular heed of the hazard warnings* |

| | |
|---|---|
|  | ***Information*** |
| | *To achieve a high degree of conceptual safety in planning and installing an electronic controller, it is essential to exactly follow the instructions given in the user guide because wrong handling could lead to rendering measures against dangers ineffective or to creating additional dangers.* |

## 2.2.7 Project Planning and Installation

- Emergency-off installations must comply with EN 60204/IEC 204 (VDE 0113). They must be operative at any time.
- Safety and precautions regulations for qualified applications have to be complied with.
- Please pay particular attention to the notices of warning which, at relevant places, will make you aware of possible sources of dangerous mistakes or faults.
- Relevant standards and VDE regulations are to be complied with in every case.
- Control elements are to be installed in such a way as to exclude unintended operation.
- Lay control cables such that interference (inductive or capacitive) is excluded if this interference could influence controller operation or its functionality.

## 2.2.8 Maintenance and Servicing

- Accident prevention regulations (in Germany: BGV A3 - VBG 4.0) to be observed when measuring or checking a controller after power-up. This applies to section 8 (Admissible deviations when working on parts) in particular.
- You are not allowed to repair Kuhnke's FIO Safety I/O Module. Please return the module to Kendrion Kuhnke Automation GmbH if defective.
- Spare parts:
  Only use parts approved of by Kendrion Kuhnke Automation GmbH. Only genuine Kuhnke modules may be used in modular controllers.
- Modular systems: always plug or unplug modules in a power-down state. You may otherwise damage the modules or (possibly not immediately recognisably!) inhibit their functionality.
- Always dispose of (rechargeable) batteries as hazardous waste.

## 2.2.9 General Notes on Installation

As component parts of machines, facilities and systems, electronic control systems must comply with valid rules and regulations, depending on their field of application.

General requirements concerning the electrical equipment of machines and aiming at the safety of these machines are contained in Part 1 of European Standard EN 60204 (corresponds to VDE 0113).

| | |
|---|---|
| | ***Information*** |
| | *In order to safely install Kuhnke's FIO Safety System, please read section → 2.2.7 Project Planning and Installation and following.* |

### Interference emission

Interfering emission of electromagnetic fields, HF compliant to EN 55011, limiting value class A, Group 1

| | |
|---|---|
| | ***Information*** |
| | *If the controller is designed for use in residential areas, high-frequency emissions must comply with limiting value class B as described in EN 55011.*<br>*Fitting the controller into earthed metal cabinets and installing filters in the supply lines may produce a shielding compliant to the above standard.* |

The design and immunity to interference of programmable logic controllers are internationally governed by standard IEC 61131-2:2007 which, in Europe, has been the basis for European Standard EN 61131-2:2007 .

| | |
|---|---|
| | ***Note*** |

| | |
|---|---|
|  | *Refer to IEC 61131-4, User's Guideline, for general installation instructions to be complied with to ensure that hardware interface factors and the ensuing noise voltages are limited to tolerable levels.* |

## Electrical immission safeguard

To eliminate electromagnetic interference, connect the control system to the protective earth conductor. Practice best cable routing.

## Cable routing and wiring

Keep power circuits separate from control circuits:

- DC voltages 60 V ... 400 V
- AC voltages 25 V ... 400 V

Joint laying of control circuits is allowed for:

- shielded data signals
- shielded analogue signals
- unshielded digital I/O lines
- unshielded DC voltages < 60 V
- unshielded AC voltages < 25 V

## Location of installation

Ensure that temperatures, contaminations, impact, vibration or electromagnetic interference are no impediment to the installation.

## Temperature

Consider heat sources such as general heating of rooms, sunlight, heat accumulation in assembly rooms or control cabinets.

## Contamination

Use suitable casings to avoid possible negative influences due to humidity, corrosive gas, liquid or conducting dust.

## Impact and vibration

Consider possible influences caused by motors, compressors, transfer lines, presses, ramming machines and vehicles.

## Electromagnetic interference

Consider electromagnetic interference from various local sources: motors, switching devices, switching thyristors, radio-controlled devices, welding equipment, arcing, switched-mode power supplies, converters / inverters.

## Particular sources of interference: inductive actuators

Switching off inductances (such as from relays, contactors, solenoids or switching magnets) produces surge voltages. It is necessary to reduce these extra voltages to a minimum. Throttling elements could be diodes, Z-diodes, varistors or RC elements. Their rating should conform to the specifications provided by the manufacturer or supplier of the actuators.

# 3 System Description

## 3.1 EtherCAT® – Ethernet Control

EtherCAT® is the most powerful Ethernet-based fieldbus system currently available on the market. EtherCAT puts up the top speed mark, and its flexible topology and simple configuration make it the perfect means of controlling extremely fast processes. To give you a clue: 1000 I/Os can be addressed in 30 µs.

Because of its high performance, the simple wiring and its open protocol support, EtherCAT is often used as a fast motion control and I/O bus driven by an industrial PC or in conjunction with control technology on a smaller scale.

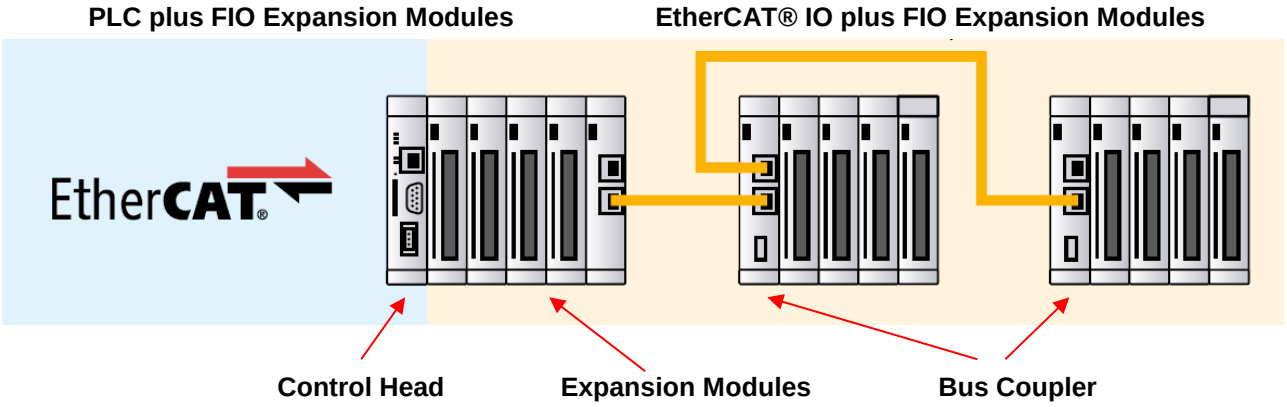
Its interconnections between the controller at one end and both the I/O modules and drives at the other are as fast as those of a backplane bus. EtherCAT controllers thus nearly act like centralised control systems, overcoming the issue of bus transfer times that conventional fieldbus systems are burdened with.

## 3.2 Kuhnke FIO

Kuhnke's FIO is a system of I/O modules for interconnecting the process signals in an EtherCAT network.

Kuhnke FIO consists of the Kuhnke FIO bus coupler and a range of Kuhnke FIO I/O modules.

The Kuhnke FIO bus coupler converts the physical transfer technology (twisted pair) to LVDS (E-bus) and generates the system voltages required by the LVDS modules. The standard 100 Base Tx lines used for office network communications connect to the one side, the Kuhnke FIO I/O modules for the process signals connect to the other. This is how the Ethernet EtherCAT protocol is retained right through to the last I/O module.




## 3.3 Kuhnke FIO Safety System

Safe inputs and outputs to expand Kuhnke's FIO module system.

Kuhnke's Safety System allows users to add FIO I/O modules with safe signals to the EtherCAT control unit, making the separate wiring of safety circuits a thing of the past. The EtherCAT protocol is used to transfer both safe and standard signals to the Kuhnke FIO Safety PLC. This integrated transfer process is based on FSoE (Fail Safe over EtherCAT), the safety protocol certified by TÜV, the German Technical Testing & Inspection Association.

### 3.3.1 Safety over EtherCAT (FSoE)

Along with EtherCAT, a safety protocol was developed and made available for EtherCAT as "Safety over EtherCAT" (FSoE = Fail Safe over EtherCAT). It is the backbone of providing functional safety over EtherCAT. TÜV has since certified both the protocol and its implementation to comply with Safety Integrity Level 3 (SIL 3) to IEC 61508. In 2010, IEC 61784-3-12 was published as the international reference standard for Safety over EtherCAT.

Since EtherCAT is used as a single-channel medium of communication, Safety over EtherCAT does not impose any constraints regarding the transfer rate and cycle time. The transport medium is considered a "black channel" which is left out of the safety assessment.

## 3.3.2 Kuhnke FIO Safety PLC

Kuhnke's FIO Safety PLC links up the inputs and outputs of FIO Safety and other FSoE system devices. At the basic level, certified function blocks are graphically "wired up" to establish the system's safety programme. In case a project demands more than the technology of the certified blocks can provide, the extra instructions available at the extended level can be used to expand the safety programme.

FIO Safety PLC has been designed as an add-on to a normal CODESYS control unit. This is a two-channel system which uses the normal control unit to communicate with the CODESYS Development System and all non-safe I/Os. Programming is based on a certified plug-in that is fully integrated in the CODESYS Development System.

## 3.3.3 Kuhnke FIO Safety I/O

Kuhnke's FIO Safety Module provides connections for standard security appliances. It installs at any place of the FIO block. Its signals are transferred by the EtherCAT bus of Kuhnke's FIO Safety PLC and processed in a safe manner. The module outputs safely switch actuators such as contactors, signal lamps or servo converters.

## 3.3.4 CODESYS Safety

Programming of FIO Safety PLC is based on a certified plug-in that is fully integrated in the CODESYS Development System.

FIO Safety PLC is a sub-node of the standard control unit and provides an application, task, lists of global variables, POEs and logical I/Os.

The integrated function diagram (FD) safety editor (to IEC 61131-3, certified for use with IEC 61508 SIL3 applications) is used for basic or extended-level programming by means of certified function blocks (IEC 61131-3 or PLCopen Safety) as specified in the user manual. Further software functions are available for safeguarding the safety functions by change tracking, safe flow of signals, safe version control (pinning), separating safe operation, debugging mode, etc..

## 3.3.5 CODESYS SafetyPLCopen Library

The PLCopen components have been defined by the PLCopen organisation, its members and external organisations specialising in all safety-related aspects. Since these are certified components, they reduce the time and costs involved in developing, verifying and testing a safety application for acceptance. They interlink by logical operations which behave like logical wiring and therefore minimise the time and programming efforts needed to create major parts of safety applications.

# 4 Product Description

## 4.1 General Description

Kuhnke FIO Safety 694 430 00

Kuhnke FIO Safety features 4 safe inputs and 2 safe outputs for distributed installation.

Figure 1: Module layout shows the basic layout of Kuhnke FIO Safety.

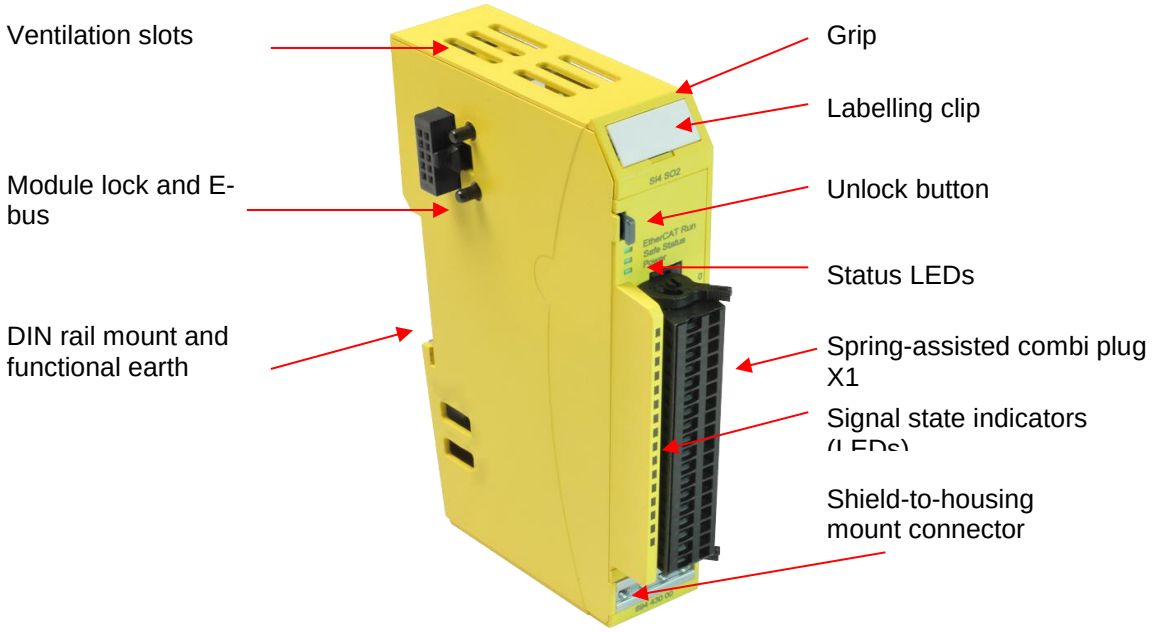



**Figure 1: Module layout**

The housing mount consists of an aluminium profile with an integrated clamping fixture used to attach the module to a 35 mm DIN rail. The housing trough including the optical fibres for the status indicators, the side faces and the front are made of plastic and contain the module. The optical fibres for the signal state indicators (LEDs) are located next to the spring-assisted combi plug. They slightly protrude from the housing and allow a clear diagnosis at a glance.

## 4.2 Application

### 4.2.1 Intended Use

Kuhnke's FIO is a system of I/O modules for interconnecting the process signals in an EtherCAT network. It consists of the bus coupler and a range of I/O modules.

The FIO Safety System comprising Kuhnke FIO Safety PLC, Kuhnke FIO Safety I/O Module and CODESYS Safety Software make the FIO I/O system fit for the functional safety of machinery.

The intended applications of the FIO Safety System include safety functions of machines and all industrial automation tasks immediately associated with them. Thus, the system may only be used for applications providing a defined fail-safe state which, in case of the FIO Safety System, is a wattless state.

Running any of the safety-related control components is subject to the safety precautions applicable to industrial control units, i.e. guarding by emergency stop and similar safety equipment as specified by the relevant national and/or international regulations. The same applies to connected equipment such as drives or light grids. Before installing and putting the system into operation, the safety instructions, connection specifications (nameplate and documentation) and the limiting values listed in this user guide's Technical Data section must be read carefully and obeyed at any time.

The FIO Safety System is not designed for applications causing potentially fatal risks or dangers to the life and health of many persons or disastrous ecological hazards unless exceptionally strict safety precautions

are taken. Such applications specifically include the monitoring of nuclear reactions in nuclear power stations as well as the control of flight or air traffic control systems, means of mass transit, medical life support systems and weapon systems.

### 4.2.2 Qualified Persons

The safety-related products may be used by the following persons only:

- Qualified persons who know the applicable concepts of functional safety as well as the relevant standards and regulations.
- Qualified persons who plan, design, install and put machine and system safety equipment into operation.

This manual's safety instructions construe qualified persons as persons whose training, experience, instructions and knowledge of the applicable standards, codes, accident prevention regulations and operating conditions authorise them to perform the required work and enable them to recognise and avoid potential hazards associated with that work. Language skills sufficient to understand this manual are therefore part of this qualification.

### 4.2.3 Disclaimer of Liability

The operator is responsible for self-reliantly running the safety-related control components in conformity with the requirements set by the competent authority.

The manufacturer shall neither be held liable nor accept any warranty for damages caused by:

- inappropriate use
- non-compliance with standard and directives
- unauthorised modifications of devices, connections or settings
- use of unapproved or unsuitable equipment or equipment groups
- non-observance of the safety instructions contained in this manual

## 4.3 Safe State

There are two different types of "safe states".

The first one is functional and depends on the machine's application, operation and software. It is the aimed-for **safe functional state** at which the system works without problems.

The second one is the **fail-safe state** and applies whenever a fault or error occurs in any of the monitored components.

### 4.3.1 Safe Functional State

The system is in a safe functional state when the safe process map shows that all inputs are "null" and when the outputs reflect this "null" state by being deenergised at the output. The data frame again reflects this state by "null" in the process map.

### 4.3.2 Fail-Safe State – External Fault

In case an external fault occurs (short circuit, cross-fault etc.), all outputs are deenergised (outputs "null") and the inputs return "null" to the safe control unit. FSoE communication is not stopped.

A fail-safe state is wattless.

The safety PLC is able to reset this state.

### 4.3.3 Fail-Safe State – Internal Fault

In case of an internal module fault, all outputs are deenergised (output "null"). Both FSoE communication and the transfer of input information stops.

A fail-safe state is wattless.

Recovering from this state requires a reset by turning the supply voltage off. This involves a complete self-test as part of the initialisation phase.

|  | ***CAUTION*** |
|---|---|
| | ***Uncontrolled movement of suspended loads, for example***<br>*Injury caused by moving or non-braked machine parts*<br>⇨ Additional external safety measures such as a mechanical brake of suspended loads should be provided for applications whose safe state requires an actuator to be actively turned on. |

### 4.3.4 Traceability

Traceability means that the time and entity that produced, processed, stored, transported, consumed or disposed of a product or trading good can be traced back at any time.
Whereas Kendrion is able to meet this requirement with regard to the production, processing, storage and transport, the purchaser is responsible for all further whereabouts of the product.

The serial number on the label stuck to the underside and stored in the object dictionary is the means of distinctly identifying and tracing the product, refer to section → 5.1 Labelling and Identification. To ensure proper traceability, the purchaser is obliged to not down this number together with the machine's name, place of installation and end customer.

|  | ***Note, information*** |
|---|---|
| | *The purchaser must ensure the units' retraceability by means of their serial number.* |

## 4.4 Useful Life

The Kuhnke FIO Safety I/O module is designed for a maximum life of 20 years.

It must therefore be taken out of service not later than one week before the end of this 20-year period (calculated as of Kendrion Kuhnke's production date).

The production date is printed on the module as part of its serial number, see section → 5.1.2 Serial Number

# 4.5 Technical Data

## 4.5.1 General Specifications

| General specifications | |
|---|---|
| **Product name** | Kuhnke FIO Safety SDI4/SDO2 |
| **Fieldbus** | EtherCAT 100 Mbit/s |
| **Controller** | ASIC ET1200 |
| **Baud rate** | 100 Mbit/s |
| **E-bus port** | 10-pin system plug in side wall |
| **Electrical insulation** | all modules electrically insulated from one another and from the bus |
| **Diagnosis** | LED: bus state, module state, broken wire/excessive current<br>→6.5 Diagnosis |
| **IO/power connection** | male 18-pole connector (not included in module package)<br>18-pole spring-assisted combi plug with mechanical ejector |
| **E-bus load** | max. 300 mA (system power supply) |
| **Terminating module** | not required |
| **Power supply (I/O / system power supply)** | |
| **Supply voltage** | 24 VDC -15%/+20% |
| **Overvoltage category** | category II to EN 61131-2:2007 |
| **Module power consumption** | approx. 7 mA plus load current |
| **Reverse polarity safeguard** | yes |
| **Nominal insulation voltage** | 500 $V_{eff}$ measured between I/O supply and E-bus |
| **Susceptibility to noise** | zone B to EN 61131-2:2007,<br>mounted on earthed DIN rail in earthed control cubicle |
| **Storage and transport conditions** | |
| **Temperature** | -25°C … + 70°C |
| **Rel. humidity** | 5% … 95%, non-condensing |
| **Atmospheric pressure** | 70 kPa to 108 kPa / 0 to 3000 m above msl |
| **Vibration** | 5 Hz to 8.4 Hz: +/- 3.5 mm amplitude, 8.4 Hz to150 Hz: 10 m/ s2 (1g) to IEC 60068-2-6, Fc test |
| **Shock** | 150 $m/s^2$ (15g), 11 ms semi-sinusoidal wave to IEC 60068-2-27 |
| **Service conditions** | |
| **Mounting position** | horizontal, stackable |
| **Degree of contamination** | II to IEC 60664-3 |
| **Admissible operating environment** | operation restricted to environments complying with IP54 or better to IEC 60529 (e.g. suitable control cabinet) |
| **Operating temperature** | 0°C ... + 55°C |
| **Rel. humidity** | 5% … 95%, non-condensing |
| **Atmospheric pressure** | 80 kPa to 108 kPa / 0 to 2000 m above msl |
| **Vibration** | 5 Hz to 8.4 Hz: +/- 3.5 mm amplitude, 8.4 Hz to150 Hz: 10 m/ s2 (1g) to IEC 60068-2-6, Fc test |
| **Shock** | 150 $m/s^2$ (15g), 11 ms semi-sinusoidal wave to IEC 60068-2-27 |

| Mechanical properties | |
|---|---|
| **Mounting** | 35 mm DIN rail (top-hat rail) |
| **Size** | 25 mm x 120 mm x 90 mm (W x H x D) |
| **Ingress Protection** | IP20 |
| **Housing mount** | aluminium |
| **Shield** | connects straight to module housing |

## 4.5.2 Safe Digital Inputs

| Safe digital inputs | |
|---|---|
| **Quantity and type** | 4x single-channel or 2x two-channel, (EN 61131-2:2007, Type 3) |
| **Diagnosis** | cross-fault, external power supply |
| **Highest safety level (depending on configuration)** | **Single-channel use:**<br>Cat. 2/PL d to EN ISO 13849-1:2015,<br>SIL2 to EN 62061:2010 / IEC 61508:2010<br>**Two-channel use:**<br>Cat. 3/PL d to EN ISO 13849-1:2015,<br>SIL3 to EN 62061:2010 / IEC 61508:2010 |
| **Input delay** | 300 µs ... 1500 µs (configurable) |
| **Sensor type** | use of sensors with OSSD outputs to EN 61496, contact-type sensors |
| **Electrical insulation** | channel/channel: no channel/E-bus: 500 $V_{eff}$ |
| **Signal level** | Off: -3 V … 5 V<br>On: 11 V … 30 V |
| **Maximum voltage** | 33 V (max. voltage to input even in case of error) |
| **Signal indication** | LED located next to terminal and parallel to input |
| **Duration of test impulse** | 300 µs ... 1500 µs (configurable),<br>phase-shifted to each channel |
| **Safe response time** | < 5 ms; see section "Response Time" |
| **Input current** | typ. 3.3 mA |
| **Input resistance** | typ. 7.3 kΩ |
| **Input capacitance** | typ. 100 nF |
| **Maximum line length** | 100 m (between sensors / module terminals) |

## 4.5.3 Safe Digital Test Pulse Outputs

| Safe digital test pulse outputs | |
|---|---|
| **Quantity and type** | 4 |
| **Nominal output current** | 50 mA, short-circuit-proof |
| **Signal indication** | LED located next to the terminal |
| **Switching voltage** | 24 VDC -15%/+20% |
| **Electric strength** | 33 V (max. voltage to output even in case of error) |
| **Duration of test impulse** | 300 µs ... 1500µs, phase-shifted to each channel |
| **Maximum line length** | 100 m (between sensor / module terminals) |

## 4.5.4 Safe Digital Outputs

| Safe digital outputs | |
|---|---|
| **Quantity and type** | 2x semiconductor, 24 VDC, tolerance to EN 61131-2:2007 |
| **Max. safety levels** | 2x cat. 3/PL e to EN ISO 13849-1:2015,<br>2x SIL3 to EN 62061:2010,<br>2x SIL3 to IEC 61508:2010 |
| **Diagnosis** | cross-fault, external power supply |
| **Signal indication** | LED located next to the terminal, controlled by CPU |
| **Minimum output current** | 2 mA, see → 6.2.8 Actuator Connection for details |
| **Maximum output current** | 2,0 A, short-circuit-proof, comply with total load and derating<br>See section → 6.2.8 Actuator Connection - Derating of Total Load for details |
| **Maximum output switching frequency** | 2,5 Hz |
| **Capacitive load** | yes, see section → 6.2.8 Actuator Connection for details<br>switching of capacity loads |
| **Braking voltage while turning off inductive loads** | typ. 40 VDC |
| **Inductive load** | yes, see section → 6.2.8 Actuator Connection for details<br>switching of inductive loads |
| **Maximum line length** | 100 m (between sensor / module terminals) |
| **Response threshold of output overload protection** | min. 2.5 A<br>typ. 3.5 A<br>max. 5.5 A |
| **Output current module$_{max}$** | 4 A, comply with total load and derating See section → 6.2.8 Actuator Connection - Derating of Total Load for details |
| **Load resistance range (at nominal voltage)** | 12 Ω ... 12 kΩ |
| **Electrical insulation** | channel/channel: no channel/E-bus: 500 $V_{eff}$ |
| **Approved actuators** | DC13 to EN60947-5-1 Table 4<br>DC1 to EN60947-4 |
| **Duration of test impulse** | configurable: 500 µs ... 1500 µs (configurable) |
| **Supply voltage** | 24 VDC -15%/+20% |
| **Electric strength** | 33 V (max. voltage to output even in case of error) |

# 4.6 Safety-related Input Ratings

## 4.6.1 Safety-related Ratings of a Single-channel Application

The table below lists the safety-related ratings of a single-channel safety function that uses one input of the safe I/O module. All components involved in the safety function must be taken into account in order to assess whether the desired safety level is achieved.

| Safety-related ratings of a single-channel application | | |
|---|---|---|
| Highest safety integrity level to EN 62061:2010 | SIL2 | |
| Highest safety integrity level to EN 61508:2010 | SIL2 | |
| Highest performance level to EN ISO 13849-1:2015 | Cat. 2/PL d | |
| Hardware fault tolerance (HFT) in single-channel application (IEC 61508:2010/EN ISO 13849-1:2015) | 0<br>(a fault of the application may cause the safeguard to fail) | |
| **Safety-related ratings** | **Ambient temperature, 25 °C** | **Ambient temperature, 55 °C** |
| Probability of failure on demand ($PFD_{avg}$), proof test interval: 10 years, (IEC 61508:2010) for one input (up to fieldbus) | $5.40 * 10^{-6}$ (0.06% of entire $PFD_{avg}$ of $10^{-2}$ at SIL2) | $2.23 * 10^{-5}$ (0.23% of entire $PFD_{avg}$ of $10^{-2}$ at SIL2) |
| Probability of failure per hour (PFH), proof test interval: 10 years, (IEC 61508:2010) for one input (up to fieldbus) | $1.24 * 10^{-10}$ 1/h (0.02% of entire PFH of $10^{-6}$ at SIL2) | $5.27 * 10^{-10}$ 1/h (0.05% of entire PFH of $10^{-6}$ at SIL2) |
| Probability of failure on demand ($PFD_{avg}$), proof test interval: 20 years, (IEC 61508:2010) for one input (up to fieldbus) | $1.10 * 10^{-5}$ (0.11% of entire $PFD_{avg}$ of $10^{-2}$ at SIL2) | $4.77 * 10^{-5}$ (0.48% of entire $PFD_{avg}$ of $10^{-2}$ at SIL2) |
| Probability of failure per hour (PFH), proof test interval: 20 years, (IEC 61508:2010) for one input (up to fieldbus) | $1.28 * 10^{-10}$ 1/h (0.02% of entire PFH of $10^{-6}$ at SIL2) | $5.79 * 10^{-10}$ 1/h (0.06% of entire PFH of $10^{-6}$ at SIL2) |
| Diagnostic coverage (DC) to EN ISO 13849-1:2015 | 98.32% | 95.89% |
| Safe failure fraction (SFF) | 99.27% | 98.51% |
| Mean time to dangerous failure (MTTF d) to EN ISO 13849-1:2015 | 100 years (calculated: 283 years) | 100 years (calculated: 185 years) |

## 4.6.2 Safety-related Ratings of a Two-channel Application

The table below lists the safety-related ratings of a two-channel safety function that uses two inputs of the safe I/O module. All components involved in the safety function must be taken into account in order to assess whether the desired safety level is achieved.

| **Safety-related ratings of a two-channel application** | | |
|---|---|---|
| Highest safety integrity level to EN 62061:2010 | SIL3 | |
| Highest safety integrity level to IEC 61508:2010 | SIL3 | |
| Highest performance level to EN ISO 13849-1:2015 | Cat. 3/PL e | |
| Hardware fault tolerance (HFT) of two-channel application (IEC 61508:2010/EN ISO 13849-1:2015) | 1<br>(a fault of the application need not cause the safeguard to fail) | |
| **Safety-related ratings** | **Ambient temperature, 25 °C** | **Ambient temperature, 55 °C** |
| Probability of failure on demand ($PFD_{avg}$), proof test interval: 10 years, (IEC 61508:2010) for two inputs (up to fieldbus) | $5{,}21 * 10^{-6}$ (0.51% of entire $PFD_{avg}$ of $10^{-3}$ at SIL3) | $2.16 * 10^{-5}$ (2.16% of entire $PFD_{avg}$ of $10^{-3}$ at SIL3) |
| Probability of failure per hour (PFH), proof test interval: 10 years, (IEC 61508:2010) for two inputs (up to fieldbus) | $1.20 * 10^{-10}$ 1/h (0.12% of entire PFH of $10^{-7}$ at SIL3) | $5.11 * 10^{-10}$ 1/h (0.51% of entire PFH of $10^{-7}$ at SIL3) |
| Probability of failure on demand ($PFD_{avg}$), proof test interval: 20 years, (IEC 61508:2010) for two inputs (up to fieldbus) | $1.06 * 10^{-5}$ (1.06% of entire $PFD_{avg}$ of $10^{-3}$ at SIL3) | $4.62 * 10^{-5}$ (4.62% of entire $PFD_{avg}$ of $10^{-3}$ at SIL3) |
| Probability of failure per hour (PFH), proof test interval: 20 years, (IEC 61508:2010) for two inputs (up to fieldbus) | $1.24 * 10^{-10}$ 1/h (0.12% of entire PFH of $10^{-7}$ at SIL3) | $5.62 * 10^{-10}$ 1/h (0.56% of entire PFH of $10^{-7}$ at SIL3) |
| Diagnostic coverage (DC) to EN ISO 13849-1:2015 | 98,32 % | 95,93 % |
| Safe failure fraction (SFF) | 99,28 % | 98,59 % |
| Mean time to dangerous failure (MTTFd) to EN ISO 13849-1:2015 | 100 years (calculated: 283 years) | 100 years (calculated: 185 years) |

# 4.7 Safety-related Output Ratings

## 4.7.1 Safety-related Ratings of a Single-channel Application

The table below lists the safety-related ratings of a single-channel safety function that uses one output of the safe I/O module. All components involved in the safety function must be taken into account in order to assess whether the desired safety level is achieved.

| Safety-related ratings of a single-channel application | | |
|---|---|---|
| Highest safety integrity level to EN 62061:2010 | SIL2 | |
| Highest safety integrity level to IEC 61508:2010 | SIL2 | |
| Highest performance level to EN ISO 13849-1:2015 | Cat. 2/PL d | |
| Hardware fault tolerance (HFT) of single-channel application (IEC 61508:2010/EN ISO 13849-1:2015) | 0<br>(a fault of the application may cause the safeguard to fail) | |
| **Safety-related ratings** | **Ambient temperature, 25 °C** | **Ambient temperature, 55 °C** |
| Probability of failure on demand ($PFD_{avg}$), proof test interval: 10 years, (IEC 61508:2010) for one output (from fieldbus) | $5.36 * 10^{-6}$ (0.06% of entire $PFD_{avg}$ of $10^{-2}$ at SIL2) | $2.24 * 10^{-5}$ (0.23% of entire $PFD_{avg}$ of $10^{-2}$ at SIL2) |
| Probability of failure per hour (PFH), proof test interval: 10 years, (IEC 61508:2010) for one output (from fieldbus) | $1.24 * 10^{-10}$ 1/h (0.02% of entire PFH of $10^{-6}$ at SIL2) | $5.31 * 10^{-10}$ 1/h (0.06% of entire PFH of $10^{-6}$ at SIL2) |
| Probability of failure on demand ($PFD_{avg}$), proof test interval: 20 years, (IEC 61508:2010) for one output (from fieldbus) | $1,10 * 10^{-5}$ (0.11% of entire $PFD_{avg}$ of $10^{-2}$ at SIL2) | $4,82 * 10^{-5}$ (0.48% of entire $PFD_{avg}$ of $10^{-2}$ at SIL2) |
| Probability of failure per hour (PFH), proof test interval: 20 years, (IEC 61508:2010) for one output (from fieldbus) | $1.28 * 10^{-10}$ 1/h (0.02% of entire PFH of $10^{-6}$ at SIL2) | $5.89 * 10^{-10}$ 1/h (0.06% of entire PFH of $10^{-6}$ at SIL2) |
| Diagnostic coverage (DC) to EN ISO 13849-1:2015 | 98,40 % | 96,56 % |
| Safe failure fraction (SFF) | 99,34 % | 98,81 % |
| Mean time to dangerous failure (MTTFd) to EN ISO 13849-1:2015 | 100 years (calculated: 264 years) | 100 years (calculated: 152 years) |

## 4.7.2 Safety-related Ratings of a Two-channel Application

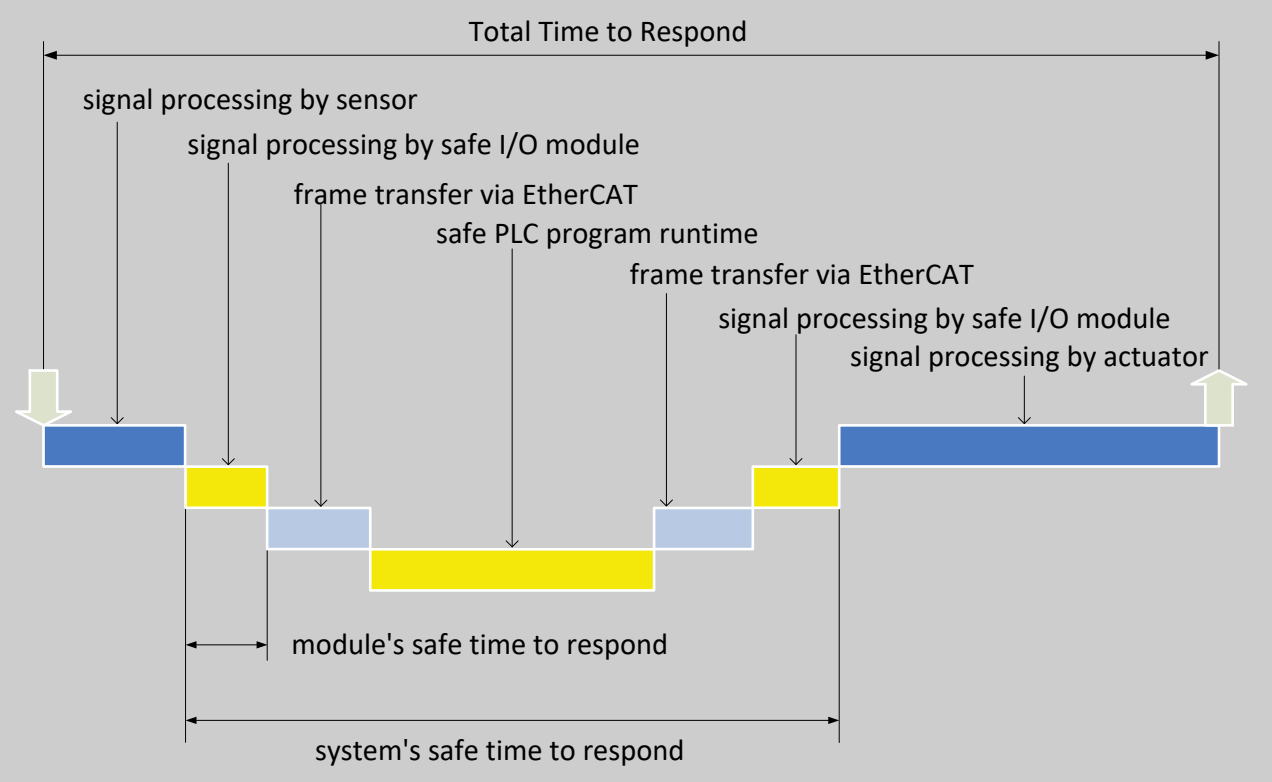
The table below lists the safety-related ratings of a two-channel safety function that uses two outputs of the safe I/O module. All components involved in the safety function must be taken into account in order to assess whether the desired safety level is achieved.

| **Safety-related ratings of a two-channel application** | | |
|---|---|---|
| Highest safety integrity level to EN 62061:2010 | SIL3 | |
| Highest safety integrity level to IEC 61508:2010 | SIL3 | |
| Highest performance level to EN ISO 13849-1:2015 | Cat. 3/PL e | |
| Hardware fault tolerance (HFT) in two-channel application (IEC 61508:2010/EN ISO 13849-1:2015) | 1<br>(a fault of the application need not cause the safeguard to fail) | |
| **Safety-related ratings** | **Ambient temperature, 25 °C** | **Ambient temperature, 55 °C** |
| Probability of failure on demand ($PFD_{avg}$), proof test interval: 10 years, (IEC 61508:2010) for two outputs (from fieldbus) | $5.52 * 10^{-6}$ (0.55% of entire $PFD_{avg}$ of $10^{-3}$ at SIL3) | $2.33 * 10^{-5}$ (2.33% of entire $PFD_{avg}$ of $10^{-3}$ at SIL3) |
| Probability of failure per hour (PFH), proof test interval: 10 years, (IEC 61508:2010) for two outputs (from fieldbus) | $1.28 * 10^{-10}$ 1/h (0.13% of entire PFH of $10^{-7}$ at SIL3) | $5.53 * 10^{-10}$ 1/h (0.56% of entire PFH of $10^{-7}$ at SIL3) |
| Probability of failure on demand ($PFD_{avg}$), proof test interval: 20 years, (IEC 61508:2010) for two outputs (from fieldbus) | $1.13 * 10^{-5}$ (1.13% of entire $PFD_{avg}$ of $10^{-3}$ at SIL3) | $5.03 * 10^{-5}$ (5.03% of entire $PFD_{avg}$ of $10^{-3}$ at SIL3) |
| Probability of failure per hour (PFH), proof test interval: 20 years, (IEC 61508:2010) for two outputs (from fieldbus) | $1.32 * 10^{-10}$ 1/h (0.13% of entire PFH of $10^{-7}$ at SIL3) | $6.18 * 10^{-10}$ 1/h (0.62% of entire PFH of $10^{-7}$ at SIL3) |
| Diagnostic coverage (DC) to EN ISO 13849-1:2015 | 98,42 % | 96,78 % |
| Safe failure fraction (SFF) | 99,36 % | 98,90 % |
| Mean time to dangerous failure (MTTFd) to EN ISO 13849-1:2015 | 100 years (calculated: 254 years) | 100 years (calculated: 140 years) |

# 4.8 Response Time

In a safety system, the total response time is made up of the following separate times:

- signal processing by sensor
- signal processing by the Kuhnke FIO Safety I/O module
- time of input data transfer across the EtherCAT bus between the Kuhnke FIO Safety I/O module and the safe PLC
- safe PLC program runtime
- time of output data transfer across the EtherCAT bus between the Kuhnke FIO Safety PLC and the Kuhnke FIO Safety I/O module
- signal processing by the Kuhnke FIO Safety I/O module
- signal processing by actuator




| | |
|---|---|
| ⚠ | ***CAUTION*** |
| | ***To calculate the safe response time, take account of the fieldbus runtimes and the Safety PLC's cycle time.***<br>*Avoid personal injury and damage to property*<br>⇨ The fieldbus runtimes and the Safety PLC's cycle time must be taken account of to rate and calculate the safe response time. |

As a general rule, a safe response time of **5 ms** may be assumed for the safe I/O module. This time ensures that the input and output signals will change and a safe state will be achieved.

The safe response time of digital inputs defines as the maximum time it takes before the FSoE frame is available on the EtherCAT bus after the signal of an input changes.

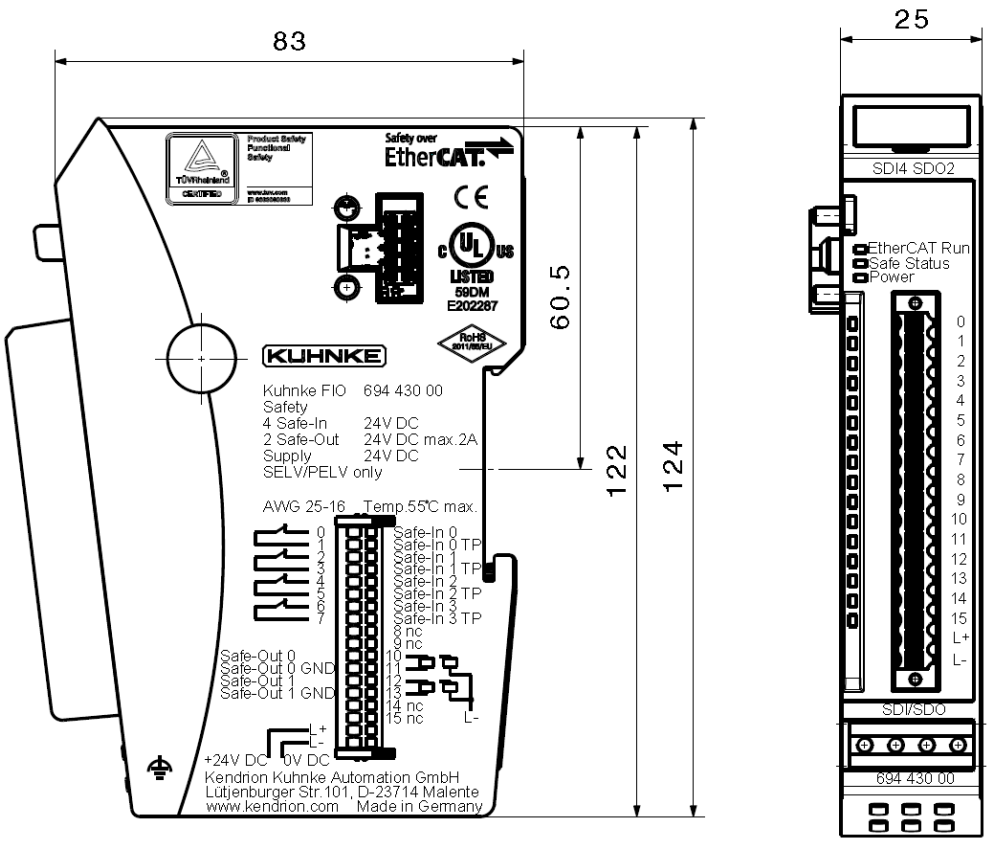
The safe response time of digital outputs defines as the maximum time it takes until the signal of a digital output changes after the EtherCAT module has received a FSoE frame.

Even if a fault occurs will the module be in a safe state before the safe response time is over. The following failure sources will provoke a change to the safe state:

- fault detected at the module inputs
- fault detected at the module outputs
- internal module fault (self-diagnosis)

| | |
|---|---|
|  | ***CAUTION*** |
| | ***Safety function pressure-sensitive mat requires a response time of 50 ms***<br>*Avoid personal injury and damage to property*<br>⇨ The pressure-sensitive mat function achieves a set response time of 50 ms between a change in mat state and providing the information on the EtherCAT bus. |

# 4.9 Dimensions




# 4.10 Transport and Storage

At times of transport and storage, protect Kuhnke FIO Safety I/O against inadmissible exposure such as mechanical stress, temperature, humidity and/or aggressive atmospheres. Transport and store Kuhnke FIO Safety I/O in its original packaging if possible.

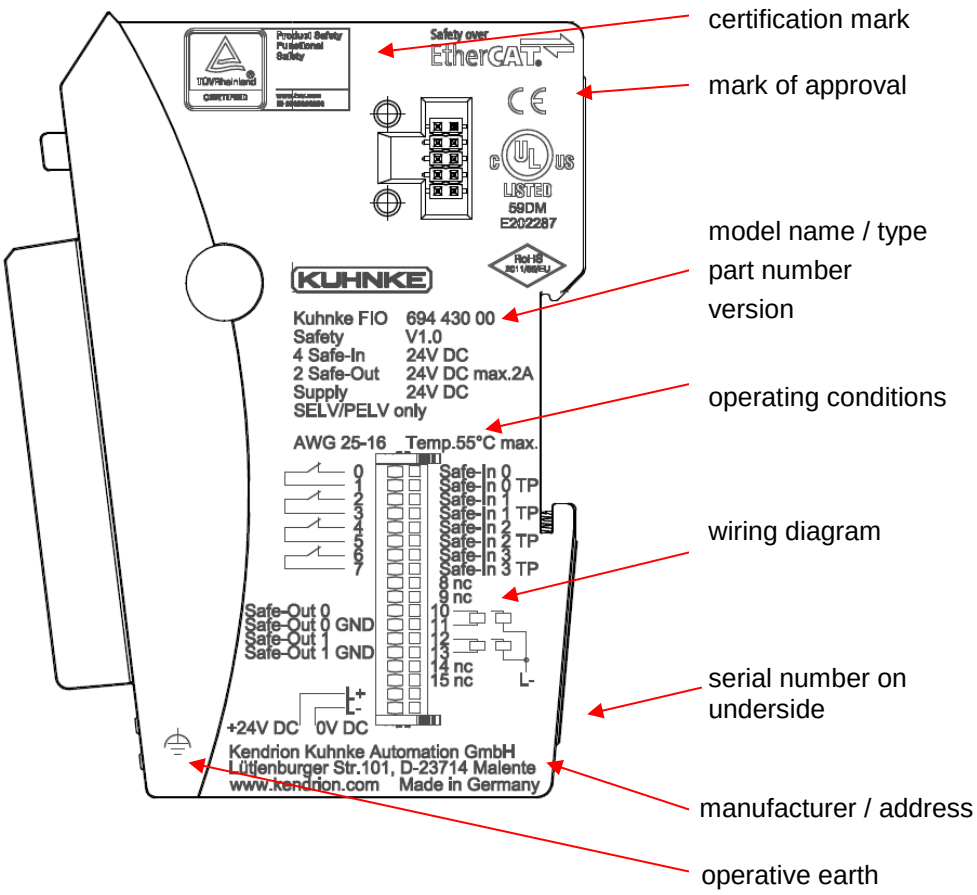
Verify that the contacts are neither soiled nor damaged when consigning the unit to stock or re-packaging it. Keep and transport Kuhnke FIO Safety I/O in a container/packaging ensuring electrostatic discharge (ESD) compliance. Some parts of the units are sensitive to ESD and may be damaged if handled inappropriately. Thus, best transport practice is to place open assemblies in statically shielded transport bags with a metal coating which avoid contamination by amines, amides or silicone. When putting Kuhnke FIO Safety I/O into service and performing any maintenance, you should also take the appropriate precautions against electrostatic discharge.

| | |
|---|---|
| ⚠ | ***CAUTION*** |
| | ***Electrostatic discharge***<br>*Destruction of or damage to the unit.*<br>⇨ Transport and store FIO Safety I/O in its original packaging.<br>⇨ Ensure that the ambient conditions are as specified at all times during transport and storage.<br>⇨ Handle FIO Safety I/O in a well-earthed environment (persons, place of work, packaging).<br>⇨ Do not touch electrically conductive parts such as data contacts. Some of the electronic components may be destroyed if exposed to electrostatic discharge. |

# 5 Construction and Functionality

## 5.1 Labelling and Identification

### 5.1.1 Imprinted Texts and Symbols



### 5.1.2 Serial Number

A label showing the serial number is affixed to the aluminium mount on the back of the module.

The numerical code incorporates the production date and a serial number. Kendrion Kuhnke can use the numerical code to distinctly identify the model, software and hardware release date. It is a means of traceability.


#### Make-up of serial number:

YY MM DD NNNNN

Example:

The unit shown above was manufactured on 15th June 2015 and has the serial number 00039.

15 06 05 00039

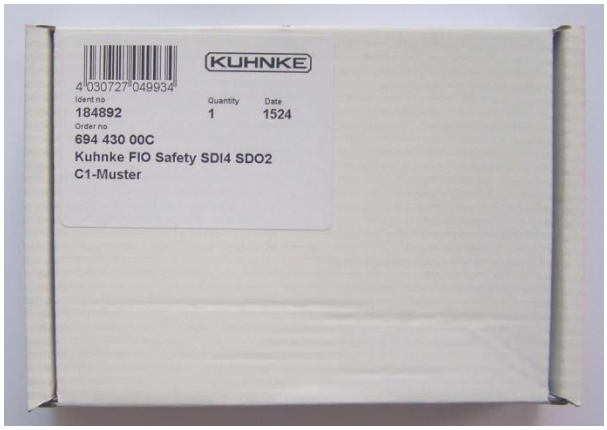
- five-digit number of nth unit built on that day
- production date as year month day

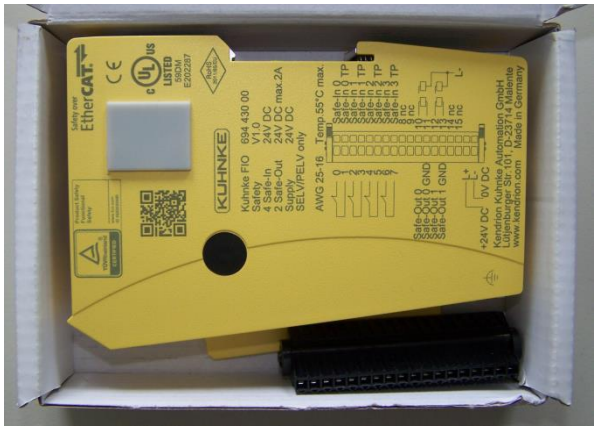
The serial number is also stored in object 1018 sub-index 4 and can be retrieved by SDO Transfer → 8.1.6 Identity Object 1018h.

## 5.2 Contents of Package

The FIO Safety I/Os package contains:

- FIO Safety I/O
- Module bus cover
- Connector



# 5.3 Connectors

## 5.3.1 E-bus and Module Lock

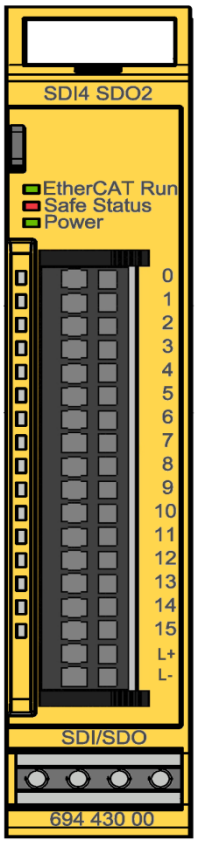
The system plugs and the module lock are located on the sides of Safety I/O. These contact pins interconnect the modules. They supply power to the module's electronic circuitry and transfer the EtherCAT signals. Verify that the end cap from the package is in place to protect the module bus connector on the last module at the right-hand side of a terminal unit against dirt.

The integrated module lock prevents the modules from coming apart under mechanical load or vibration.

| | |
|---|---|
|  | ***CAUTION*** |
| | ***Interconnecting units of different design*** |
| | *Damage to the unit's mechanical elements* |
| | ⇨ Use approved modules in a FIO network only. |

## 5.3.2 Spring-assisted Combi Plug X1

The spring-assisted combi plug is located at the front of FIO Safety I/O. The sensors and actuators and the module's power supply all attach to this connector.




| Connector X1 | | |
|---|---|---|
| Pin | Function | Signal |
| 0 | Safe-In 0 | SI0 |
| 1 | Safe-In 0 TP | SI0 TP |
| 2 | Safe-In 1 | SI1 |
| 3 | Safe-In 1 TP | SI1 TP |
| 4 | Safe-In 2 | SI2 |
| 5 | Safe-In 2 TP | SI2 TP |
| 6 | Safe-In 3 | SI3 |
| 7 | Safe-In 3 TP | SI3 TP |
| 8 | - Do not connect - | GND |
| 9 | - Do not connect - | GND |
| 10 | Safe-Out 0 | SO0 + |
| 11 | Safe-Out 0 GND | SO0 - |
| 12 | Safe-Out 1 | SO1 + |
| 13 | Safe-Out 1 GND | SO1 - |
| 14 | - Do not connect - | GND |
| 15 | - Do not connect - | GND |
| 16 | 24 V supply to power element (outputs) | L+ |
| 17 | GND | L- |

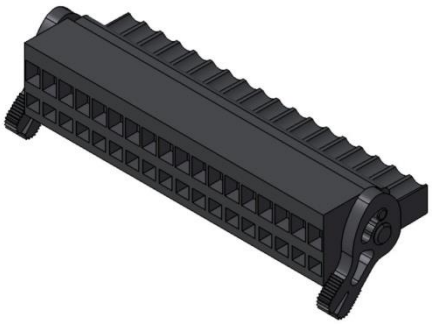


Figure: Single-row spring-assisted connector with releasing lever

| | |
|---|---|
| | ***Note, information*** |
| | *Connection to the Kuhnke FIO Safety I/O module must be made by the spring-assisted connector from the package only. Refer to section → 6.2 Electrical Installation further down below for details on how to connect sensors and actuators.* |

| | |
|---|---|
| | ***CAUTION*** |
| | ***Safe function jeopardised by cross-faults*** |
| | *Improper installation may cause malfunctions due to cross-faults at the contacts* |
| | ⇨ By design and if installed correctly, the spring-assisted connector prevents cross-faults at the contacts . Ensure a correct and technically perfect installation because cross-faults or shorts may jeopardise the module's safe function. |

## 5.3.3 Wiring Example

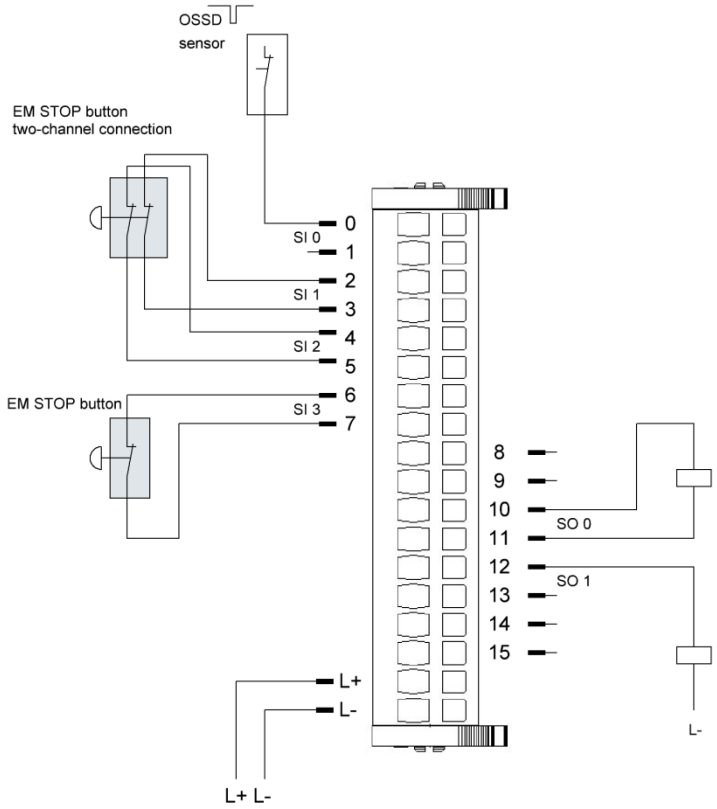



Figure2: Example of how to wire the inputs and outputs

The Kuhnke FIO Safety I/O module is intended to provide functional safety to industrial automation and to protect humans and machines in conformity with Machinery Directive 2006/42/EC.

It therefore supports the connection of many different safety-related sensors.

Examples:

- Single-channel and two-channel contact-type sensors such as EMERGENCY STOP switches
- Sensors with single and two-channel OSSD signals such as light grids
- Selector switches, safety mats and connecting blocks

Provided that the admissible maximum installed loads are not exceeded, resistive and inductive loads can be operated at the outputs, see section → 4.5.2
Safe Digital Outputs.

| | |
|---|---|
| | ***Note, information*** |
| | *Refer to section **7 Connection Examples** for examples of how to connect various sensors and actuators.* |

| | |
|---|---|
| | ***CAUTION*** |
| | ***Safe function jeopardised by cross-faults*** |
| | *Improper installation may cause malfunctions due to cross-faults at the contacts* |
| | ⇨ When test pulses are enabled, the Kuhnke FIO Safety I/O module will detect cross-faults between the inputs / outputs and other signal lines of the same module. Note that you must prevent cross-faults with the security functions of other modules. You should therefore protect the signal lines and/or lay them separately. |

## 5.3.4 I/O Supply

The I/O supply of the safe outputs and the associated test pulse outputs connects to terminals L+ and L-. The supply voltage is rated at 24 VDC. It is monitored.

The cord must have external protection against short circuit and overload triggering at max. 10 A.

Power to Kuhnke FIO Safety I/O may be supplied by PELV/SELV-ready 24 VDC power supply units to EN50178 / EN60950-1 only. This applies to both the system power supply → 6.2.3 System Power Supply and the I/O supply → 6.2.4 I/O Supply.

| | |
|---|---|
|  | ***CAUTION*** |
| | ***Risk of fire by overload or overvoltage*** |
| | *Damage to the unit* |
| | ⇨ Power to Kuhnke's FIO Safety I/O module may be supplied by PELV/SELV-ready 24 VDC power supply units to EN50178 / EN60950-1 only.<br>⇨ The maximum voltage supplied must not exceed 33 V even in case of an error.<br>⇨ The cord must have external protection against short circuit and overload triggering at max. 10 A. |

| | |
|---|---|
|  | ***CAUTION*** |
| | ***Module defect by reversing the polarity of the voltage supplied*** |
| | *Although Kuhnke's FIO Safety I/O module is reverse polarity-proof, reversing the polarity will still put considerable stress on the electronic circuitry and may cause module defects!* |
| | ⇨ Avoid a reversal of polarity. |

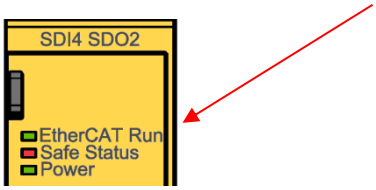
In case the supply of power is interrupted, drops or increases beyond the rated limits, the module will change to the safe state and output the appropriate error code to the service block → 6.5.7 Error Codes.

Refer to section 6.5 Diagnosis for further details on how the module responds to a non-conforming supply of power.

# 5.4 Indicators and Controls

## 5.4.1 LED "EtherCAT Run"

LED "EtherCAT Run" indicates the state of EtherCAT communication.




| LED "EtherCAT Run" | | |
|---|---|---|
| LED | State | Explanation / State |
| Off | Init | Initialising,<br>no data exchange |
| Off/green, 1:1 | Pre-Op | Pre-operational,<br>no data exchange |
| Off/green, 5:1 | Safe-Op | Safe operation,<br>inputs readable |
| Green, on | Op | Operational, unrestricted data exchange |

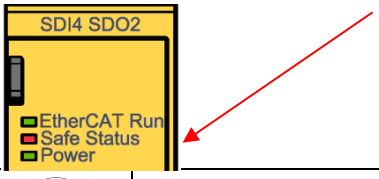
## 5.4.2 LED "Safe Status"

Duo LED safe "status" indicates the state of the module regarding its safety function.


| LED "Safe Status" | | |
|---|---|---|
| LED | State | Explanation |
| Green,<br>on | OK | Safe I/O provides safe functionality |
| Red,<br>on | Error | Safe I/O in fail-safe state |

## 5.4.3 LED "Power"

LED "Power" indicates the state of the power supply to Kuhnke's FIO Safety I/O module.




| LED "Power" | State | Explanation |
|---|---|---|
| Off | | No power supplied to the module. |
| Green,<br>on | OK | Operating voltage supplied to the module. |

| | |
|---|---|
| | ***Information*** |
| | *Kuhnke's FIO Safety I/O module feature a voltage watchdog for the 24 VDC supply voltage. It enables the module's safe state when a voltage is out of the specified range.* |

## 5.4.4 LEDs "Channel"

The "Channel" LEDs are allocated to the module's terminals. Every group of 2 LEDs indicates the state of the associated functional unit of output and/or input.

### Safe digital inputs SI 0 .. SI 3 in conjunction with test pulse outputs

**LEDs "Channel"; Safe digital inputs SI 0 .. SI 3**

| LED position | Channel | Function | LED | Explanation |
|---|---|---|---|---|
| 0 | Input SI 0 | SI0 state | Off | No valid input signal on channel 0, logical "0" |
| | | | Green | 24 VDC supplied to channel 0, logical "1" |
| 1 | | SI0 diagnosis | Off | Normal operation |
| | | | Red | External power supply or cross-fault |
| 2 | Input SI 1 | SI1 state | Off | No valid input signal on channel 1, logical "0" |
| | | | Green | 24 VDC supplied to channel 1, logical "1" |
| 3 | | SI1 diagnosis | Off | Normal operation |
| | | | Red | External power supply or cross-fault |
| 4 | Input SI 2 | SI2 state | Off | No valid input signal on channel 2, logical "0" |
| | | | Green | 24 VDC supplied to channel 2, logical "1" |
| 5 | | SI2 diagnosis | Off | Normal operation |
| | | | Red | External power supply or cross-fault |
| 6 | Input SI 3 | SI3 state | Off | No valid input signal on channel 3, logical "0" |
| | | | Green | 24 VDC supplied to channel 3, logical "1" |
| 7 | | SI3 diagnosis | Off | Normal operation |
| | | | Red | External power supply or cross-fault |

***Information***

- *The red "diagnosis" LEDs are disabled if the safe digital inputs are used without the safe digital test pulse outputs.*
- *The green "status" LEDs of the inputs will indicate the presence of a 24 VDC signal at an input even if that input has not been set up in the configuration.*

### Safe digital outputs SO 0 and SO 1

**LEDs "Channel"; Safe digital outputs SO 0 and SO 1**

| LED position | Channel | Function | LED | Explanation |
|---|---|---|---|---|
| 10 | Output SO 0 | Status | Off | No output signal at output 0, logical "0" |
| | | | Green | Output signal at output 0, logical "1" |
| 11 | | Diagnosis | Off | Normal operation |
| | | | Red | External power supply or cross-fault |
| 12 | Output SO 1 | Status | Off | No output signal at output 1, logical "0" |
| | | | Green | Output signal at output 1, logical "1" |
| 13 | | Diagnosis | Off | Normal operation |
| | | | Red | External power supply or cross-fault |

## 5.5 Operating Software

The FSoE master's configuration tool is used for operation and configuration . Refer to the FSoE master user guide for further information and details.

# 6 Installation and Operation

Before installing the Kuhnke FIO Safety Module, verify that it has been transported and stored at the ambient conditions specified in sections → 4.10 Transport and Storage and → 4.5 Technical Data.

Module operation is subject to the service conditions specified in section → 4.5 Technical Data.

| | |
|---|---|
|  | ***CAUTION*** |
| | ***Inappropriate operation***<br>*Malfunction of Kuhnke's FIO Safety I/O module*<br>⇨ Only persons qualified for dealing with safety matters are allowed to add, replace and put Safety I/O Modules into operation.<br>⇨ Before installing, servicing or putting Kuhnke FIO Safety into service, please also read the safety information in the preface of this document.<br>⇨ Before putting the unit into service, verify that all safety functions work as specified. |

## 6.1 Mechanical Installation

Environment of installation

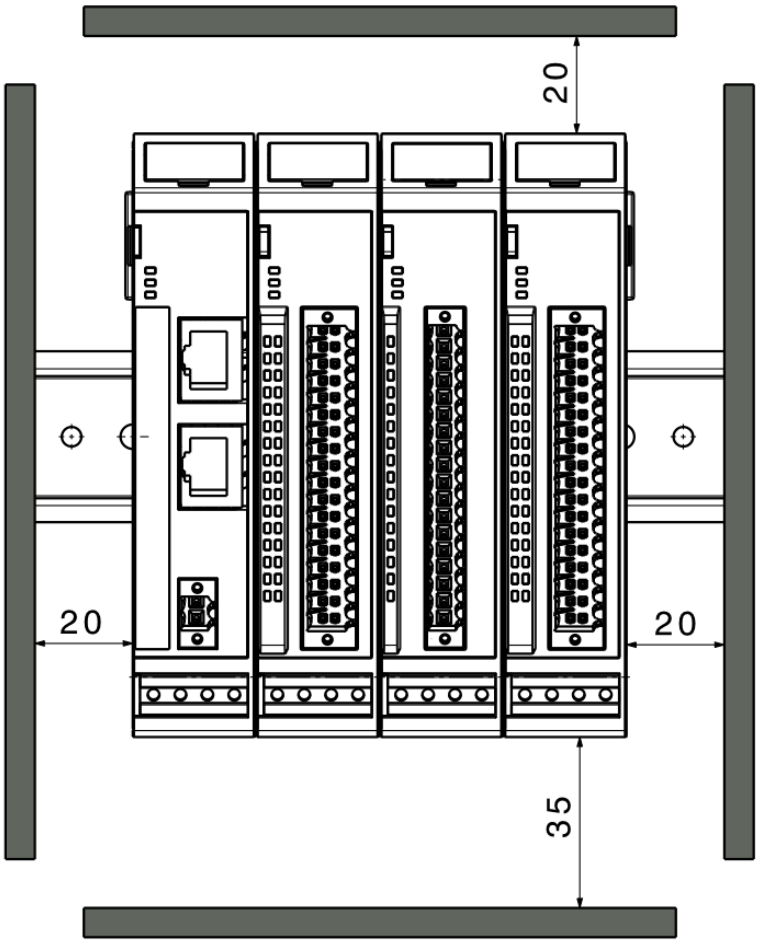
Protect KUHNKE FIO I/O against inadmissible contamination. Do not allow the units to contaminate more than specified for degree II in IEC 60664-3.

Whereas an enclosure providing IP 54 protection (e.g. an appropriate control cabinet) ensures that degree of contamination II is complied with, please consider that operation under condensing humidity is NOT allowed.

| | |
|---|---|
|  | ***WARNING*** |
| | ***Potentially hazardous failures due to contamination***<br>*Contaminations more severe than those described for degree of contamination II of IEC 60664-3 may cause potentially hazardous failures.*<br>⇨ Do ensure that the operating environment complies with at least IP 54, e.g. by installing the unit in a suitable control cabinet. |

## 6.1.1 Mounting Position

Kuhnke FIO I/Os mount on 35 mm x 7.5 mm rails to DIN EN 50022. Mount with rail horizontally with the modules' multiple socket connectors pointing away from the wall. To ensure that enough air gets in through the ventilation slots, leave at least 20 mm to the top and 35 mm to the bottom of a module and any adjacent devices or cabinet surfaces. Leave at least 20 mm of lateral distance to third-party units and cabinet surfaces.



Order of modules in multi-FIO systems

| | |
|---|---|
| | ***NOTE*** |
| | ***Order of modules in multi-FIO systems*** <br> *In order to ensure that the entire FIO system works properly, arrange the FIO modules by their specific E-bus load, placing the modules with the highest E-bus load immediately next to the head module (bus coupler or controller). Take account of the head module's maximum bus load.* <br> *If possible, place the Kuhnke FIO Safety I/O module immediately next to the head module.* |

## 6.1.2 To Snap on a Single Module

⇨ Push up the module against the mounting rail from below, allowing the metal spring to snap in between mounting rail and mounting area as illustrated.

⇨ Push the top of the module against the mounting wall until it snaps in.

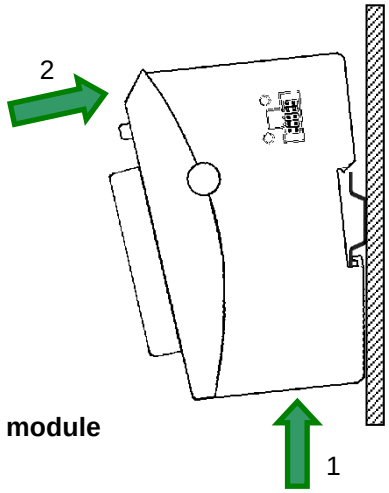



**Figure 3: Rail mounting of module**

## 6.1.3 To Interconnect Two Modules

⇨ After snapping on the first module to the rail, snap on the second module about 1 cm away towards the right of the first module.

⇨ Push the second module along the rail towards the first module until you hear the locking device snap in. Correctly mounting the modules is the only way of ensuring that the system works properly.

⇨ To prevent inadmissible contamination, mount the cover of the module bus connectors on the rightmost module of the FIO system.

| | |
|---|---|
| | ***CAUTION*** |
| | ***Short circuit fault of module bus contacts*** <br> *A short of the module bus contacts may cause the communication with the safe module to fail.* <br> ⇨ Verify that the cover of the module bus connector is mounted on the rightmost module of the FIO system. |

## 6.1.4 To Disconnect Two Modules

- ⇨ Push down the unlock button (see Figure 4) of the module that you wish to disconnect from the module to the left of it.
- ⇨ Push both modules away from one another until they are about 1 cm apart.

## 6.1.5 To Take Down a Single Module

- ⇨ Push the module up and against the metal spring located on the underside of the rail guide.
- ⇨ Tip the module away from the rail as shown in the illustration.
- ⇨ Pull the module down and out of the mounting rail.

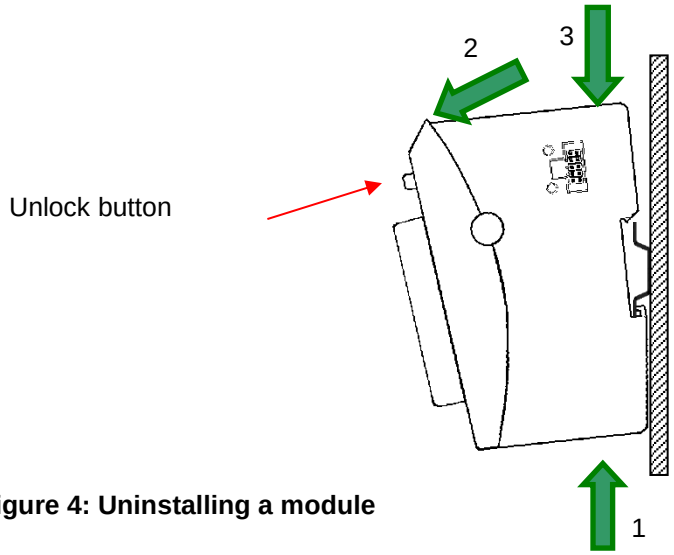



**Figure 4: Uninstalling a module**

# 6.2 Electrical Installation

## 6.2.1 Earth

Connect the Kuhnke FIO modules to earth by attaching the metal housing to functional earth. Since the functional earth connector dissipates HF currents, it is of utmost importance for the module's noise immunity.

HF interference is dissipated from the electronics board to the metal housing. The metal housing therefore needs to be suitably connected to a functional earth connector. You would normally ensure that the connection between the module housing and the DIN rail as well as the connection between the DIN rail and the control cabinet conducts well and that the control cabinet is properly connected to earth.

In exceptional cases, you may connect earth directly to the front of the module.

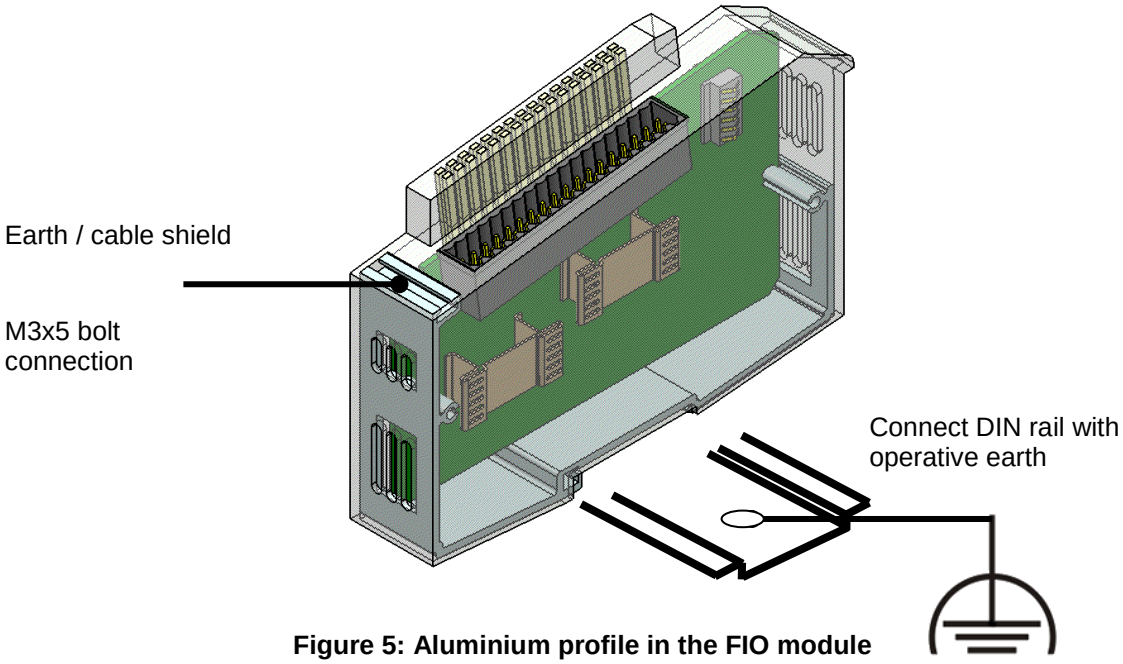



**Figure 5: Aluminium profile in the FIO module**

| | |
|---|---|
| | ***Information*** |
| | *Earth wires should be short and have a large surface (copper mesh). Refer to http://de.wikipedia.org/wiki/ground_(electronics)* for further details |

| | |
|---|---|
| | ***Note*** |
| | *When installing production or other lines, measure the earth potential of the DIN rail as specified in the applicable guidelines (earth test to VDE 0100) . Measuring the earth potential must show that every protective earthing and operational earthing is within the boundaries set by the applicable standards. Also consider the repeat testing frequency resulting from the hazard assessment.* |

## 6.2.2 Module Interconnection

The FIO modules electrically connect by completely pushing the modules together. This automatically connects the modules to both the EtherCAT bus and the system power supply. If possible, place the Kuhnke FIO Safety I/O module immediately next to the head module. Refer to section → 6.1 Mechanical Installation for details about how to interconnect two modules.

Please note that the maximum current supplied by the bus coupler limits the number of FIO modules you may connect to a single block.

## 6.2.3 System Power Supply

A system connector supplies the Kuhnke FIO Safety I/O system with system power from an upstream bus coupler or a compact controller. This system power supply is used for the analysis circuitry and for bus communication only.

| | |
|---|---|
|  | ***Note, information*** |
| | *Please take note of the system power supply details provided in the operating instructions of the upstream bus couplers or compact PLCs as well as the additional system power supply instruction in this user guide.* |

| | |
|---|---|
|  | ***WARNING*** |
| | ***Potentially hazardous failures due to wrong voltages supplied*** |
| | *Supplying the wrong voltages may damage or destroy the unit and may provoke potentially hazardous failures.* |
| | *Preventive measures:* |
| | ⇨ Only use PELV/SELV-ready power supply units to EN50178 or EN60950-1 to supply 24 VDC to bus couplers or compact PLCs that any Kuhnke FIO Safety I/O modules are connected to.<br>⇨ Only use the GND terminal to connect the power supply unit to earth (PELV system). Do not use earthing variants that connect earth to +24V.<br>⇨ Remember that, even in case of a fault, a maximum voltage of U max. < 33 V may be supplied to these assemblies.<br>⇨ To ensure that there is as little interference as possible, install a central power supply point and establish a star topology of as short wires as possible between the central point and the block of FIO modules. |

## 6.2.4 I/O Supply

The power supplied to the safe outputs and the associated test pulse outputs connects to terminals L+ and L-. The supply voltage is rated at 24 VDC. It is monitored. In case of overvoltage (> +20%) and low voltage (> -15%) alike, the module changes to its safe state.

| | |
|---|---|
|  | ***WARNING*** |
| | ***Potentially hazardous failures due to wrong voltages supplied*** |
| | *Supplying the wrong voltages may damage or destroy the unit and may provoke potentially hazardous failures.* |
| | *Preventive measures:* |
| | ⇨ Only use PELV/SELV-ready power supply units to EN50178 or EN60950-1 to supply 24 VDC to the I/Os of FIO Safety I/O.<br>⇨ Fuse the I/O power supply of FIO Safety I/O with max. 10 A.<br>⇨ Only use the GND terminal to connect the power supply unit to earth (PELV system). Do not use earthing variants that connect earth to +24V.<br>⇨ Remember that, even in case of a fault, a maximum voltage of U max. < 33 V may be supplied to these assemblies.<br>⇨ Do not reuse but replace units operated on voltages > 33 V.<br>⇨ To ensure that there is as little interference as possible, install a central power supply point and establish a star topology of as short wires as possible between the central point and the block of FIO modules. |

### I/O power supply fusing

The cord must have external protection against short circuit and overload triggering at max. 10 A, min. 60 v.

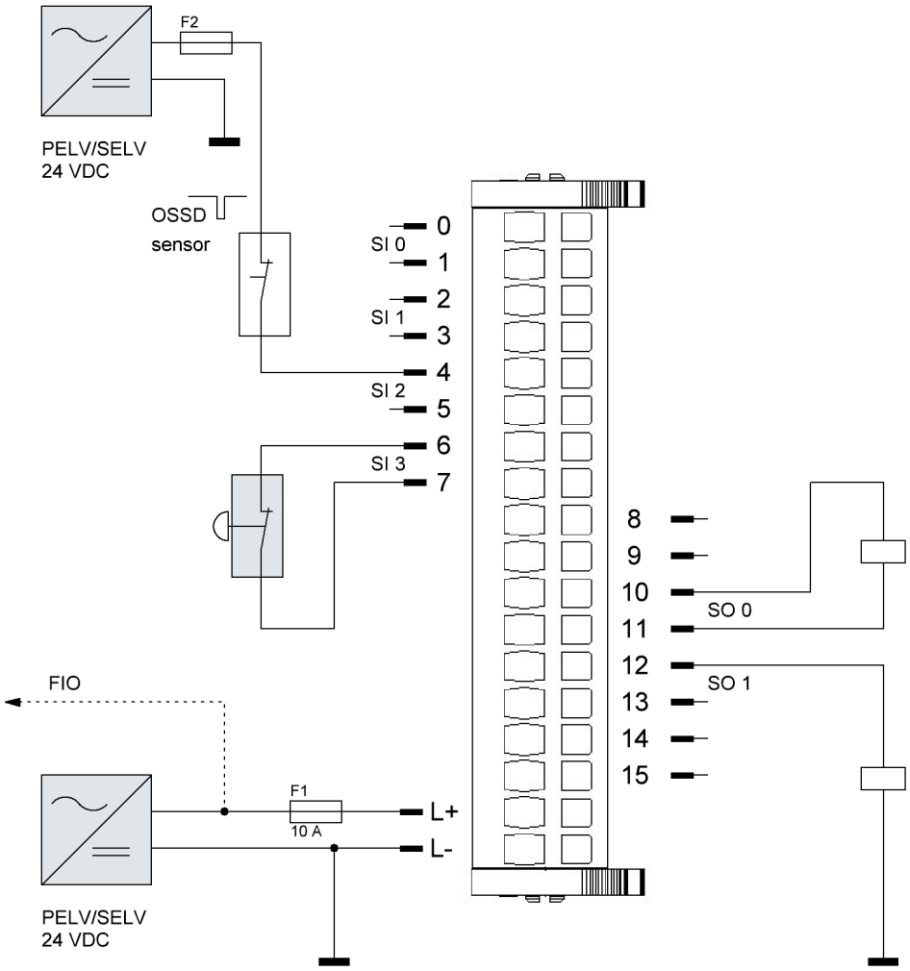
| | |
|---|---|
|  | ***WARNING*** |
| | ***Risk of fire due to short circuit!*** *A short circuit in the module or the power supply lines may cause the system to overheat or provoke a fire.* *Preventive measures:* ⇨ Install a fuse triggering at max. 10 A. |

## 6.2.5 Sensor and Actuator Power Supply

All sensors and actuators of the FIO Safety I/O system supplied with power from an external source must still run on safe low operating voltage (SELV/PELV). This power may also be fed to the I/Os of the FIO Safety I/O module.

| | |
|---|---|
|  | ***WARNING*** |
| | ***Potentially hazardous failures due to wrong voltages supplied to sensors and actuators*** *Supplying the wrong voltages may damage or destroy the unit and may provoke potentially hazardous failures.* *Preventive measures:* ⇨ Only use PELV/SELV-ready power supply units to EN50178 or EN60950-1 to supply 24 VDC to sensors and actuators connected to the Kuhnke FIO Safety I/O modules. ⇨ Only use the GND terminal to connect the power supply unit to earth (PELV system). Do not use earthing variants that connect earth to +24V. ⇨ Remember that, even in case of a fault, a maximum voltage of U max. < 33 V may be supplied to the sensors and actuators. ⇨ Do not reuse but replace units operated on voltages > 33 V. ⇨ To prevent that voltages are carried over, provide a low-impedance connection between the chassis ground of the unit supplying power to the sensors and actuators and the unit supplying 24 VDC to the I/Os of the Kuhnke FIO Safety I/O module. |

## 6.2.6 Power Supply Wiring Example



## 6.2.7 Sensor Connection

| | |
|---|---|
| ⚠ | ***CAUTION*** |
| | ***Consideration of the parameterization*** |
| | *For single-channel applications (inputs and outputs), the test pulse frequency should be adapted to the application. It must be ensured that in applications in which a frequent change of state occurs, the test pulse frequency is selected at least 100 times greater than the state change time of the application.* |
| | ⇨ See FSoE Parameters 6.3.2 |

### Single-channel contact-type sensor

The inputs of single-channel contact-type sensors work entirely separate from one another. Wiring should take account of the fact that every input signal is allocated to the test pulse output. Use the configuration to separately enable each of the inputs → 6.3.3 Input Parameters.


Analysis of states

The module checks the states of the inputs and transfers the result to the safe control unit.

The process data image of a safe input transfers

- "0" if a "0" signal is supplied to the input **or** if an error has been detected;
- "1" if a "1" signal is supplied to the input **or** if an error has not been detected.

**To disable the clock signals**

If the appropriate parameter disables the clock signals, you may supply 24 VDC to the sensor from an external power source. If so, please remember that disabled test pulse outputs prevent the detection of faults in the external wiring.

| | |
|---|---|
| ⚠ | ***WARNING*** |
| | ***Non-detection of a corrupt external wiring when test pulse outputs are disabled*** |
| | *Unsafe machine state, safety hazard* |
| | ⇨ Always use the correct and enabled test pulse output to supply power to contact-type sensors. |

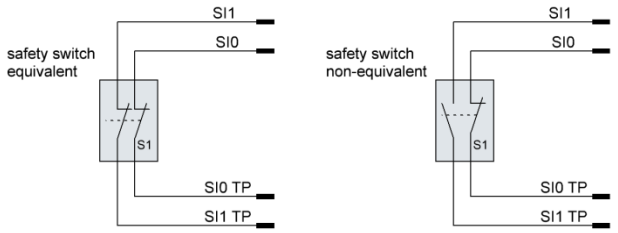
| | |
|---|---|
| ⚠ | ***WARNING*** |
| | ***External filter with direct connection of the module to the 24V supply*** |
| | *It is generally advisable to use the safe inputs with the module-specific test pulse outputs or OSSD outputs from external sensors. A direct connection of the safe inputs is only allowed for a 24V supply filtered in accordance with EN 61326-3-1 (interference level for surge, burst and conducted RF interference for I / O signals with direct mains supply).* |

Refer to section → 7.1 Safety Function with Single-channel Input for connection examples.

### Two-channel contact-type sensors

Two-channel contact-type sensors allow different inputs to be connected to the test pulse output of a two-channel sensor. A software module of the safe control unit provides the required analysis of the input signals.

The software can be used to interconnect any of the safe inputs. Wiring should take account of the fact that every input signal is allocated to the test pulse output. You must use the configuration to enable the safe inputs you use → 6.3.3 Input Parameters.




The process data image of a safe input transfers

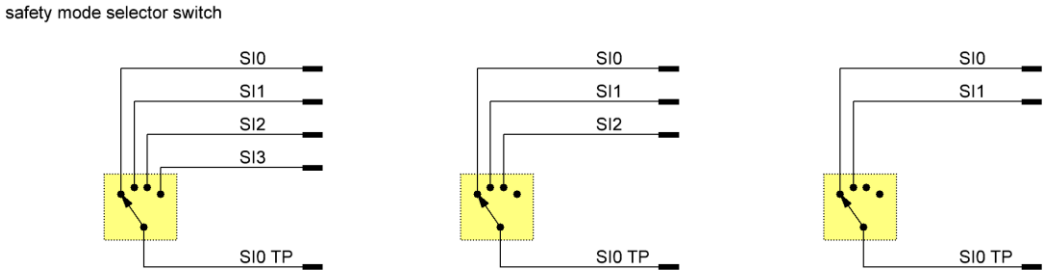
- "0" if a "0" signal is supplied to the input **or** if an error has been detected;
- "1" if a "1" signal is supplied to the input **or** if an error has not been detected.

Refer to section → 7.2 Safety Function with Two-channel Input for connection examples.

## Multi-channel contact-type sensors

Multi-channel switches such as mode selectors or "toggle"-type switchgear connect to several safe inputs only using test pulse output SI0 TP to provide the correct function. You must use the configuration to enable the safe inputs you use and parameter "External Inputs" to choose the mode selector function → 6.3.3 Input Parameters and 7.4 Mode Selector, Rotary Table.

Switches with 2, 3 or 4 channels can be analysed.




| Allocation of safe inputs for the mode selector function | | |
|---|---|---|
| No. of channels | Safe inputs used | Clock signal |
| 4 | SI0, SI1, SI2, SI3 | SI0 TP |
| 3 | SI0, SI1, SI2 | SI0 TP |
| 2 | SI0, SI1, | SI0 TP |

Safe inputs you do not use are available for other functions.

PLCopen module "Mode Selector" or a similar module of the safe control unit is used for multi-channel analysis. The achievable category to EN ISO 13849 depends on the switching device's error model (e.g. mode selector) and must needs be analysed in conjunction with the PLCopen module's error detection.

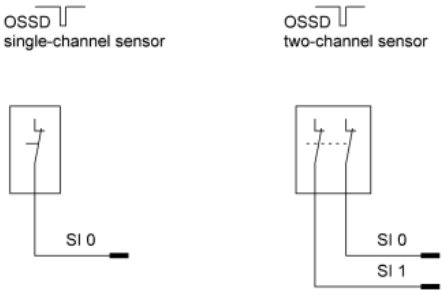
Refer to section → 7.4 Mode Selector, Rotary Table for connection examples.

| | |
|---|---|
| | ***NOTE*** |
| | ***Test pulse output***<br>*In mode selector mode, test pulse output TP0 can be set to "0". However, this will not affect the test pulse as such since, in mode selector mode, the test pulse always runs at maximum frequency.* |

| | |
|---|---|
| | ***NOTE*** |
| | ***Time discrepancy in mode selector/rotary table mode*** |
| | *A set time discrepancy of 100 ms has been implemented for signals missing at the inputs when changing to mode selector mode.* |

## Electronic sensors, OSSD sensor

The OSSD sensor provides the fault detection function when connecting an OSSD sensors. Depending on the sensor's functionality, the retrieval of signals is able to detect cross-faults between the 24 V power supply and earth as well as cross-faults between the sensor signals.




Wiring of sensors providing OSSD signals

Two-channel sensors delivering OSSD signals can be connected to any safe input of the Kuhnke FIO Safety I/O module. A software module of the safe control unit provides the required allocation and analysis of the input signals.

Sensors with OSSD signals do not support the module's test pulses. You must therefore set the input channels to "Test pulse duration =0" → 6.3.3 Input Parameters.

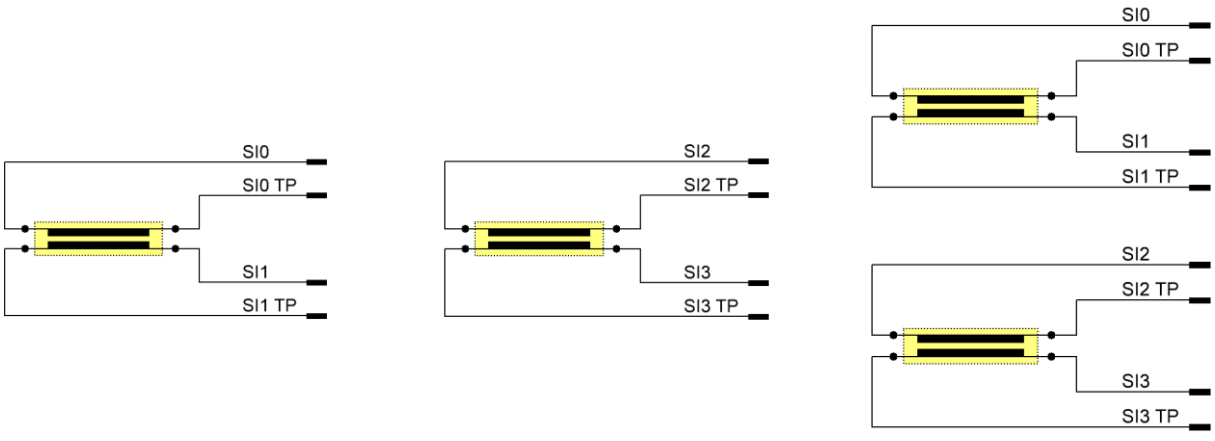
To prevent voltages from being carried over, provide a low-impedance connection between the chassis ground of both the sensor and the Kuhnke FIO Safety I/O module.

## Pressure-sensitive mat, bumper

Pressure-sensitive mats and bumpers are used to safeguard the floor around a machine. The mats are placed in the danger zone and make the control unit change to its safe functional state whenever pressure is exerted on them. In this case, a high signal is sent from both inputs.

Kuhnke's FIO Safety I/O module supports four-wire mats. Two safe digital inputs and the associated test pulse output are used for one mat / bumper.

You must use the configuration to enable the safe inputs you use and parameter "External Inputs" to choose the bumper function → 6.3.3 Input Parameters.
You may use up to two mat channels.



| Allocation of safe inputs for the bumper function | | | |
|---|---|---|---|
| Parameter "External Inputs" | | Safe inputs used | Safe inputs used |
| Bit 7 | Bit 6 | | |
| 0 | 0 | bumper function not selected | none |
| 0 | 1 | SI0, SI1, | SI0 TP, SI1 TP |
| 1 | 0 | SI2, SI3 | SI2 TP, SI3 TP |
| 1 | 1 | SI0, SI1, SI2, SI3 | SI0 TP, SI1 TP, SI2 TP, SI3 TP |

Safe inputs you do not use are available for other functions.
PLCopen module "SF_ESPE" or a similar module of the safe control unit is used for mat / bumper analysis. The achievable category to EN ISO 13849 depends on the switching device's error model and must needs be analysed in conjunction with the PLCopen module's error detection.

Refer to section → 7.5 Safety Mats, Connecting Blocks and Bumpers for connection examples.

**NOTE**

***Lay the feed lines of pressure-sensitive mats and bumpers together***

*In order to avoid influences and malfunctions due to EMC effects, lay the four wires (e.g. SI0, SI0 TP, SI1, SI1 TP) together.*

**CAUTION**

***"Short circuit in mat" fault is not detected***

*The safe I/O module fails to detect a short circuit between the mat contacts. This is interpreted as the mat being actuated. You must also verify that the safeguard is wired correctly.*

⇨ Periodically check that the mat is working properly.

**CAUTION**

***Safety function pressure-sensitive mat requires a response time of 50 ms***

*Avoid personal injury and damage to property*

⇨ The pressure-sensitive mat function achieves a response time of 50 ms between a change in mat state and providing the information on the EtherCAT bus.

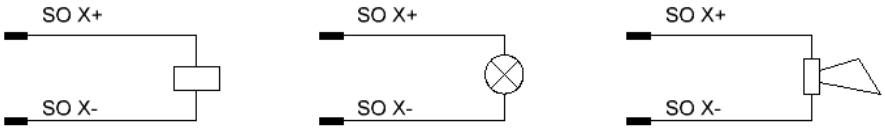
## 6.2.8 Actuator Connection

**NOTE**

***Faults at the outputs provoke a change to the safe state***

The outputs are protected against overload and short circuit, see section → 4.5.4 Safe Digital Outputs for details. Overload and short circuit cause the module to change to its safe state. The module responds in the same way to external power fed to and cross-faults at the outputs.

Resistive loads, inductive loads and resistive loads with some capacitive fractions can be connected to the digital power outputs of the FIO Safety I/O module. They also support signal lamps dissipating resistive power of up to 10 W.

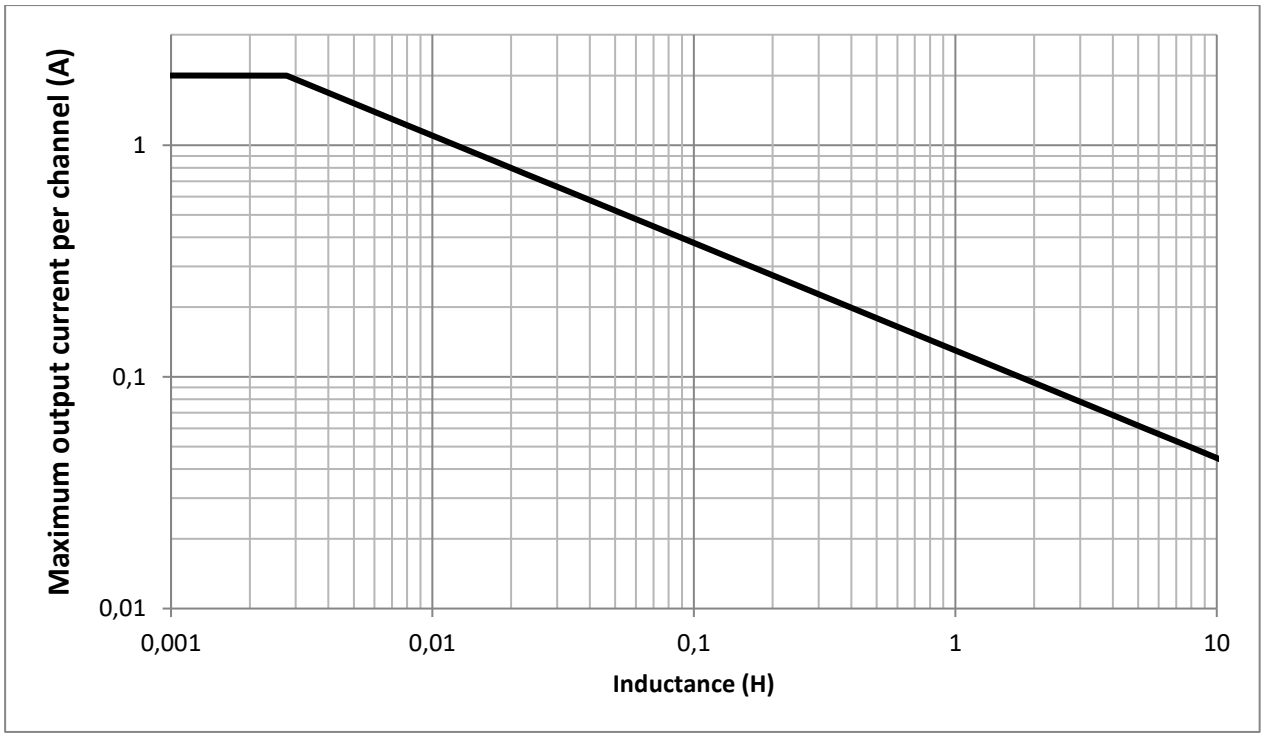



## Actuators with external GND reference

Provided that the configuration is taken account of, actuators with external GND reference can be connected to the Kuhnke FIO Safety I/O module.

## Switching of inductive loads

If the internal free wheel circuit is enabled, the digital power outputs of the FIO Safety I/O module can be used to operate inductive loads. The graph below illustrates the maximum inductance of the load vs. the load current.




| | |
|---|---|
| | ***NOTE*** |
| | ***Defect caused by thermal overload due to excessive inductance!***<br>*Setting the inductance and the load current to higher than the specified values may thermally destroy the digital power output. Destroying the digital power output may cause the safety function to fail.* |

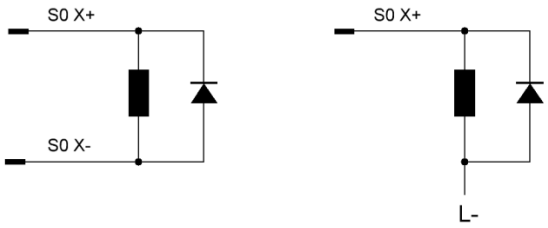
Use an external free wheel circuit if the external load exceeds the specified inductance limits.

## External free wheel circuit

| | |
|---|---|
| | ***NOTE*** |
| | ***Take heed of the perturbation of the external free wheel circuit*** |

| | |
|---|---|
| | Depending on the actual safety function, it may or may not be affected by the external free wheel circuit which the safety assessment must take account of. |

An external free wheel circuit will transduce the magnetic energy when turning off the inductive load.




Verify that the external free wheel circuit is designed to withstand the ensuing dissipation heat.

When connecting the inductive load to the outputs, be sure to limit the negative voltage of the external free wheel element you choose to anything smaller than -30 V because the digital output will otherwise transduce the magnetic energy to heat.

| | |
|---|---|
| | ***NOTE*** |
| | ***Note the heat dissipated by the external free wheel element!*** |
| | *If you choose the correct external free wheel element, this element instead of the safe I/O module will transduce the magnetic energy when turning off the inductive load.* |
| | *Verify that the external free wheel circuit is designed to withstand the ensuing dissipation heat.* |

## Switching of digital inputs

Digital inputs of I/O modules can be switched by the module's SO X+ outputs. Verify that you have enabled parameter "extGroundOutput" of the output you use. Output test pulse configuration must consider the input capacitance of the input to be actuated. See the section on the switching of capacitive loads below.

To ensure that the test pulses of the digital power outputs are filtered properly when the safe digital inputs of the Safety IO module are used, the inputs' configurable filters should be set to the same test pulse duration (parameter "Test pulse duration") as the digital power output.

## Switching of capacity loads

Switching of capacitive loads must take account of the limits below described with reference to the output current and the test pulse length.

Test pulses cyclically test the module's digital outputs. If you connect a capacitive load to the digital power output, you may have to modify the test pulse duration. A test pulse length not adapted to the load may cause the module to change to its safe state.

The outputs support loads connected to SOX+ and SOX- as well as to SOX+ and an external GND potential. Different maximum capacitive loads apply to both configurations because they are built around a different internal composition of the outputs. Every output supports a maximum capacitive load of 2.2 µF.

| **Output capacity of actuators with external GND reference or digital inputs to SOX+** | | |
|---|---|---|
| Test pulse length | Output current 2 mA | Output current 20 mA |
| 500 µs | 50 nF | 300 nF |
| 1000 µs | 110 nF | 600 nF |
| 1500 µs | 175 nF | 1000 nF |

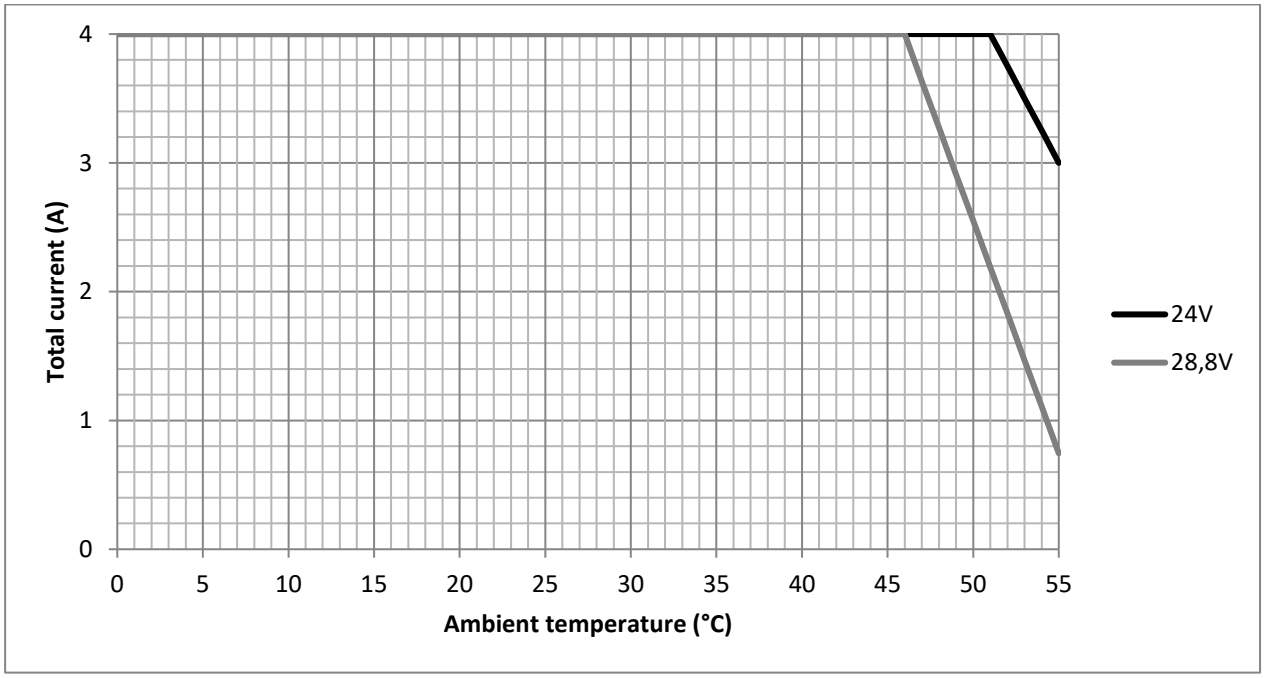
| **Output capacity of actuators with GND reference connected to SOX+ and SOX-** | | |
|---|---|---|
| Test pulse | Output current 2 mA | Output current 20 mA |

| length | | |
|---|---|---|
| 500 µs | 17 nF | 310 nF |
| 1000 µs | 48 nF | 620 nF |
| 1500 µs | 77 nF | 950 nF |

## Total current derating

| | |
|---|---|
| ⚠ | ***CAUTION*** |
| | ***Do not operate the FIO Safety I/O module out of the specified range*** |
| | *Faults by component overload* |
| | ⇨ Operate the module under the ambient conditions listed in section Technical Data only while observing the derating of the outputs. |

The maximum rated total current of the output module varies with the I/O module's ambient temperature. Refer to the diagram below for the resulting total current.

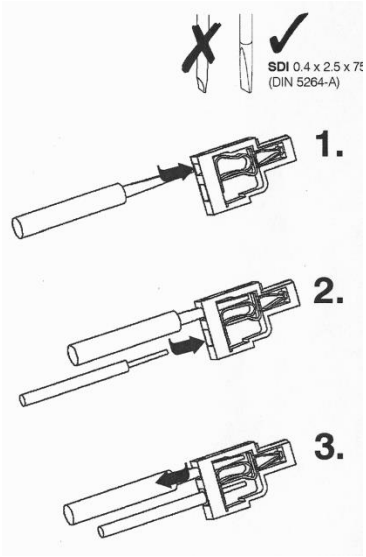



The output current derating shown on the graph was measured under free convection in a typical installation (I/O modules on the left and right, 50% duty cycle, identical supply voltage).

## 6.2.9 Multiple socket connector (MSC)

The multiple socket connector features tension springs which make wiring quick and easy. Use the unlock button to easily disconnect the wires where there is little space.Only use the MSC from the package to connect to Kuhnke's FIO module.

| | |
|---|---|
| MSC model: | Weidmüller, OMNIMATE Signal – BL/SL series 3.50 |
| Tool: | Screwdriver, 0.4 x 2.5 x 75 [mm] blade (DIN 5264-A) |
| Clamping range, rated connection | min. 0.14 mm² … max. 1.5 mm² |
| Wire diameter AWG, | min. AWG 26 … max. AWG 14 |
| Outside diameter of insulation, | max. 2.9 mm |
| Wire diameter, single-wire, | min. H05(07) V-U 0.2 mm² … max. H05(07) V-U 1.5 mm² |
| Wire diameter, fine wire, | min. H05(07) V-K 0.2 mm² … max. H05(07) V-K 1.5 mm² |
| Wire diameter with connector sleeve to DIN 46 228/1, | min. 0.2 mm² … max. 1.5 mm² |
| Wire diameter with connector sleeve with collar to DIN 46 228/4, Stripped end 10 mm | min. 0.2 mm² … max. 1 mm² |
| Nominal current: | 10 A (CSA) / 10 A (UL) |




| | |
|---|---|
| | ***WARNING*** |
| | ***Potentially hazardous failure due to improper wiring*** |
| | *Short circuits between adjacent terminals may damage or destroy the unit and may provoke potentially hazardous failures.* |
| | ⇨ Preventive measures: Ensure proper wiring |

| | |
|---|---|
| | ***NOTE*** |
| | ***Destruction by wrong tool*** |
| | *Damage to Kuhnke's FIO Safety I/O module* |
| | ⇨ Use suitable tools for wiring the multiple socket connector only!<br>⇨ Tool: Screwdriver, 0.4 x 2.5 x 75 [mm] blade (DIN 5264-A) |

# 6.3 Configuration

| | |
|---|---|
| | ***Attention*** |
| | ***Check the safety function***<br>*Potential faults due to maladjusted configuration*<br>• After initial installation and after replacing a module, check the safety function! |

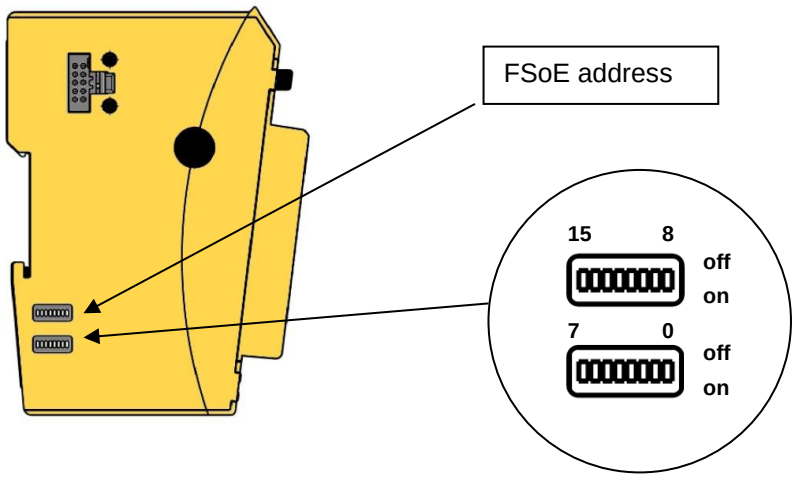
## 6.3.1 Address Setup

FIO Safety has a safe module address (FSoE slave address) which clearly identifies it in the safe communication network. The address is set manually by means of binary switches on the left side of the module.

Use the 2x 8 DIP switches to set the FSoE address. Addresses range between 1 and 65535.

| | |
|---|---|
| | ***Information*** |
| | *After setting the FSoE address, disconnect the FIO Safety module once from the power supply to ensure that the address is accepted and a module test started automatically.* |

| | |
|---|---|
| | ***Information*** |
| | *There is no access to the DIP switches once several modules have been lined up.*<br>*To set the FSoE slave address at the DIP switch, first remove the module from the row of modules.* |




| | |
|---|---|
| | ***NOTE*** |
| | ***Destruction by wrong tool***<br>*Damage to Kuhnke's FIO Safety I/O module*<br>⇨ Use suitable tools for setting the address only!<br>Use a suitable object (e.g. the tip of a ball pen or a screwdriver) to set the DIP switches.<br>Do not exert pressure on the switching elements! |

| | |
|---|---|
| | ***NOTE*** |

***Inappropriate setup actions at the Kuhnke FIO Safety I/O module***

*Machine failure and damage to the FIO Safety module*

⇨ Turn off the I/O supply before removing the FIO Safety module from the row of module for setup.

***Attention***

***Safety function not available***

*Startup disallowed by wrongly set address*

⇨ Do a function test to verify that the address coding switches have been set correctly.

| DIP switch | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Address | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 0 | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF |
| 1 | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | ON |
| 2 | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | ON | OFF |
| 3 | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | ON | ON |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| … | … | … | … | … | … | … | … | … | … | … | … | … | … | … | … | … |
| 65535 | ON | ON | ON | ON | ON | ON | ON | ON | ON | ON | ON | ON | ON | ON | ON | ON |

***Information***

*The FSoE address you set may only occur once in the communication network. The master will find and notify the user of a FSoE address that occurs more than once or is not used.*

## 6.3.2 FSoE Parameters

***CAUTION***

***Improper operation of parameter setup***

*Malfunction of Kuhnke's FIO Safety I/O module due to bad parameter setup*

⇨ Only persons qualified for dealing with safety matters are allowed to add, replace and put Safety I/O Modules into operation.

⇨ Before installing, servicing or putting Kuhnke FIO Safety into service, please also read the safety information in the preface of this document.

⇨ Before putting the unit into service, verify that all safety functions work as specified.

⇨ The module will not work if parameter settings are out of the specified valid range.

| FSoE parameter | |
|---|---|
| **Parameter** | Unit |
| Range<br>[Default] | Description / note |
| **FSoE address** | - |
| 1 ... 65535<br>[1] | FSoE slave address set at DIP switch |
| **Connection ID** | - |
| 1 ... 65535<br>[1] | Unique ID of the connection to a FSoE slave |
| **WatchdogTime** | ms |
| 20 … 65534 (0xFFFE)<br>[100] | Watchdog time of FSoE frame |
| **Used Inputs** | Dec |
| 0 .... 15<br>[15] | Enables the inputs used<br>Selection from a drop-down list depends on the configurator |

| Binary | Decimal | Active Inputs |
|---|---|---|
| 0 0 0 0 | 0 | No inputs used |
| 0 0 0 1 | 1 | Input 0 |
| 0 0 1 0 | 2 | Input 1 |
| 0 0 1 1 | 3 | Inputs 0,1 |
| 0 1 0 0 | 4 | Input 2 |
| 0 1 0 1 | 5 | Inputs 0,2 |
| 0 1 1 0 | 6 | Inputs 1,2 |
| 0 1 1 1 | 7 | Inputs 0,1,2 |
| 1 0 0 0 | 8 | Input 3 |
| 1 0 0 1 | 9 | Inputs 0,3 |
| 1 0 1 0 | 10 | Inputs 1,3 |
| 1 0 1 1 | 11 | Inputs 0,1,3 |
| 1 1 0 0 | 12 | Inputs 2,3 |
| 1 1 0 1 | 13 | Inputs 0,2,3 |
| 1 1 1 0 | 14 | Inputs 1,2,3 |
| 1 1 1 1 | 15 | Inputs 0,1,2,3 |

| | |
|---|---|
| **External Inputs** | Dec |
| Bits 0-3<br>$0000_2$.... $1111_2$<br>[$0000_2$] | Disables the generation of the module's test pulses if the sensors connected generate their own test pulses (OSSD) at the outputs or, optionally, for operation without test pulses (OSSD) and disables special functions rotary switch and pressure-sensitive mat.<br><br>Test pulse outputs, bits 0-3<br>0 test pulse output is used<br>1 test pulse output is not used (external test pulses enabled) |
| Bits 4,5<br>$00_2$… $11_2$<br>[$00_2$] | Mode selector, bits 4 and 5<br>00 disabled<br>01 2 channels (inputs 0 & 1)<br>10 3 channels (inputs 0 - 2)<br>11 4 channels (inputs 0 – 3) |

Bits 6,7
$00_2$ … $11_2$
[$00_2$]

Pressure-sensitive mat / bumper, bits 6 & 7
00 disabled
01 inputs 0 & 1
10 inputs 2 & 3
11 inputs 0 & 1 and inputs 2 & 3

| Bit | | | | | | | Decimal | Setting |
|---|---|---|---|---|---|---|---|---|
| 7 | | 5 | 4 | 3 | 2 | | | |
| 0 | | 0 | 0 | 0 | 0 | 0 | 0 | No function |
| 0 | | 0 | 0 | 0 | 0 | 1 | 1 | Test pulse output of input 0 disabled |
| 0 | | 0 | 0 | 0 | 0 | 0 | 2 | Test pulse output of input 1 disabled |
| 0 | | 0 | 0 | 0 | 1 | 0 | 4 | Test pulse output of input 2 disabled |
| 0 | | 0 | 0 | 1 | 0 | 0 | 8 | Test pulse output of input 3 disabled |
| 0 | | 0 | 0 | 1 | 1 | 1 | 15 | All test pulse outputs of all inputs disabled |
| 0 | | 0 | 1 | 0 | 0 | 0 | 16 | Mode selector, two channels (inputs 0 & 1) |
| 0 | | 1 | 0 | 0 | 0 | 0 | 32 | Mode selector, three channels (inputs 0 - 2) |
| 0 | | 1 | 1 | 0 | 0 | 0 | 48 | Mode selector, four channels (inputs 0 - 3) |
| 0 | | 0 | 0 | 0 | 0 | 0 | 64 | Pressure-sensitive mat, inputs 0 & 1 |
| 1 | | 0 | 0 | 0 | 0 | 0 | 128 | Pressure-sensitive mat, inputs 2 & 3 |
| 1 | | 0 | 0 | 0 | 0 | 0 | 192 | Pressure-sensitive mat, inputs 0 & 1 and 2 & 3 |

Red cells:
- In mode selector or pressure-sensitive mat modes, disabling a test pulse output will provoke an error message
- Settings in red cells are therefore forbidden

Green cells:
- Pressure-sensitive mat mode available for inputs 0&1 or 2+3
- Mode selector mode available for inputs 0&1, 0-2 or 0-3

Blue cells:
- Test pulse outputs can be disabled

Example:
Assuming you wish to run a pressure-sensitive mat at inputs 0&1 of the Kuhnke FIO Safety SDI4 SDO2 module while disabling the test pulses of the other inputs (2&3). Set up as follows:

64 + 4 + 8 = 76

| | |
|---|---|
| WatchdogTime | 100 |
| usedInputs | 15 |
| externalInputs | 76 |
| usedOutputs | 3 |
| extGroundOutputs | 3 |

**usedOutputs** Dec

$00_2$.... $11_2$
[$00_2$]

Enables the outputs you use (0 and / or 1)
Selection from a drop-down list depends on the configurator

00 outputs disabled
01 SO 0 enabled, SO 1 disabled
10 SO 0 disabled, SO 1 enabled
11 SO 0 enabled, SO 1 enabled

**extGroundOutputs** Dec

$00_2$ .... $11_2$
[$00_2$]

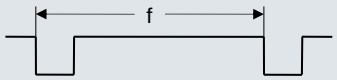
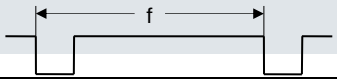
Enable if the actuator is not connected to module terminal SO X- but uses an external ground connection.
Selection from a drop-down list depends on the configurator

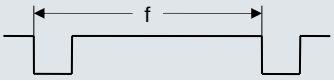
**Test pulse duration input 0** µs

300 ... 1500
[500]

Test pulse length of input 0
Input filter of input 0


The digital test pulse output is interrupted for the set duration of every test pulse. The Kuhnke FIO Safety I/O module checks whether the digital inputs may turn Null and whether there are any short circuits to noise voltages on the signal line.
Adapt the test pulse duration to the peripherals you use.

| **Test pulse duration input 1** | µs |
|---|---|
| 300 ... 1500<br>[500] | Test pulse length of input 1<br>Input filter of input 1<br>  <br>The digital test pulse output is interrupted for the set duration of every test pulse. The Kuhnke FIO Safety I/O module checks whether the digital inputs may turn Null and whether there are any short circuits to noise voltages on the signal line.<br>Adapt the test pulse duration to the peripherals you use. |
| **Test pulse duration input 2** | µs |
| 300 ... 1500<br>[500] | Test pulse length of input 2<br>Input filter of input 2<br>  <br>The digital test pulse output is interrupted for the set duration of every test pulse. The Kuhnke FIO Safety I/O module checks whether the digital inputs may turn Null and whether there are any short circuits to noise voltages on the signal line.<br>Adapt the test pulse duration to the peripherals you use. |
| **Test pulse duration input 3** | µs |
| 300 ... 1500<br>[500] | Test pulse length of input 3<br>Input filter of input 3<br>  <br>The digital test pulse output is interrupted for the set duration of every test pulse. The Kuhnke FIO Safety I/O module checks whether the digital inputs may turn Null and whether there are any short circuits to noise voltages on the signal line.<br>Adapt the test pulse duration to the peripherals you use. |
| **Test pulse duration output 0** | µs |
| 500... 1500<br>[800] | Test pulse length of input 0<br>  <br>The digital power output is interrupted for the set duration of every test pulse. The Kuhnke FIO Safety I/O module checks whether the power outputs may be turned off and whether there are any short circuits to noise voltages on the output line. Adapt the test pulse duration to the load applied. |
| **Test pulse duration output 1** | µs |
| 500... 1500<br>[800] | Test pulse length of input 1<br>  <br>The digital power output is interrupted for the set duration of every test pulse. The Kuhnke FIO Safety I/O module checks whether the power outputs may be turned off and whether there are any short circuits to noise voltages on the output line. Adapt the test pulse duration to the load applied. |
| **Test frequency input 0** | Hz |
| 0 ... 25<br>[1] | Test pulse frequency of input 0<br>"0" = no test pulse<br>  |
| **Test frequency input 1** | Hz |
| 0 ... 25<br>[1] | Test pulse frequency of input 1<br>"0" = no test pulse<br>  |
| **Test frequency input 2** | Hz |
| 0 ... 25<br>[1] | Test pulse frequency of input 2<br>"0" = no test pulse<br>  |

| | | |
|---|---|---|
| **Test frequency input 3** | | Hz |
| 0 ... 25<br>[1] | Test pulse frequency of input 3<br>"0" = no test pulse |  |
| **Test frequency output 0** | | min-1 |
| 0 ... 25<br>[1] | Test pulse frequency of output 0<br>"0" = no test pulse[1] |  |
| **Test frequency output 1** | | min-1 |
| 0 ... 25<br>[1] | Test pulse frequency of output 1<br>"0" = no test pulse[2] |  |

## 6.3.3 Input Parameters

| | |
|---|---|
| | ***CAUTION*** |
| | ***Consideration of the parameterization***<br>*For single-channel applications (inputs and outputs), the test pulse frequency should be adapted to the application. It must be ensured that in applications in which a frequent change of state occurs, the test pulse frequency is selected at least 100 times greater than the state change time of the application.*<br>⇨ See FSoE Parameters 6.3.2 |

### Parameters "Used Inputs" and "External Inputs"

Use these parameters to enable the inputs of the Kuhnke FIO Safety I/O module and to select the input function. Use parameter "External Inputs" to disable the module's test pulse outputs that deliver test pulses to each of the inputs. Use this setting for sensors generating their own test pulses (some light barriers, for example).

| | |
|---|---|
| | ***WARNING*** |
| | ***Non-detection of a corrupt external wiring when test pulse outputs are disabled***<br>*Unsafe machine state, safety hazard*<br>⇨ Always use the correct and enabled test pulse output to supply power to contact-type sensors.<br>⇨ Note: Consider protecting the cables and/or laying them separately to ensure a sufficient degree of safety. |

In "Mode Selector" mode, you can connect 2, 3 or 4 inputs to test pulse output SI0 TP and to a mode selector. Disable the test pulse outputs you do not need. Refer to manual section →7.4 Mode Selector for a wiring example. Inputs you do not use and the associated test pulse outputs can be used for other functions.

"Pressure-sensitive Mat/Bumper" mode uses pairs of 2 inputs and the associated test pulse outputs. Parameter "External Input" allows you to separately choose the function of inputs 0 & 1 and 2 & 3. Inputs you do not use and the associated test pulse outputs can be used for other functions. Refer to manual section →7.5 Safety Mats, Connecting Blocks and Bumpers for a wiring example.

[1] The test pulses of both outputs must be deactivated so that no test pulses are generated.
Please also observe the notes in the chapter Output Parameters 6.3.4

[2] See footnote 1

### Parameter "Test pulse duration input"

If used together with the module's test pulse outputs, test pulses cyclically check the input circuit connected to the Kuhnke FIO Safety I/O module for faults such as short circuits or internal defects. Parameter "Test pulse duration output" sets the time of a test pulse allocated to a digital test pulse output. It also sets the filtering time of the digital inputs. You may have to modify the test pulse duration if the signals are affected by capacitive properties of the input circuit, for example.

### Parameter "Test frequency input"

If used together with the module's test pulse outputs, test pulses cyclically check the input circuit connected to the Kuhnke FIO Safety I/O module for faults such as short circuits or internal defects. Parameter "Test pulse duration input" sets the switching frequency and, thus, the frequency of test pulses allocated to a digital test pulse output.

| | |
|---|---|
|  | ***WARNING*** |
| | ***Non-detection of a corrupt external wiring when test pulse outputs are disabled***<br>*Unsafe machine state, safety hazard*<br>⇨ Always use the correct and enabled test pulse output to supply power to contact-type sensors.<br>⇨ Note: Consider protecting the cables and/or laying them separately to ensure a sufficient degree of safety. |

## 6.3.4 Output Parameters

| | |
|---|---|
|  | ***CAUTION*** |
| | ***Consideration of the parameterization***<br>*For single-channel applications (inputs and outputs), the test pulse frequency should be adapted to the application. It must be ensured that in applications in which a frequent change of state occurs, the test pulse frequency is selected at least 100 times greater than the state change time of the application.*<br>⇨ See FSoE Parameters 6.3.2 |

### Parameter "extGroundOutputs"

Enable if the sensor is not connected to module terminal SO X- but uses an external ground connection. Pick from a drop-down list provided by the configurator software. Linking the sensor to an external ground connection instead of terminal SO X- disallows you to control an external 24 VDC power supply.

Also set this parameter if output SO X+ supplies an electronic load such as a digital input of an I/O module.

### Parameter "Used Outputs"

Enables the outputs you use (SO 0 and / or SO 1)

Pick from a drop-down list

### Parameter "Test pulse duration output"

Test pulses cyclically check the digital outputs of the Kuhnke FIO Safety I/O module for faults such as short circuits or internal defects. Parameter "Test pulse duration output" sets the time of a test pulse allocated to a digital output. If you connect a capacitive load to the digital power output, you may have to modify the test pulse duration.

**NOTE**

***Test pulses to the outputs***

*Match the connected loads and the test pulse duration setting such that the test pulses are prevented from switching the loads.*

## Parameter "Test frequency output"

Test pulses cyclically test the digital outputs of the Kuhnke FIO Safety I/O module. Parameter "Test frequency output" sets the switching frequency and, thus, the frequency of test pulses allocated to a digital output. Adapt this parameter to real-life conditions particularly when using inductive or capacitive loads.

**CAUTION**

***Shut-off of test pulses to the output***

*Owing to the construction of the outputs, shutting off the test pulses to an output channel will not stop test pulses from being generated at that output if test pulse are still set for the other output channel. Frequency and length of these test pulses are determined by the other output. Verify that these test pulses cannot switch the actuators connected.*

- ⇨ To stop the generation of test pulses, you must disable the test pulses to both outputs.

**WARNING**

***Non-detection of incorrect external wiring while test pulses are disabled***

*Unsafe machine state, safety hazard*

- ⇨ Use the output test pulses to detect cross-faults at the outputs and other faults.
- ⇨ Note: Consider protecting the cables and/or laying them separately to ensure a sufficient degree of safety.
- ⇨ Switching off the test pulses is not recommended, it can reduce the safety of the application.

**CAUTION**

***Minimum length of test pulses***

*Owing to the construction of the outputs, different test pulse length settings of the two output channels will generate test pulses of the minimum length set for both outputs of both channels.*

- ⇨ Verify that both outputs comply with this minimum value to ensure that all test pulses are of a minimum length. Verify that this minimum test pulse length cannot switch the actuators connected.

**WARNING**

***Reduced diagnosis with deactivated test pulses at the outputs***

*Switching off the test pulses is not recommended, it can reduce the safety of the application. With the test pulses switched off at the outputs, it is necessary to maintain the diagnosis of the outputs by:*

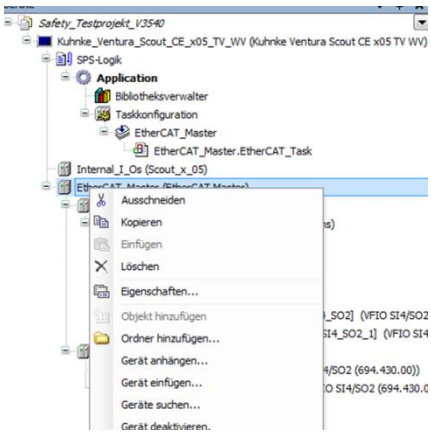
- ⇨ The outputs are switched once a year and the switching is done functionally (by the application) or by completely turning the device off.

# 6.4 Putting into Service

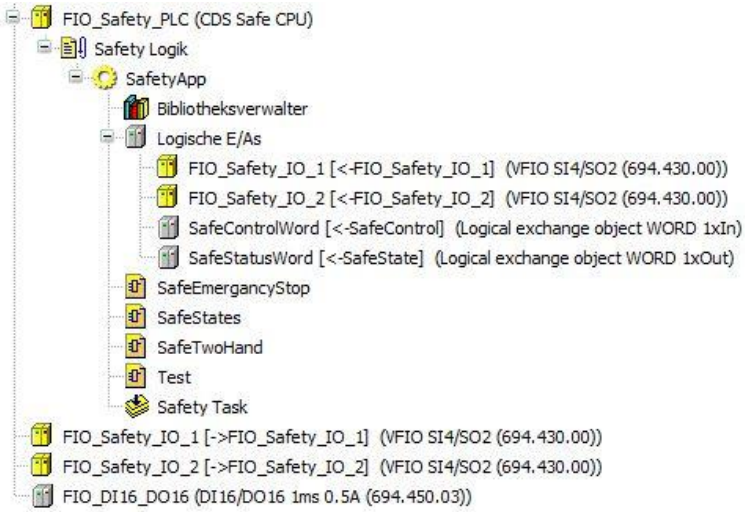
| | |
|---|---|
| | ***Note, information*** |
| | ***Usage note***<br>Kuhnke's FIO Safety I/O module may be used ETG-compliant configurations with conforming products. Such products include slave services, master and development systems, and functional safety products. Check the products for the "EtherCAT Conformance tested" to see if they have passed an official test for conformity. Certified products are listed in the EtherCAT Product Guide published by the EtherCAT Technology Group. |

## Topology of CODESYS devices

Like in all other CODESYS projects, the project environment of safety projects must identically reflect the hardware topology. You can either set up the topology manually or, provided that all device descriptions have been installed, start a search for devices in CODESYS. Right-click on the EtherCAT master and pick "Geräte suchen..." (Find devices) from the context menu. In the next dialog, you just need to confirm to "Alle Geräte ins Projekt kopieren" (Copy all devices to project).




CODESYS configuration example:




Refer to the manual of your PLC to know how to set up a CODESYS project.

# 6.5 Diagnosis

## 6.5.1 Self-test

When system voltage is supplied to the Kuhnke Safety module, it initially runs a complete system test. Only if this system test is passed will the module be able to operate and first of all change to its "fail-safe" state.

This is indicated by LED "Safe Status" lighting up red.

The FIO Safety I/O module will retain the fail-safe state until all internal tests have been passed, valid data has been received from the control unit, and faults are not detected in any of the external hardware, sensors, actuators and their wiring.

A safe functional state is indicated by LED "Safe Status" lighting up green.

The module will retain its fail-safe state if it fails to qualify for the safe state, e.g. because of errors in the application's module setup. To find the cause of the problem, check the error code in the service block → 6.5.6 Table of Faults.

In service, the system test is repeated cyclically as a background process.

To repeat the initial system test, just turn the power supply off and back on again.

## 6.5.2 Kuhnke FIO Safety I/O Module Faults

The cyclic system test will duly detect all faults in the module within the minimum safe failover time specified in section Technical Data in conformity with the requirements of the standards listed in the certificate. The module will change to its fail-safe state.

This is indicated by LED "Safe Status" lighting up red.

|  | ***DANGER*** |
|---|---|
| | ***Use of devices in a fail-safe state***<br>*The following faults may provoke a hazard*<br>⇨ Whenever a fault occurs, initiate all the required repairs or replacements. |

## 6.5.3 Wrong Wiring

Wiring faults such as

- a cross-fault between the inputs,
- external power supplied to the inputs,
- wrong TP allocation to a specific input,
- external power supplied to the outputs, or
- a short at the outputs

will change the Kuhnke FIO Safety I/O module to its safe state. The red Diagnosis LED of the affected channel lights up.

Error messages may also be provoked by badly adjusted loads. Please refer to sections 4.5.4 Safe Digital Outputs and 6.2.8 Actuator Connection.

## 6.5.4 Temperature Faults

|  | ***CAUTION*** |
|---|---|
| | ***Do not operate the FIO Safety I/O module out of the specified range***<br>*Faults by component overload caused by excessive temperature*<br>⇨ Operate the module under the ambient conditions listed in section Technical Data only while observing the derating of the outputs. |

The module is designed for ambient temperatures between 0 °C and max. 55 °C and for being installed in a control cabinet. The FIO Safety I/O module features an extra internal temperature sensor. Excess temperature will change the module to its safe state. You cannot start the module at temperatures below 0 °C.

## 6.5.5 Wrong Supply Voltage

The supply voltage is rated at 24 VDC. It is monitored. In case of overvoltage (> +20%) and low voltage (< -15%) alike, the module changes to its safe state.

## 6.5.6 Table of Faults

Depending on their type, faults detected are indicated by the diagnosis LEDs of the Kuhnke FIO Safety I/O module and made available as a diagnostic message in error register object $1001_h$. Diagnostic messages help you identify the fault and to take the required corrective actions.

The tables below list and describe the faults, their causes, effects and corrective actions.

Whenever a fault occurs, you should first of all remove its cause and acknowledge the fault in the error register according to instructions.

**Table of faults**

| Fault | Possible Cause | Corrective Action |
|---|---|---|
| **Module fails to start, inputs are not read.** | Wrong FSoE address set at the binary switch | • Check address setting at the module<br>• Check address selected in the safety PLC<br>• Check module for mechanical damage and replace as necessary |
| **Inputs enabled although outputs are in safe state** | FSoE slave address changed in service<br>System power supply interrupted<br>System power supply too low | • Check error code in the service block<br>• Do not change the address coding switch in service<br>• Check module for mechanical damage and replace as necessary<br>• Check supply voltage |
| **Module is in safe state, diagnosis LEDs of the inputs light up red** | Wrong wiring, e.g. test pulse signals swapped<br>Cross-fault between the inputs<br>External power supplied to the outputs | • Check error code in the service block<br>• Check module wiring |
| **Module is in safe state, one diagnosis LED at the output lights up red** | Overload on an output<br>Cross-fault at an output<br>External power supplied to an output | • Check error code in the service block<br>• Check module wiring<br>• Check the output current of the output |
| **Module is in safe state, LED "Safe Status" lights up red** | EtherCAT connection interrupted<br>Internal module fault | • Check wiring of the EtherCAT fieldbus cables<br>• Check that FIO modules interconnect properly |
| **Module is in safe state, LED "Safe Status" lights up red** | I/O power is low | • Check I/O power<br>• Check wiring |

## 6.5.7 Error Codes

| Error codes (object dictionary 0x2007 or 0x2017 - Err.code) | | |
|---|---|---|
| **Error Code (hex)** | **Cause** | **Comment** |
| Effect | Corrective Action | |
| **0x0001** | **Internal software error** | Internal module monitoring has detected an error. Inputs and outputs change to the safe state, FSoE communication stops. |
| Module in safe state | • Module RESET by turning the system power off and back on again – self-test repeats.<br>• Replace module if error prevails | |
| **0x0002** | **Internal hardware fault** | Internal module monitoring has detected a hardware fault. Inputs and outputs change to the safe state, FSoE communication stops. |
| Module in safe state | • Module RESET by turning the system power off and back on again – self-test repeats.<br>• Replace module if error prevails | |
| **0x0402** | **Low voltage** | Voltage supplied to the module is below the admissible range. Inputs and outputs change to the safe state, FSoE communication stops. |
| Module in safe state | • Check actual system power supplied<br>• Check length and stress on the feed line | |
| **E.g. 0x0201** | **Parameter error** | Module fails to change to its functional state. |
| Module in safe state | • Check module parameter setup<br>• Use parameter settings in the admissible range only | |
| **E.g. 0x0291** | **Cross-fault at or external power supplied to input** | Cross-fault to another input or test pulse output or external power supplied; red diagnosis LED of affected channel lights up.<br>Inputs and outputs turn "0" at the module and in the process map. |
| Module in safe state | • Check sensor<br>• Check test pulse outputs<br>• Check connector and wiring | |
| **E.g. 0x0291** | **Short circuit or overload** | Short circuit in the output wiring or wrong output load, red diagnosis LED of affected channel lights up |
| Module in safe state | • Check actuator<br>• Check connector and wiring<br>• Check free wheel wiring at contactor | |
| **E.g. 0x0280** | **Cross-fault at or external power supplied to output** | Cross-fault to another output or another signal; red diagnosis LED of affected channel lights up |
| Module in safe state | • Check actuator<br>• Check connector and wiring | |

***Information***

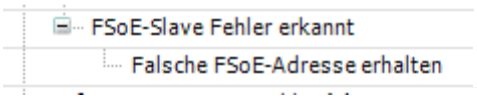
*For a detailed description of the entry in object $2007_h$ or $2017_h$ "Err.code", refer to the table in section 8.1.10*

## 6.5.8 EtherCAT Link Lost

All modules change to their safe state when the EtherCAT link is lost or interrupted. Once the fault has been removed, an Error Acknowledge is enough to restart the EtherCAT bus.

## 6.5.9 Wrong FSoE Address

A wrong FSoE address causes all modules to retain their safe state. The fault is detected by the master and cannot be acknowledged.

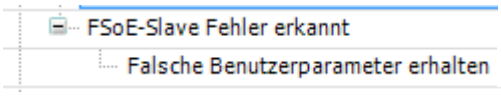



(FSoE slave error detected)
(Wrong FSoE address received)

Once all FSoE addresses are correct, the safety modules will restart normal operation after one power cycle.

## 6.5.10 Wrong Configuration of the Kuhnke FIO Safety SDI4/SDO2 Module

By design, safety control units prevent configuration errors from provoking dangerous states. Therefore, after downloading a safety project with a bad configuration, all safety module are in a safe state. The master shows the incorrect configuration.




(FSoE slave error detected)
(Wrong user parameters returned)

To restart the safety modules, first remove the incorrect configuration, then download the project again and finally Acknowledge the error[3].

[3] Provided that there are no faults

## 6.6 Reset / Acknowledge Error

The error class decides whether and how an error can be acknowledged, see section → 8.1.13 .Err.class 200Ah

| Error Class | Explanation | Acknowledged / Reset by |
|---|---|---|
| 0 | No error | Not required |
| 1 | Serious or synchronization error | PowerCycle |
| 2 | Internal communication error | PowerCycle |
| 3 | I/O error | Error Acknoledge |
| 4 | Error in ErrorHandler or at the outputs | PowerCycle |
| 5 | Fatal error | Non-acknowledgeable |

**PowerCycle:**

After removing the cause of the error, you can reset the Kuhnke FIO Safety SDI4/SDO2 module by a power cycle (PowerCycle -> turn off and back on) provided that the automatic self-test is passed.

**Error Acknowledge:**

Input or output errors can be reset by the safety PLC.

***WARNING***

***Reset / acknowledge may cause a dangerous state***

*Apart from the exceptions specified, acknowledging an error will immediately restore the safe output to its normal state of operation.*

- ⇨ Before acknowledging an error, verify that its cause has been removed professionally.
- ⇨ Before acknowledging an error, verify that acknowledging it will not cause a dangerous machine state.
- ⇨ At the machine or system planning stage, make sure that acknowledging an error must not be possible unless you have full view of the danger zone.

## 6.7 Maintenance / Servicing

### 6.7.1 General

Only qualified persons are allowed to work on FIO Safety.

***CAUTION***

***Unsafe and undefined machine state***

*Destruction or malfunction*

- ⇨ Do not plug, mount, unplug or touch the connectors during operation!
- ⇨ Turn off all power sources before working on the modules. This also applies to any peripherals such as encoders or programming devices with external power source, etc.
- ⇨ Check that none of the ventilation slots is covered.

### 6.7.2 Servicing

FIO Safety requires neither servicing for the specified service life nor any action if it is kept and operated at the admissible ambient conditions specified in section Technical Data.

### 6.7.3 Preventive Maintenance

Prevent inadmissible contamination while operating and storing FIO Safety.Do not use or continue to use the Kuhnke FIO Safety I/O module in case it has been exposed to inadmissible contamination.

| | |
|---|---|
|  | ***CAUTION*** |
| | ***Unsafe and undefined machine state***<br>*Risk of injury*<br>⇨ You are not allowed to operate an inadmissibly contaminated module. Neither is cleaning the unit allowed. |

## 6.8 Replacing a Kuhnke FIO Safety I/O Module

When you replace a Kuhnke FIO Safety I/O module, its configuration is retained and transferred to the new module when you restart the system. The programming environment will tell you is the new module is incompatible. You must carry out appropriate tests to verify whether there are any other failure modes such as using the wrong terminals or making wiring mistakes.

The text below describes how to replace a Kuhnke FIO Safety I/O module with a Kuhnke FIO Safety I/O module of the same type.

| | |
|---|---|
|  | ***CAUTION*** |
| | ***Unsafe and undefined machine state***<br>*Risk of injury*<br>⇨ Turn off the power supply of the control unit and the FIO modules before replacing a Kuhnke FIO Safety I/O module.<br>⇨ After you have replaced any Kuhnke FIO Safety I/O modules, separately test the safety function before you restart the machine or system.<br>⇨ Design you wiring tests such that you will reliably discover the use of a wrong terminal. |

| | |
|---|---|
|  | ***NOTE*** |
| | *You must set up your entire project again if you replace a Kuhnke FIO Safety I/O module with a module of another type. If so, refer to the user guide of the new module.* |

### Procedure

- Verify that the new module meets the following requirements:
  - Same type of device
  - Same or higher version, see section → 5.1 Labelling and Identification
- Enable the safe system or machine state.
- Turn off the power supply of the control unit and the FIO modules.
- To remove the old module (see sections → 6.1.4 To Disconnect Two Modules and 6.1.5 To Take Down a Single Module):
  - Dissolve the line of FIO modules by pressing the unlock button of the module to be separated from the module to its left and sliding both modules about 1 cm apart.
  - Push the module up and against the metal spring located on the underside of the rail guide.
  - Tip the module away from the rail as shown in the illustration.
  - Pull the module down and out of the mounting rail.

- Locate the FSoE address at the address coding switch of the module you are replacing and transfer that address to the new module → 6.3.1 Address Setup
- Install the new module at the same place within the line of FIO modules as one you just removed (→ 6.1.2 To Snap on a Single Module).
- Plug the inline connectors to the correct ports.

### Restart

- Verify that the machine or system is in a safe state and that there is nothing and nobody in the danger zone.
- Turn the supply voltage back on.
- Start the new safety module as if you initially operate a module → 6.4 Putting into Service
  - The configuration of the old module has been retained and will be transferred to the new module when you restart the system.
- Check all safety functions after replacing a module.

## 6.9 Durability

Kuhnke FIO Safety I/O modules have a design life of max. 20 years after the date of manufacture (5.1.2 Serial Number ) by Kendrion Kuhnke Automation GmbH. Take the module out of service at the end of its useful life → 6.9.3 Taking out of Service.

### 6.9.1 Repairs / Customer Service

You are not allowed to open or try to repair a FIO Safety I/O module.

Doing so will void the warranty.

| | |
|---|---|
|  | ***Note, information*** |
| | ***In case of a potentially hazardous failure***<br>*In case a module failure is potentially hazardous, return the module to the manufacturer where the fault will be identified.*<br>⇨ The manufacturer's address is printed on the Kuhnke FIO Safety SDI/SDO2 module and in manual section → 9.1.1 Malente Headquarters |

### 6.9.2 Warranty

The statutory period and conditions of warranty apply. Warranty expires if unauthorised attempts are made to repair the unit / product or any other intervention is performed, see section 2.1.4 Warranty.

### 6.9.3 Taking out of Service

The manufacturer of the machine or system specifies the procedure of taking the product out of service. The process must fully comply with the specified procedure.

Make sure that the modules of the Kuhnke FIO Safety system you are taking out of service are provided for further use as intended. Refer to section Technical Data for detailed transport and storage requirements.

### 6.9.4 Disposal

Dispose of the Kuhnke FIO Safety system in conformity with the applicable environmental regulations and make sure that it is not returned into circulation.

Treat the packaging as recyclable paper and cardboard.

# 7 Connection Examples

This section describes examples of applications that make use of the Kuhnke FIO Safety I/O module functions to provide a safety function. It also describes the resulting safety ratings.

| | |
|---|---|
|  | ***CAUTION*** |
| | ***Using the examples described in this section is not enough to obtain the safety function needed to reduce the risk as established in the risk assessment (SIL/Cat./PL).***<br>*Personal injury and damage to property*<br>⇨ Choose suitable and approved sensors (e.g. to EN 60947-5-1 / -5.) and make sure that your switching devices have the appropriate B10d value.<br>⇨ You may have to take further actions to obtain the safety function when using the system together with safe devices, sensor and actuators (e.g. reading the relay contact signals). Refer to the user guide of you safe devices for further details.<br>⇨ Configure your Kuhnke FIO Safety I/O module with reference to the actual environment. |

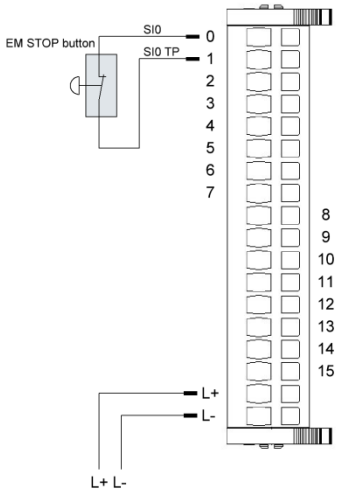
The safety ratings listed for the examples below solely apply to the part of the safety function covered by the safe I/O module. Please note that the safety ratings below only apply if the test pulses are enabled.

| | |
|---|---|
|  | ***WARNING*** |
| | ***Non-detection of incorrect external wiring while test pulses are disabled***<br>*Unsafe machine state, safety hazard*<br>⇨ Always use the corresponding activated test pulse output for the supply of contact-type sensors.<br>⇨ Use the output test pulses to detect cross-faults at the outputs and other faults.<br>⇨ Note: Consider protecting the cables and/or laying them separately to ensure a sufficient degree of safety.<br>⇨ Switching off the test pulses is not recommended, it can reduce the safety of the application. |

| | |
|---|---|
|  | ***WARNING*** |
| | ***Reduced diagnosis with deactivated test pulses at the outputs***<br>*Switching off the test pulses is not recommended, it can reduce the safety of the application. With the test pulses switched off at the outputs, it is necessary to maintain the diagnosis of the outputs by:*<br>⇨ The outputs are switched once a year and the switching is done functionally (by the application) or by completely turning the device off. |

# 7.1 Safety Function with Single-channel Input

| | |
|---|---|
| ⚠ | ***CAUTION*** |
| | ***Consideration of the parameterization*** |
| | *For single-channel applications (inputs and outputs), the test pulse frequency should be adapted to the application. It must be ensured that in applications in which a frequent change of state occurs, the test pulse frequency is selected at least 100 times greater than the state change time of the application.* |
| | ⇨ See FSoE Parameters 6.3.2 |




You may connect contact-type sensors such as emergency stop buttons straight to a safe digital input.

By default, a test pulse output is dedicated to every input channel. This test pulse output supplies a specific signal you may use to detect wiring problems such as a short circuit to 24 VDC, GND or other signal channels. The state of connected switches is indicated by LEDs allocated to the channels (see section → 5.4 Indicators and Controls).

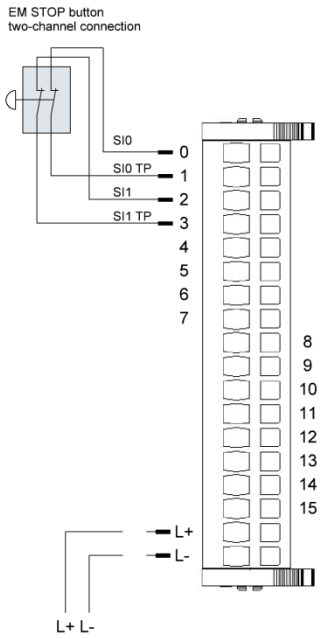
Whenever an emergency stop button is pressed, the safety PLC will generate a stop signal. Resetting the emergency stop device must not be enough to initiate a restart signal.

## Safety ratings of single-channel sensors

The safety ratings listed in the table below reflect the maximum values a single-channel safety function may achieve when using a single input of the safe I/O module. They solely apply to the part of the safety function covered by the safe I/O module. All components involved in the safety function must be taken into account in order to assess whether the desired safety ratings are achieved. The quality of the safe sensor is of crucial importance with particular regard to the safety function of analysing a single-channel sensor. Use approved sensors only (e.g. to EN 60947-5-1 / -5.) and take account of your switching device's B10d value. The safety assessment of the safety function must also consider the safety ratings of the safe PLC used in the application.

| **Safety ratings when applying the module's test pulses to single-channel contact-type sensors** | |
|---|---|
| Highest safety integrity level to EN 62061:2010 | SIL2 |
| Highest safety integrity level to IEC 61508:2010 | SIL2 |
| Category and highest performance level to EN ISO 13849-1:2015 | Cat. 2/PL d |
| Hardware fault tolerance (HFT) of single-channel application (IEC 61508:2010/EN) | 0<br>(a fault of the application may cause the safeguard to fail) |

# 7.2 Safety Function with Two-channel Input




For applications requiring single-fault safety such as EMERGENCY OFF, EMERGENCY STOP, you may connect two digital inputs to two switching devices of safe sensors and further to the safety module.

A software module of the safety PLC provides the required analysis of the switching contacts.

"**FB_ESTOP**" is a safety-related component intended to monitor an EMERGENCY STOP button. FB_ESTOP can be used for both the emergency switch off function (stop category 0) or – with the assistance of additional peripherals - the EMERGENCY STOP function (stop categories 1 or 2).

FB_ESTOP can be used to monitor single and two-channel EMERGENCY STOP switches. The component's discrepancy time monitoring is enabled for two-channel applications.

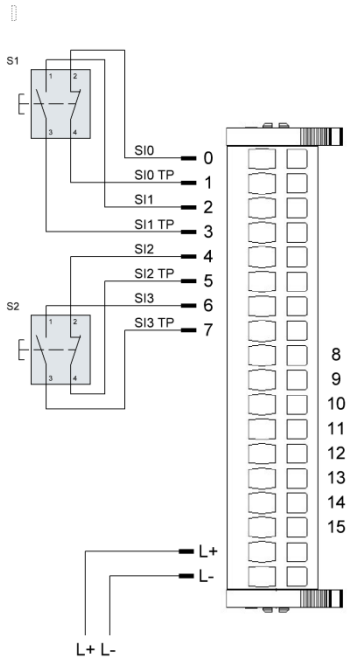
**Discrepancy time monitoring:** The discrepancy time defines as the maximum length of time both inputs may be in different states without the component interpreting this as a fault. Discrepancy time monitoring starts whenever the state of one input changes. The components will detect a fault if, at the end of the discrepancy time, both inputs are in different states.

## Safety ratings of two-channel sensors

The safety ratings listed in the table below reflect the maximum values a two-channel safety function may achieve when using two inputs of the safe I/O module. They solely apply to the part of the safety function covered by the safe I/O module. All components involved in the safety function must be taken into account in order to assess whether the desired safety ratings are achieved. The quality of the safe sensor is of crucial importance with particular regard to the safety function of analysing a two-channel sensor. Use approved sensors only (e.g. to EN 60947-5-1 / -5.) and take account of your switching device's B10d value. The safety assessment of the safety function must also consider the safety ratings of the safe PLC used in the application.

| **Safety ratings<br>when applying the module's test pulses to two-channel contact-type sensors** | |
|---|---|
| Highest safety integrity level to EN 62061:2010 | SIL3 |
| Highest safety integrity level to IEC 61508:2010 | SIL3 |
| Category and highest performance level to EN ISO 13849-1:2015 | Cat. 3/PL e |
| Hardware fault tolerance (HFT) of two-channel application (IEC 61508:2010/EN) | 1<br>(a fault of the application need not cause the safeguard to fail) |

# 7.3 Two-hand Actuation




Two contact-type sensors can be connected to four safe digital inputs.

A software module of the safety PLC provides the analysis required for two-hand operation.

Two-hand circuit type 2

Software component " **FB_TWOHAND_TYP2**" supports function "two-hand circuit type 2" in conformity with European Standard EN 574:2008. If S1 and S2 are set to TRUE in the correct order, bTwoHandOut will also become TRUE. The component also checks that both buttons have been released before setting output bTwoHandOut to TRUE again.

Two-hand circuit type 3

Software component " **FB_TWOHAND_TYP3**" supports function "two-hand circuit type 3" in conformity with the European Standard. If S1 and S2 are set to TRUE in the correct order and within 500 ms, bTwoHandOut will also become TRUE. The component also checks that both buttons have been released before setting output S_TwoHandOut to TRUE again.

Note: Category 3 does not support more than one two-hand circuit of type III B.

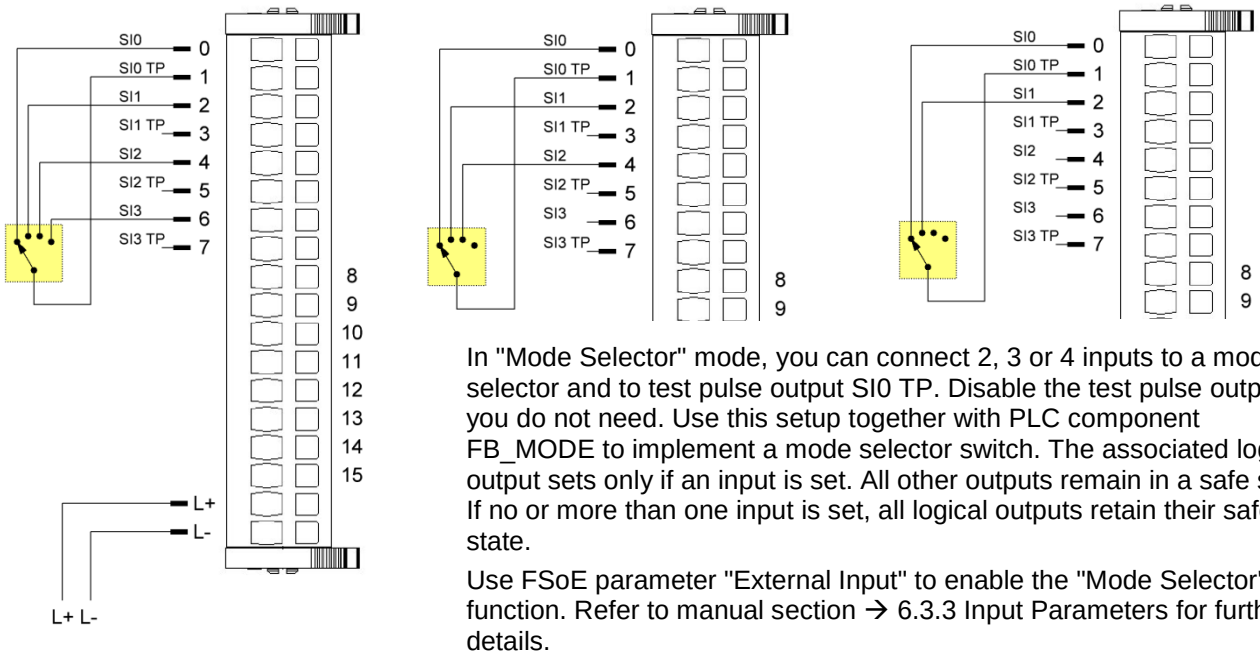
## Safety ratings of two-channel sensors

The safety ratings listed in the table below reflect the maximum values a two-channel safety function may achieve when using four inputs of the safe I/O module. They solely apply to the part of the safety function covered by the safe I/O module. All components involved in the safety function must be taken into account in order to assess whether the desired safety ratings are achieved. The quality of the safe sensor is of crucial importance with particular regard to the safety function of analysing a two-hand operation. Use approved sensors only (e.g. to EN 60947-5-1 / -5.) and take account of your switching device's B10d value. The safety assessment of the safety function must also consider the safety ratings of the safe PLC used in the application.

| Safety ratings for function two-hand operation | |
|---|---|
| Highest safety integrity level to EN 62061:2010 | SIL3 |
| Highest safety integrity level to IEC 61508:2010 | SIL3 |
| Category and highest performance level to EN ISO 13849-1:2015 | Cat. 3/PL e |
| Hardware fault tolerance (HFT) of two-channel application (IEC 61508:2010/EN) | 1<br>(a fault of the application need not cause the safeguard to fail) |

| | |
|---|---|
| ⚠ | ***CAUTION*** |
| | ***Safety hazard due to wrong handling of the two-hand circuit***<br>⇨ Comply with EN 574:2008 and other requirements and standards published on two-hand circuits.<br>⇨ Switches/sensors, wiring and application must comply with EN 574:2008. |

# 7.4 Mode Selector, Rotary Table




In "Mode Selector" mode, you can connect 2, 3 or 4 inputs to a mode selector and to test pulse output SI0 TP. Disable the test pulse outputs you do not need. Use this setup together with PLC component FB_MODE to implement a mode selector switch. The associated logical output sets only if an input is set. All other outputs remain in a safe state. If no or more than one input is set, all logical outputs retain their safe state.

Use FSoE parameter "External Input" to enable the "Mode Selector" function. Refer to manual section → 6.3.3 Input Parameters for further details.

| Safety ratings of mode selector applications in conjunction with switches/sensors approved to EN 13849-2, Table D.3 | |
|---|---|
| Highest safety integrity level to EN 62061:2010 | SIL2 |
| Highest safety integrity level to IEC 61508:2010 | SIL2 |
| Category and highest performance level to EN ISO 13849-1:2015 | Cat. 1/PL c |
| Hardware fault tolerance (HFT) of two-channel application (IEC 61508:2010/EN) | 0<br>(a fault of the application may cause the safeguard to fail) |

| Safety ratings of mode selector applications in conjunction with certified switches/sensors of the appropriate safety classification | |
|---|---|
| Highest safety integrity level to EN 62061:2010 | SIL3 |
| Highest safety integrity level to IEC 61508:2010 | SIL3 |
| Category and highest performance level to EN ISO 13849-1:2015 | Cat. 3/PL e |
| Hardware fault tolerance (HFT) of two-channel application (IEC 61508:2010/EN) | 1<br>(a fault of the application need not cause the safeguard to fail) |

***NOTE***

***Test pulse output***

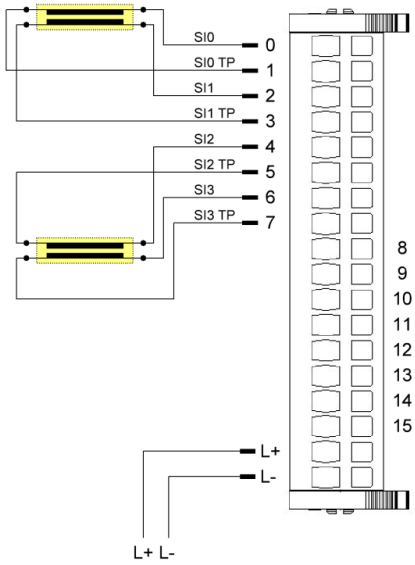
*In mode selector mode, test pulse output TP0 can be set to "0". However, this will not affect the test pulse as such since, in mode selector mode, the test pulse always runs at maximum frequency.*

**NOTE**

***Time discrepancy in mode selector/rotary table mode***

*A set time discrepancy of 100 ms has been implemented for signals missing at the inputs when changing to mode selector mode.*

## 7.5 Safety Mats, Connecting Blocks and Bumpers




Safety mats protect operators in danger zones. Connecting blocks and bumpers are normally used as safeguards along closing edges or against potentially hazardous moving objects. They share the same tripping method. Two parallel areas of contact are kept at a certain distance and do not make contact until the device is actuated. An electric current going through the areas of contact ensures that they are ready for use. The picture illustrates that one area of contact is allocated to one channel and the other area to another channel. Mechanical load on the area of contact makes the inputs connect. This is not interpreted as a short circuit but as actuation. Use FSoE parameter "External Input" to enable the "Bumper" function. Refer to manual section → 6.3.3 Input Parameters for further details. This mode only supports pressure-sensitive mats working according to the open circuit principle, i.e. the test pulses required to maintain a safe function are supplied by the safe I/O module.

The function uses either inputs SI0 and SI1 and/or inputs SI2 and SI3. The pressure-sensitive mat function achieves a response time of **50 ms** between a change in mat state and providing the information on the EtherCAT bus.

### Safety characteristics of dual-channel sensors

The safety characteristics specified in the following table are the maximum values that can be achieved with a two-channel safety function using two inputs of the safe IO module. The values apply exclusively to the part of the safety function that is covered by the safe IO module. To achieve the desired safety characteristics, all components involved in the safety function must be taken into account. For the safety function of a safety mat application, the quality of the safe sensor is particularly crucial for this. Only approved sensors should be used (eg according to EN 60947-5-1 / -5.) And the B10d value of the switching element used should be taken into account. In addition, the safety characteristics of the safe PLC used must be included in the safety evaluation of the safety function.

| Safety ratings for pressure-sensitive mat applications | |
|---|---|
| Highest safety integrity level to EN 62061:2010 | SIL3 |
| Highest safety integrity level to IEC 61508:2010 | SIL3 |
| Category and highest performance level to EN ISO 13849-1:2015 | Cat. 3/PL e |
| Hardware fault tolerance (HFT) of two-channel application (IEC 61508:2010/EN) | 1<br>(a fault of the application need not cause the safeguard to fail) |

**NOTE**

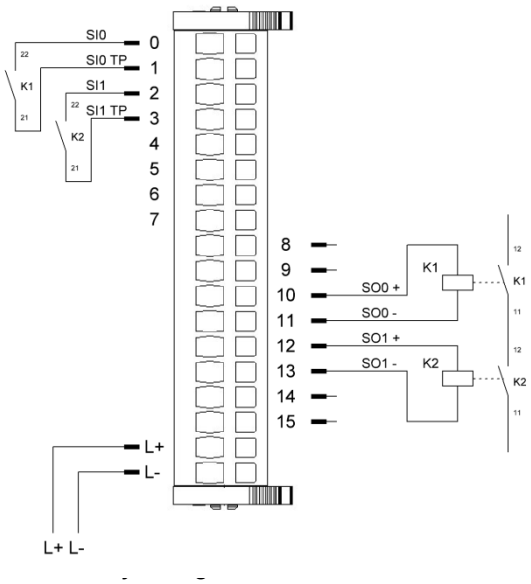
***Lay the feed lines of pressure-sensitive mats and bumpers together***

*In order to avoid influences and malfunctions due to EMC effects, lay the four wires (e.g. SI0, SI0 TP, SI1, SI1 TP) together.*

| | |
|---|---|
| ⚠ | **CAUTION** |
| | ***"Short circuit in mat" fault is not detected*** |
| | *The safe I/O module fails to detect a short circuit between the mat contacts. This is interpreted as the mat being actuated. You must also verify that the safeguard is wired correctly.* |
| | ⇨ Periodically check that the mat is working properly. |

| | |
|---|---|
| ⚠ | **CAUTION** |
| | ***Safety function pressure-sensitive mat requires a response time of 50 ms*** |
| | *Avoid personal injury and damage to property* |
| | ⇨ The pressure-sensitive mat function achieves a response time of 50 ms between a change in mat state and providing the information on the EtherCAT bus. |

## 7.6 Connecting Two Actuators with Internal GND Reference




The wiring example illustrates how two outputs of the safe I/O module are used to actuate a safety function. Switch contacts K1 and K2 both affect the safety function together.

Using the SOX terminals of the outputs allows the actuator to separate from the GND connection and, thus, change to its safe state when external power is supplied to an cross-faults affect the actuator (contact SOX+). Whereas you may set up this circuit without the SOX- terminals, you must ensure that external power and cross-faults are excluded if you do.

In order to monitor the relay states, you must connect the positively drive n.c. contacts of K1 and K2 to safe digital inputs. Set the safe PLC to analyse the values returned and, thus, the states of the switching devices.

S

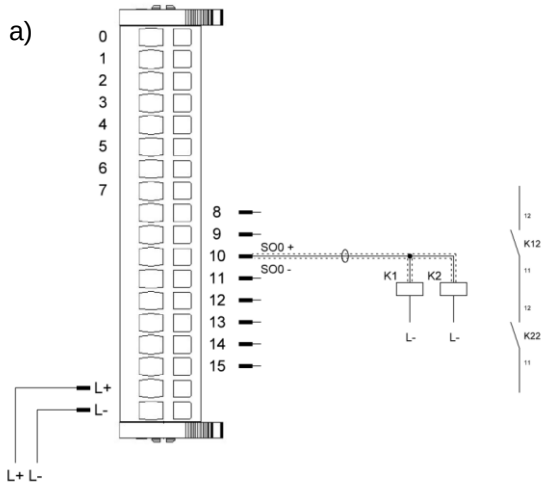
lect the maximum values a two-channel safety function may achieve when using two outputs of the safe I/O module. They solely apply to the part of the safety function covered by the safe I/O module. All components involved in the safety function must be taken into account in order to assess whether the desired safety ratings are achieved. The quality of the safe actuator is of crucial importance with particular regard to the safety function of analysing a two-channel actuator. Only use approved actuators in due consideration of their B10d value. The safety assessment of the safety function must also consider the safety ratings of the safe PLC used in the application.

| Safety ratings of applications using two outputs for a safety function | |
|---|---|
| Highest safety integrity level to EN 62061:2010 | SIL3 |
| Highest safety integrity level to IEC 61508:2010 | SIL3 |
| Category and highest performance level to EN ISO 13849-1:2015 | Cat. 3/PL e |
| Hardware fault tolerance (HFT) in two-channel application (IEC 61508:2010/EN) | 1 (a fault of the application cannot cause the safeguard to fail) |

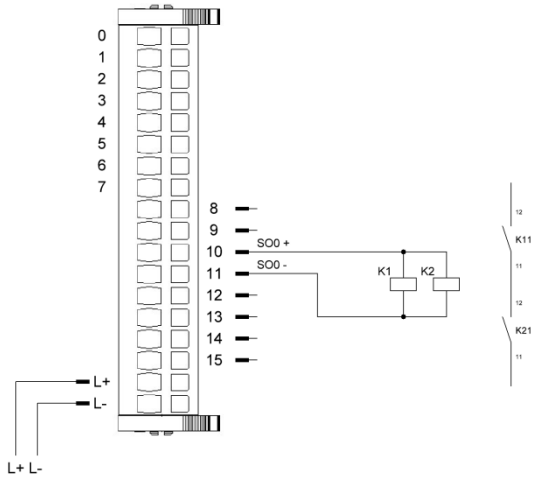
# 7.7 Connecting Two Parallel Actuators to One Safe Output

| | |
|---|---|
| ⚠ | ***CAUTION*** |
| | ***Consideration of the parameterization*** <br> *For single-channel applications (inputs and outputs), the test pulse frequency should be adapted to the application. It must be ensured that in applications in which a frequent change of state occurs, the test pulse frequency is selected at least 100 times greater than the state change time of the application.* <br> ⇨ See FSoE Parameters 6.3.2 |

a)




b)




The wiring example illustrates how one output of the safe I/O module is used to actuate a safety function.
Use a two-channel actuator to achieve the safety integrity levels of the table below. Before connecting it to the I/O module, verify that short circuits and cross-faults on the connecting lead are excluded.

| | |
|---|---|
| 🕮 | ***Note, information Image a)*** |
| | ***Fault prevention required!*** <br> ***Take the actions required to prevent a short circuit or cross-fault on the lead connecting the FIO Safety I/O module's contact and the safe actuators.*** |

| | |
|---|---|
| 🕮 | ***Note, information Image b)*** |
| | ***Fault prevention required!*** <br> ***In order to detect faults in the wiring, it is necessary to activate the test pulses for the corresponding output.*** |

| | |
|---|---|
| ⚠ | ***CAUTION*** |
| | ***Consider the fault detection time!*** <br> *The setup needs 5 ms to detect a fault. Faults may therefore produce high impulses of this width.* <br> *Use a two-channel connection of the outputs in case your application responds to these impulses.* |

In order to monitor the relay states, you must connect the positively drive n.c. contacts of K1 and K2 to safe digital inputs. Set the safe PLC to analyse the values returned and, thus, the states of the switching devices.

| Best safety ratings of applications using one output for a safety function | |
|---|---|
| Highest safety integrity level to EN 62061:2010 | SIL3 |
| Highest safety integrity level to IEC 61508:2010 | SIL3 |
| Category and highest performance level to EN ISO 13849-1:2015 | Cat. 3/PL e |
| Hardware fault tolerance (HFT) of single-channel application (IEC 61508:2010/EN) | 1<br>(a fault of the application does not cause the safeguard to fail) |

# 8 Appendix

## 8.1 Object Dictionary

### 8.1.1 Device Type 1000h

| | |
|---|---|
| **Name** | Device Type |
| **Index** | 1000h |
| **Object Code** | VARIABLE |
| **No. of Elements** | 0 |
| **Data Type** | UNSIGNED32 |
| **Access** | read only |
| **PDO Mapping** | no |
| **Value Range** | set |
| **Default Value** | 1389h |

### 8.1.2 Error Register 1001h

| | |
|---|---|
| **Name** | Error Register |
| **Index** | 1001h |
| **Object Code** | VARIABLE |
| **No. of Elements** | 0 |
| **Data Type** | UNSIGNED8 |
| **Access** | read only |
| **PDO Mapping** | No, TX-PDO |
| **Default Value** | 00h |

In case of an error, the associated error bit is set.

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| RES | RES | PROF | COM | TEMP | VOL | CUR | GEN |

| | |
|---|---|
| GEN: Generic fault | non-acknowledgeable, power cycle required |
| CUR: Current | non-acknowledgeable, power cycle required |
| VOL: Voltage | acknowledgeable via EtherCAT or by power cycle |
| TEMP: Temperature | non-acknowledgeable, power cycle required |
| COM: Communication | non-acknowledgeable, power cycle required |
| PROF: Device profile | acknowledgeable via EtherCAT |
| RES: Reserved, always "0" | non-acknowledgeable, power cycle required |

### 8.1.3 Manufacturer Device Name 1008h

| | |
|---|---|
| **Name** | Manufacturer Device Name |
| **Index** | 1008h |
| **Object Code** | VARIABLE |
| **No. of Elements** | 0 |
| **Data Type** | VISIBLE_STRING (27) |
| **BitSize** | 216 |
| **Access** | read only |
| **PDO Mapping** | no |

| | |
|---|---|
| **Value Range** | set |
| **Default Value** | Kuhnke FIO Safety SDI4/SDO2 |

Subindex 0 of this object contains the string length. Subindex 1 contains each of the characters. The character string has no terminating zero.

## 8.1.4 Manufacturer Hardware Version 1009h

| | |
|---|---|
| **Name** | Manufacturer Hardware Version |
| **Index** | $1009_h$ |
| **Object Code** | VARIABLE |
| **No. of Elements** | 0 |
| **Data Type** | VISIBLE_STRING (4) |
| **BitSize** | 32 |
| **Access** | read only |
| **PDO Mapping** | no |
| **Value Range** | set |
| **Default Value** | 322E3130 (2.10) |

## 8.1.5 Manufacturer Software Version 100Ah

| | |
|---|---|
| **Name** | Manufacturer Software Version |
| **Index** | $100A_h$ |
| **Object Code** | VARIABLE |
| **No. of Elements** | 0 |
| **Data Type** | VISIBLE_STRING (4) |
| **BitSize** | 32 |
| **Access** | read only |
| **PDO Mapping** | no |
| **Value Range** | set |
| **Default Value** | 312E3030 (1.00) |

## 8.1.6 Identity Object 1018h

| | |
|---|---|
| **Name** | Identity Object |
| **Index** | $1018_h$ |
| **Object Code** | RECORD |
| **No. of Elements** | 5 |
| **Data Type** | IDENTITY |

| | |
|---|---|
| **Name** | Highest Sub-index Supported |
| **Subindex** | $00_h$ |
| **Data Type** | UNSIGNED8 |
| **Access** | read only |
| **PDO Mapping** | no |
| **Default Value** | >4< |

| | |
|---|---|
| **Name** | Vendor ID |
| **Subindex** | $01_h$ |

| | |
|---|---|
| **Data Type** | UNSIGNED32 |
| **Access** | read only |
| **PDO Mapping** | no |
| **Default Value** | $0048554B_h$ |

| | |
|---|---|
| **Name** | Product Code |
| **Subindex** | $02_h$ |
| **Data Type** | UNSIGNED32 |
| **Access** | read only |
| **PDO Mapping** | no |
| **Default Value** | $0x2B487_h$ (177287) |

| | |
|---|---|
| **Name** | Revision Number |
| **Subindex** | $03_h$ |
| **Data Type** | UNSIGNED32 |
| **Access** | read only |
| **PDO Mapping** | no |
| **Default Value** | $0000002A_h$ (42) |

| | |
|---|---|
| **Name** | Serial Number |
| **Subindex** | $04_h$ |
| **Data Type** | UNSIGNED32 |
| **Access** | read only |
| **PDO Mapping** | no |
| **Units** | YY MM DD NNNNN<br><br>yyyyyy mmmm ddddd nnnnnnnnnnnnnnnn<br>6-bit 4-bit 5-bit 17-bit<br><br>Year 2014 is coded as '0'. |
| **Value Range** | 14 01 01 00001 (0x00420001) …<br>77 12 31 99999 (0xFF3F869F) |
| **Example** | 16052300001 ⇔ 0x096E0001 |

The object contains details of the manufacturer, the product code and the revision and serial number.

## 8.1.7 Supply 24V Voltage $2001_h$ for µC1 and $2011_h$ for µC2

| | |
|---|---|
| **Name** | Supply24Voltage |
| **Index** | $2000_h$ |
| **Object Code** | VARIABLE |
| **No. of Elements** | 0 |
| **Data Type** | UNSIGNED16 |
| **Access** | Read |
| **PDO Mapping** | no |
| **Units** | mV |
| **Value Range** | 0 … 65535 |
| **Default Value** | No default value |

## 8.1.8 Out 1 Current $2005_h$ for µC1 and $2015_h$ for µC2

| | |
|---|---|
| **Name** | Out1Current |
| **Index** | $2005_h$ |
| **Object Code** | VARIABLE |
| **No. of Elements** | 0 |
| **Data Type** | UNSIGNED16 |
| **Access** | Read |
| **PDO Mapping** | no |
| **Units** | mA |
| **Value Range** | 0 … 2400 |
| **Default Value** | No default value |

## 8.1.9 Ext Temperature $2006_h$ for µC1

| | |
|---|---|
| **Name** | Ext Temperature |
| **Index** | $2006_h$ |
| **Object Code** | VARIABLE |
| **No. of Elements** | 0 |
| **Data Type** | UNSIGNED32 |
| **Access** | Read |
| **PDO Mapping** | no |
| **Units** | 0,01 °C |
| **Value Range** | 0 … 8000 |
| **Default Value** | No default Value |

| | |
|---|---|
| | ***Note, Information*** |
| | ***To get the temperature displayed, only the least significant 16-bit can be evaluated.*** |

## 8.1.10 Err.code $2007_h$ for µC1 and $2017_h$ for µC2

| | |
|---|---|
| **Name** | Err.code |
| **Index** | $2007_h$ |
| **Object Code** | VARIABLE |
| **No. of Elements** | 0 |
| **Data Type** | UNSIGNED16 |
| **Access** | Read |
| **PDO Mapping** | no |
| **Default Value** | $00000000_h$ |

The table below explains the entries in object $2007_h$ or $2017_h$ "Err.code".

| Id | Hex | Explanation |
|---|---|---|
| 0 | 0x0000 | OK: No error |
| 1 | 0x0001 | HWT_PARAMETER_ERROR<br>Hardware test parameter error |

| Id | Hex | Explanation |
|---|---|---|
| 2 | 0x0002 | HWT_INIT_ERROR<br>Hardware test initialisation error |
| 100 | 0x0064 | HWT_MEM_MARCHC_ERROR<br>Hardware test RAM check error |
| 101 | 0x0065 | HWT_MEM_GALPAT_ERROR<br>Hardware test RAM check error |
| 200 | 0x00C8 | HWT_STACK_UNDERFLOW_ERROR<br>Hardware test stack underflow |
| 201 | 0x00C9 | HWT_STACK_OVERFLOW_ERROR<br>Hardware test stack underflow |
| 300 | 0x012C | HWT_CPU_ERROR<br>Hardware test CPU error |
| 400 | 0x0190 | WT_FW_ERROR<br>Hardware test firmware error |
| 500 | 0x01F4 | HWT_FWINTERFACE_ERROR<br>Hardware test firmware error |
| 504 | 0x01F8 | HWT_ADC_ERROR:  Test handler: error in ADC value range checks |
| 505 | 0x01F9 | HWT_DMA_ERROR:  Test handler: DMA checksum error |
| 506 | 0x01FA | HWT_CRC_ERROR:  Test handler: CRC check error |
| 507 | 0x01FB | HWT_TIMER_ERROR:  Test handler: CPU timer check error |
| 508 | 0x01FC | HWT_CLOCK_ERROR:  Test handler: CPU clock signal check error |
| 509 | 0x01FD | HWT_SOFTERROR: Soft error detected in hardware test |
| 510 | 0x01FE | HWT_DIVZERO: Division by 0 detected in hardware test |
| 512 | 0x0200 | TIMEOUT_ERR:  Software timeout detected |
| 513 | 0x0201 | OUT_OF_RANGE_ERR:  Parameter or value out of allowed range |
| 514 | 0x0202 | OVERWRITE_ERR: Register buffer data overwritten |
| 515 | 0x0203 | UNDERFLOW_ERR: Register buffer data underflow |
| 516 | 0x0204 | PRG_CNTRL_ERR:  Program sequence control error detected |
| 528 | 0x0210 | INIT_ERROR: Initialization error |
| 592 | 0x0250 | ASSERT_TRUE_ERR:  Assertion of expression = ''true'' failed |
| 593 | 0x0251 | ASSERT_NOT_NULL_ERR:  Assertion of unequal to NULL failed |
| 594 | 0x0252 | ASSERT_GE_ERR:  Assertion of ''>='' comparison failed |
| 595 | 0x0253 | ASSERT_GT_ERR:  Assertion of ''>'' comparison failed |
| 596 | 0x0254 | ASSERT_LE_ERR:  Assertion of ''<='' comparison failed |
| 597 | 0x0255 | ASSERT_LT_ERR:  Assertion of ''<'' comparison failed |
| 598 | 0x0256 | ASSERT_NE_ERR:  Assertion of ''<>'' comparison failed |
| 599 | 0x0257 | ASSERT_EQ_ERR:  Assertion of ''='' comparison failed |
| 600 | 0x0258 | ASSERT_FALSE_ERR:  Assertion of expression = ''false'' failed |
| 640 | 0x0280 | TP_OUT_NOT_SPECIFIED:  Bad output test pulse - internal sequence error (ErrReg: 32) |
| 641 | 0x0281 | TP_OUT_NOT_RECOGNIZED:  Output test pulse not detected (ErrReg: 32) |
| 642 | 0x0282 | TP_OUT_NOT_ACTIVE:  Output test pulse not enabled (ErrReg: 32) |
| 656 | 0x0290 | TP_INP_BUSY:  Input test pulse operation is busy (ErrReg: 32)<br>input test pulse monitoring not completed before a new test pulse occurred |
| 657 | 0x0291 | TP_INP_CROSSTALK:  Input test pulse cross talk detected (ErrReg: 32) |
| 658 | 0x0292 | TP_INP_NOT_RECOGNIZED:  Input test pulse not detected (ErrReg: 32) |
| 659 | 0x0293 | TP_INTINP_NOT_RECOGNIZED:  Internal input test pulse not detected (ErrReg: 32) |

| Id | Hex | Explanation |
|---|---|---|
| 660 | 0x0294 | TP_INP_LOST: Internal input test pulse lost (ErrReg: 32) |
| 661 | 0x0295 | TP_INVALID_COUNT_FOR_SELECTOR: Test pulse error in mode selector mode (ErrReg: 32) |
| 662 | 0x0296 | TP_INVALID_OUTPUT_WIRING |
| 672 | 0x02A0 | MRAM_NOT_INITIALIZED |
| 673 | 0x02A1 | MRAM_READ_ERR: MRAM Read error |
| 674 | 0x02A2 | MRAM_WRITE_ERR: MRAM write error |
| 675 | 0x02A3 | MRAM_INDEX_OUT_OF_RANGE: MRAM address index out of valid range |
| 676 | 0x02A4 | MRAM_CORRUPT_PAGE_SIZE: MRAM invalid page size |
| 677 | 0x02A5 | MRAM_CRC_ERR: MRAM data CRC check failed |
| 678 | 0x02A6 | MRAM_MAGICNUMBER_ERR: MRAM magic number not recognized |
| 768 | 0x0300 | RESET_LOW_POWER: Reset due to low power supply |
| 769 | 0x0301 | RESET_WINDOW_WD: Reset by window watchdog |
| 770 | 0x0302 | RESET_INDEPENDENT_WD: Reset by independent watchdog timer |
| 771 | 0x0303 | RESET_SW: Reset by software reset |
| 772 | 0x0304 | RESET_POWER_ON_DOWN: Reset by power up or down |
| 773 | 0x0305 | RESET_NMI: Reset by non-maskable interrupt |
| 774 | 0x0306 | RESET_BROWNOUT: Reset by CPU brown out detection |
| 775 | 0x0307 | RESET_NO_REASON: Reset for unkown reason |
| 1024 | 0x0400 | ADC_REF_LOW: ADC reference voltage too low |
| 1025 | 0x0401 | ADC_REF_HIGH: ADC reference voltage too high |
| 1026 | 0x0402 | ADC_24V_LOW: 24 V ADC supply voltage too low (< 24V - 10%) (ErrReg: 4) |
| 1027 | 0x0403 | ADC_24V_HIGH: 24 V ADC supply voltage too high (> 24V + 15%) (ErrReg: 4) |
| 1028 | 0x0404 | ADC_5V_LOW: Internal 5 V supply voltage too low (ErrReg: 4) |
| 1029 | 0x0405 | ADC_5V_HIGH: Internal 5 V supply voltage too high (ErrReg: 4) |
| 1030 | 0x0406 | ADC_3_3V_LOW: Internal 3.3 V supply voltage too low |
| 1031 | 0x0407 | ADC_3_3V_HIGH: Internal 3.3 V supply voltage too high |
| 1032 | 0x0408 | ADC_TEMP_LOW: On-chip temperature too low (ErrReg: 8) |
| 1033 | 0x0409 | ADC_TEMP_HIGH: On-chip temperature too high (ErrReg: 8) |
| 1034 | 0x040A | ADC_CURR_HIGH: Total output current too high (ErrReg: 2) |
| 1035 | 0x040B | ADC_24V_FATAL: 24 V ADC supply voltage much too high (> 60V) (ErrReg: 4) |
| 1280 | 0x0500 | LINE_TIMEOUT: Sync line level monitoring timeout from base board |
| 1281 | 0x0501 | NOVALIDCPUID: Invalid CPU identifier setting |
| 1282 | 0x0502 | TIMEOUTTIMERERR: Timeout timer error |
| 1283 | 0x0503 | DIPSWITCHREADERR: DIP switch could not be read |
| 1284 | 0x0504 | DIPSWITCHCHANGED: DIP switch setting changed in service |
| 1285 | 0x0505 | DIPSWITCHXCHGERROR: CPU-to-CPU exchange of address DIP settings failed |
| 1286 | 0x0506 | DIPSWITCH_INVALID_ADDRESS: Invalid FSoE address selected (address = 0) (ErrReg: 32) |
| 1312 | 0x0520 | CLK_ERROR: Partner clock frequency out of valid range |
| 1313 | 0x0521 | CLK_PARTNER_LOW: Partner clock frequency too low |
| 1314 | 0x0522 | CLK_PARTNER_HIGH: Partner clock frequency too high |
| 1328 | 0x0530 | HW_REVISION_ERROR: Invalid PCB HW revision detected (the SW currently running not designed for this HW revision) |
| 1536 | 0x0600 | INPUTXCHGERROR: CPU-to-CPU exchange of safety input information failed |

| Id | Hex | Explanation |
|---|---|---|
| 1537 | 0x0601 | INPUT_TIMEOUT: Input test pulse timed out (ErrReg: 32) |
| 1552 | 0x0610 | INPUT_EXTMATTE_KS: Short circuit detected in external safety input carpet (ErrReg: 32)<br>not used |
| 1553 | 0x0611 | INPUT_EXTMATTE_OPEN: Safety mat not connected / open load, short circuit or wire failure (ErrReg: 32) |
| 1792 | 0x0700 | OUTPUTXCHGERROR: CPU-to-CPU exchange of safety output information failed |
| 1793 | 0x0701 | OUTPUTFAIL: Output test pulse not detected (ErrReg: 32) |
| 1794 | 0x0702 | OUTPUT_WAITFB: Output test pulse waiting for feedback signal (ErrReg: 32) |
| 1795 | 0x0703 | OUTPUT_TIMEOUT: Timeout in handling of output (ErrReg: 32) |
| 1796 | 0x0704 | OUTPUT_HSTP_TIMEOUT: Output test pulse of high side switch timed out |
| 1797 | 0x0705 | OUTPUT_LSTP_TIMEOUT: Output test pulse of low side switch timed out |
| 1798 | 0x0706 | OUTPUT_LSTP_CONNECT_ERR: Output test pulse of low side switch timed out<br>Bad wiring - output set to external ground, wrong signal detected on feedback line |
| 1799 | 0x0707 | OUTPUT_USTP_TIMEOUT: Output test pulse of common high side switch timed out |
| 1800 | 0x0708 | OUTPUT_NOPAR_USED: Output is parameterized as not used and shall be switched on (ErrReg: 32) |
| 2048 | 0x0800 | BCOM_NOTREADY: Communication with base board not ready / operational |
| 2049 | 0x0801 | BCOM_BUSY: Communication with base board is busy |
| 2050 | 0x0802 | BCOM_NONEWDATA: Communication with base board - no new data received |
| 2051 | 0x0803 | BCOM_CRCERR: Communication with base board – CRC error |
| 2052 | 0x0804 | BCOM_BITERR: Communication with base board – shifted bits detected |
| 2304 | 0x0900 | XCOM_NOTREADY: Communication with safety partner MC not ready / operational |
| 2305 | 0x0901 | XCOM_BUSY: Communication with safety partner MC is busy |
| 2306 | 0x0902 | XCOM_NONEWDATA:<br>Communication with safety partner MC – no new data received |
| 2307 | 0x0903 | XCOM_CRCERR: Communication with safety partner MC – CRC error detected |
| 2560 | 0x0A00 | I2C_TIMEOUT: I2C communication timeout detected |
| 2561 | 0x0A01 | I2C_BUSY: I2C bus is busy |
| 2816 | 0x0B00 | FSOE_RESET_IND: Test pulse error in mode selector mode (ErrReg: 16)<br>FailSafeOverEtherCAT – FSoE slave returns error to FSoE master |
| 2817 | 0x0B01 | FSOE_INVALID_CMD: Test pulse error in mode selector mode (ErrReg: 16)<br>FailSafeOverEtherCAT – invalid command |
| 2818 | 0x0B02 | FSOE_UNKNOWN_CMD: Test pulse error in mode selector mode (ErrReg: 16)<br>FailSafeOverEtherCAT – unknown command |
| 2819 | 0x0B03 | FSOE_INVALID_CONNID: Test pulse error in mode selector mode (ErrReg: 16)<br>FailSafeOverEtherCAT – invalid connection ID |
| 2820 | 0x0B04 | FSOE_INVALID_CRC: Test pulse error in mode selector mode (ErrReg: 16)<br>FailSafeOverEtherCAT – checksum error |
| 2821 | 0x0B05 | FSOE_WD_EXPIRED: Test pulse error in mode selector mode (ErrReg: 16)<br>FailSafeOverEtherCAT – Watchdog time out |
| 2822 | 0x0B06 | FSOE_INVALID_ADDRESS: Test pulse error in mode selector mode (ErrReg: 16)<br>FailSafeOverEtherCAT – invalid address |
| 2823 | 0x0B07 | FSOE_INVALID_DATA: Test pulse error in mode selector mode (ErrReg: 16)<br>FailSafeOverEtherCAT – invalid data |

| Id | Hex | Explanation |
|---|---|---|
| 2824 | 0x0B08 | FSOE_INVALID_COMMPARALEN: Test pulse error in mode selector mode (ErrReg: 16)<br>FailSafeOverEtherCAT – invalid length of communication parameters |
| 2825 | 0x0B09 | FSOE_INVALID_COMMPARA: Test pulse error in mode selector mode (ErrReg: 16)<br>FailSafeOverEtherCAT – invalid communication parameters |
| 2826 | 0x0B0A | FSOE_INVALID_USERPARALEN: Test pulse error in mode selector mode (ErrReg: 16)<br>FailSafeOverEtherCAT – invalid length of user parameters |
| 2827 | 0x0B0B | FSOE_INVALID_USERPARA: Test pulse error in mode selector mode (ErrReg: 16)<br>FailSafeOverEtherCAT – invalid user parameters |
| 2828 | 0x0B0C | FSOE_INVALID_TP_INP_DURATION: FailSafeOverEtherCAT – invalid safety input parameter test pulse duration (ErrReg: 16) |
| 2829 | 0x0B0D | FSOE_INVALID_TP_INP_FREQUENCY: FailSafeOverEtherCAT – invalid safety input test pulse frequency (ErrReg: 16) |
| 2830 | 0x0B0E | FSOE_INVALID_TP_OUT_DURATION: FailSafeOverEtherCAT – invalid safety output parameter test pulse duration (ErrReg: 16) |
| 2831 | 0x0B0F | FSOE_INVALID_TP_OUT_FREQUENCY: FailSafeOverEtherCAT – invalid safety output test pulse frequency (ErrReg: 16) |
| 2832 | 0x0B10 | FSOE_INVALID_WATCHDOG_TIME: FailSafeOverEtherCAT – invalid safety parameter watchdog time (ErrReg: 16) |
| 2833 | 0x0B11 | FSOE_INVALID_INP_EXT_SUPPLY: FailSafeOverEtherCAT – invalid safety parameter for inputs having external supply (ErrReg: 16)<br>or inputs not used according to parameter setup |
| 2834 | 0x0B12 | FSOE_INVALID_INP_IN_USE: FailSafeOverEtherCAT – invalid safety parameter for inputs in use (ErrReg: 16) |
| 2835 | 0x0B13 | FSOE_INVALID_INP_USED_EXT_MISMATCH: FailSafeOverEtherCAT – mismatch of safety parameters for inputs in use and externally supplied inputs (ErrReg: 16) |
| 2836 | 0x0B14 | FSOE_INVALID_OUT_IN_USE: FailSafeOverEtherCAT – invalid safety parameter for outputs in use (ErrReg: 16) |
| 2837 | 0x0B15 | FSOE_INVALID_OUT_USED_EXT_MISMATCH: FailSafeOverEtherCAT – mismatch of safety parameters for outputs in use and externally earthed outputs (ErrReg: 16) |
| 2944 | 0x0B80 | FSOE_EXTENDED_ERROR: FailSafeOverEtherCAT – test pulse error in mode selector mode, extended error (ErrReg: 16) |
| 2992 | 0x0BB0 | FSOE_ERROR: FailSafeOverEtherCAT – invalid internal state in safety stack (ErrReg: 16) |
| 3072 | 0x0C00 | TH_GLOBAL_ERROR:<br>Global hardware test error |
| 3073 | 0x0C01 | TH_TIMEOUT: Internal hardware test sequence timeout |
| 3329 | 0x0D01 | MC1_ID_INVALID: Identification of MC 1 failed |
| 3330 | 0x0D02 | MC2_ID_INVALID: Identification of MC 2 failed |
| 3331 | 0x0D03 | MC3_ID_INVALID: Identification of MC 3 failed |
| 3584 | 0x0E00 | FOREIGN_ERROR_DETECTED: Error detected by other MC |
| 3841 | 0x0F01 | FLASH_TIMEOUT: Timeout writing to FLASH |
| 3842 | 0x0F02 | FLASH_LOCKED: FLASH operation failed because ''LOCK'' bit could not be reset |
| 3851 | 0x0F0B | FLASH_BUSY: FLASH operation busy,<br>sequence error in FLASH programming |
| 3854 | 0x0F0E | FLASH_ERROR: FLASH operation error,<br>programmer the FLAH memory failed |

## 8.1.11 Err.line 2008h for µC1 and 2018h for µC2

| | |
|---|---|
| **Name** | Err.line CPU 1/2 |
| **Index** | 2008h |
| **Object Code** | VARIABLE |
| **No. of Elements** | 0 |
| **Data Type** | UNSIGNED16 |
| **Access** | Read |
| **PDO Mapping** | no |
| **Default Value** | 00000000h |

## 8.1.12 Err.module 2009h for µC1 and 2019h for µC2

| | |
|---|---|
| **Name** | Err.module CPU 1/2 |
| **Index** | 2009h |
| **Object Code** | VARIABLE |
| **No. of Elements** | 0 |
| **Data Type** | UNSIGNED8 |
| **Access** | Read |
| **PDO Mapping** | no |
| **Default Value** | 00000000h |

The table below explains the entries in object 2009h or 2019h "Err.module".

| Id | Explanation |
|---|---|
| 0 | OBJ_UNKNOWN_ID – unknown module |
| 4 | OBJ_FSOETASK_ID – error occurred in "CFSoETask.cpp" |
| 8 | OBJ_INPUT_ID - error occurred in "CInput.cpp" |
| 12 | OBJ_MAINTASK_ID - error occurred in "CMainTask.cpp" |
| 16 | OBJ_PRGCONTRLTASK_ID - error occurred in "CProgramControlTask.cpp" |
| 20 | OBJ_SYNCSAFETYPARTNER_ID - error occurred in "CSyncSafetyPartner.cpp" |
| 24 | OBJ_XCOM_ID - error occurred in "CXCom.cpp" |
| 28 | OBJ_SAFETYHAL_ID - error occurred in "CSafetyHal.cpp" |
| 32 | OBJ_YSTIMER_ID - error occurred in "CysTimer.cpp" |
| 36 | OBJ_MSTIMER_ID - error occurred in "CmsTimer.cpp" |
| 44 | OBJ_BASEBOARDCOM_ID - error occurred in "CBaseBoardComm.cpp" |
| 48 | OBJ_DIPSWITCH_ID - error occurred in "CDIPSwitch.cpp" |
| 52 | OBJ_HELPER_ID - error occurred in "CHelper.cpp" |
| 56 | OBJ_SYNCLINE_ID - error occurred in "CSyncSafetyPartner.cpp" |
| 60 | OBJ_TIMETABLE_ID - error occurred in "CTimeTableManager.cpp" |
| 64 | OBJ_TESTHANDLER_ID - error occurred in "CTestHandler.cpp" |

| Id | Explanation |
|---|---|
| 80 | OBJ_TIME_ITERATOR_ID - error occurred in "CTimeTableIterator.cpp" |
| 96 | OBJ_SPI_ID - error occurred in "CSpi.cpp" |
| 97 | OBJ_TIMER_ID - error occurred in "CTimer.cpp" |
| 98 | OBJ_BACKUPSRAM_ID - error occurred in "CBackupSRam.cpp" |
| 99 | OBJ_PWR_ID - error occurred in "CPwr.cpp" |
| 100 | OBJ_RCC_ID - error occurred in "CRcc.cpp" |
| 101 | OBJ_GPIO_ID - error occurred in "OBJ_GPIO_ID" |
| 102 | OBJ_DMASTREAM_ID - error occurred in "CDmaStream.cpp" |
| 103 | OBJ_ADC_ID - error occurred in "CAdc.cpp" |
| 104 | OBJ_WD_ID - error occurred in "CWatchdog.cpp" |
| 105 | OBJ_FLASH_ID - error occurred in "CFlash.cpp" |
| 106 | OBJ_I2C_ID - error occurred in "CI2c.cpp" |
| 128 | OBJ_INPUTHANDLER_ID - error occurred in "CInputHandler.cpp (Safe-In 1) " |
| 129 | OBJ_INPUTHANDLER_ID - error occurred in "CInputHandler.cpp (Safe-In 2) " |
| 130 | OBJ_INPUTHANDLER_ID - error occurred in "CInputHandler.cpp (Safe-In 3)" |
| 131 | OBJ_INPUTHANDLER_ID - error occurred in "CInputHandler.cpp (Safe-In 4)" |
| 144 | OBJ_OUTPUT_ID - error occurred in "COutput.cpp (Safe-Out 1)" |
| 145 | OBJ_OUTPUT_ID - error occurred in "COutput.cpp (Safe-Out 2)" |
| 148 | OBJ_USTESTPULSE_ID - error occurred in "CUSTestOuls.cpp" |
| 160 | OBJ_OUTPUTHANDLER_ID - error occurred in "COutputHandler.cpp" |
| 164 | OBJ_OUTPFSWITCH_ID - error occurred in "COutpFSSwitch.cpp" |

## 8.1.13 Err.class $200A_h$ for µC1 and $201A_h$ for µC2

| | |
|---|---|
| **Name** | Err.class CPU 1/2 |
| **Index** | $200A_h$ |
| **Object Code** | VARIABLE |
| **No. of Elements** | 0 |
| **Data Type** | UNSIGNED8 |
| **Access** | Read |
| **PDO Mapping** | no |
| **Default Value** | $00000000_h$ |

The table below explains the entries in object $200A_h$ or $201A_h$ "Err.class".

| Id | Explanation |
|---|---|
| 0 | No error |
| 1 | Serious or synchronization error |

| Id | Explanation |
|---|---|
| 2 | Internal communication error |
| 3 | I/O error |
| 4 | Error in ErrorHandler or at the outputs |
| 5 | Fatal error |

## 8.1.14 System Uptime [s] 200C$_h$

| | |
|---|---|
| **Name** | System uptime [s] (implicit MRAM test) |
| **Index** | 200C$_h$ |
| **Object Code** | VARIABLE |
| **No. of Elements** | 0 |
| **Data Type** | UNSIGNED32 |
| **Access** | Read |
| **PDO Mapping** | no |
| **Units** | sec |
| **Default Value** | No default Value |

## 8.1.15 Temperature Warning 0x2016$_h$

| | |
|---|---|
| **Name** | Temperature warning |
| **Index** | 2016$_h$ |
| **Object Code** | VARIABLE |
| **No. of Elements** | 0 |
| **Data Type** | UNSIGNED8 |
| **Access** | Read |
| **PDO Mapping** | no |
| **Value** | 0°C – 55°C = 0; <0°C or >55°C = 1 |
| **Default Value** | No default value |

## 8.1.16 Objects - For Internal Use Only

The objects listed below are not intended for use by the end user. Some of them are used for configuring and their values cannot be retrieved.

| | |
|---|---|
| 0x10F1h | Error Settings |
| 0x1600h | FSOE Rx PDO Mapping |
| 0x1A00h | FSOE Tx PDO Mapping |
| 0x1C00h | Sync Manager Type |
| 0x1C12h | Rx PDO Assign |
| 0x1C13h | Tx PDO Assign |
| 0x1C32h | SM Output Parameter |
| 0x1C33h | SM Input Parameter |
| 0x2000h | Ref Voltage for µC1 |
| 0x2010h | Ref Voltage for µC2 |
| 0x2002h | Supply 5 Voltage to µC1 |
| 0x2012h | Supply 5 Voltage to µC2 |
| 0x2003h | Supply 3.3 Voltage to µC1 |
| 0x2013h | Supply 3,3 Voltage to µC2 |
| 0x2004h | IC Temperature (Uncalibrated) for µC1 |
| 0x2014h | IC Temperature (Uncalibrated) for µC2 |

| | |
|---|---|
| 0x200Bh | Number of CORA Test Cycles of µC1 |
| 0x201Bh | Number of CORA Test Cycles of µC2 |
| 0x2020h | MaxAsicDataUnequalCounter |
| 0x2220h | MC1 Main Loop Cycle Time |
| 0x2221h | MC2 Main Loop Cycle Time |
| 0x5001h | Id MC1 |
| 0x5002h | Id MC2 |
| 0x5003h | Id MC3 |
| 0x6000h | FSOE Slave Frame Elements |
| 0x6001h | FSOE Inputs |
| 0x7000h | FSOE Master Frame Elements |
| 0x7001h | FSOE Outputs |
| 0x8000h | Input Parameter |
| 0x8001h | Output Parameter |
| 0x8002h | Test Pulse Duration |
| 0x8003h | Test Frequency |
| 0x9001h | FSOE Communication Parameter |
| 0xF980h | Safe Address |

# 8.2 Standards Complied With

## 8.2.1 Product Standard Applied

- EN 61131-2:2007
  Programmable logic controllers – Part 2: Equipment requirements and tests

## 8.2.2 Safety Standards and Directives

- IEC 61508:2010 Parts 1-7
  Functional safety of electrical/electronic/programmable electronic safety-related systems
- EN ISO 13849-1:2015
  Safety of machinery – Safety-related parts of control systems
  Part 1: General principles for design
- EN 62061:2005 + AC:2010 + A1:2013 + A2:2015
  Safety of machinery - Functional safety of electrical, electronic and programmable electronic safety-related control systems
- EN 60204-1:2006 + A1:2009 + AC:2010 (excerpts)
  Safety of machinery – Safety-related parts of control systems -
  Part 1: General principles for design

## 8.2.3 EMC Standards

### EMC immunity to:

- Generic standard DIN EN 61000-6-2:2005
  Electromagnetic compatibility (EMC) – Part 6-2: Generic standards - Immunity for industrial environments
- Product standard DIN EN 61131-2:2007
  Programmable logic controllers – Part 2: Equipment requirements and tests

### Elevated immunity levels of safety-related applications:

- DIN EN 61326-3-1:2008
  Electrical equipment for measurement, control and laboratory use - EMC requirements – Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) – General industrial applications

### EMC noise emission to:

- Generic standard DIN EN 61000-6-4:2007
  Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments
- Product standard EN 61131-2:2007
  Programmable logic controllers – Part 2: Equipment requirements and tests

# 8.3 Regulations and Declarations

## 8.3.1 Mark of Conformity

The original EC-Declaration of Conformity and the associated documentation can be made available to the competent authorities. Please contact the Project Management, as necessary.

KENDRION | INDUSTRIAL

WE MAGNETISE THE WORLD

**Kendrion Kuhnke Automation GmbH**
Industrial Control Systems

Lütjenburger Straße 101• 23714 Malente
Deutschland
Telefon: +49 4523 402-0
Telefax: +49 4523 402-201

## Konformitätserklärung
## Declaration of Conformity

Wir erklären, dass das nachfolgend bezeichnete Produkt den Bestimmungen der unten markierten EG- Richtlinien entspricht.

We declare that the following named product conforms with the requirements of the below marked EEC Directives.

| | |
|---|---|
| Bezeichnung/<br>Description | Kuhnke FIO Safety IO SDI4/SDO2 |
| Typ/<br>Type | Best.-Nr. 694 430 00 |
| Kendrion Kuhnke Ident-Nr./<br>Kendrion Kuhnke indentication number | 186696 |
| Angewandte Normen/<br>Considered standards | EN 61131-2:2007,<br>IEC 61508:2010 Teile 1-7 |
| Angewandte harmonisierte Normen (MRL)/<br>Considered harmonized standards (MD) | EN ISO 13849-1:2015,<br>EN 62061:2005 + AC:2010 + A1:2013 + A2:2015 |
| Benannte Stelle (bezgl. MRL 2006/42/EG)/<br>*Notified Bodies* | TÜV Rheinland Industrie Service GmbH<br>Alboinstr. 56<br>12103 Berlin / Germany<br>Tel.: +49 30 7562-1557,<br>Fax: +49 30 7562-1370,<br>E-Mail: industrie-service@de.tuv.com<br>NB-Nr.: 0035 |

Berücksichtigte EG-Richtlinie:
Considered EEC-Directives:

| | | |
|---|---|---|
| ☐ | 2006/95/EC | Niederspannungsrichtlinie/Low Voltage Directive |
| ☒ | 2014/30/EU | Elektromagnetische Verträglichkeit/ EMV/Electromagnetic compatibility EMC |
| ☐ | 2004/104/EC | Funkenstörung von Kraftfahrzeugen EMV Electromagnetic compatibility of vehicles EMC |
| ☒ | 2011/65/EU | Beschränkung der Verwendung bestimmter gefährlicher Stoffe in Elektro- und Elektronikgeräten (RoHS-2)/ Restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS-2) |
| ☒ | 2006/42/EG | Maschinenrichtlinie entsprechend Baumusterbescheinigung (01/205/5512.00/16) |

Wird das Produkt in eine Maschine eingebaut oder mit anderen Maschinen zu einer Maschine zusammengebaut, so ist vor der Inbetriebnahme zu prüfen, ob die Maschine, in dieses Produkt eingebaut werden soll, den Bestimmungen der Richtlinien entspricht.

If the device is mounted in a machine or assembles with other machinery to constitute a machine in front of the operation of the machine it is necessary to test that the machine itself conforms with the requirements of the directive.

Malente, 02.05.2016

Ort, Datum
Place, date of issue

i.V.

Entwicklungsleiter/
Development Manager

INDUSTRIAL CONTROL SYSTEMS KUHNKE
KU-0106/0715

Seite 1 von 1

## 8.3.2 TÜV Certificate

# EC Type-Examination Certificate

Product Safety
Functional
Safety

TÜVRheinland CERTIFIED

www.tuv.com
ID 0000000000

**Reg.-Nr./No.: 01/205/5512.00/16**

| | | | |
|---|---|---|---|
| **Prüfgegenstand**<br>**Product tested** | Sichere digitale Ein-/Ausgabebaugruppe mit sicherer Kommunikation über FSoE<br>Safe digital I/O module with safety communication FSoE | **Zertifikats-inhaber**<br>**Certificate holder** | Kendrion Kuhnke Automation GmbH<br>Lütjenburger Str. 101<br>23714 Malente<br>Germany |
| **Typbezeichnung**<br>**Type designation** | Kuhnke FIO Safety SDI4 / SDO2 - 694 430 00 | | |
| **Prüfgrundlagen**<br>**Codes and standards** | EN ISO 13849-1:2015<br>EN 62061:2005 + AC:2010 + A1:2013 + A2:2015<br>IEC 61508 Parts 1-7:2010 | | EN 61131-2:2007<br>EN 60204-1:2006 + A1:2009 + AC:2010 (in extracts) |
| **Bestimmungsgemäße Verwendung**<br>**Intended application** | Das I/O-Modul erfüllt die Anforderungen der Prüfgrundlagen (Kat. 3 / PL e nach EN ISO 13849-1, SIL CL 3 nach EN 62061 / IEC 61508) und kann in Anwendungen bis zu diesen Sicherheitsleveln eingesetzt werden.<br>The I/O module complies with the requirements of the relevant standards (Cat. 3 / PL e acc. to EN ISO 13849-1, SIL CL 3 acc. to EN 62061 / IEC 61508) and can be used in applications up to these safety levels. | | |
| **Besondere Bedingungen**<br>**Specific requirements** | Die Hinweise in der zugehörigen Installations- und Betriebsanleitung sowie des Sicherheitshandbuchs sind zu beachten.<br>The instructions of the associated Installation, Operating and Safety Manual shall be considered. | | |

Es wird bestätigt, dass der Prüfgegenstand mit den Anforderungen nach Anhang I der Richtlinie 2006/42/EG über Maschinen übereinstimmt.
It is confirmed, that the product tested complies with the requirements for machines defined in Annex I of the EC Directive 2006/42/EC.

Gültig bis / Valid until 2021-07-27

Der Ausstellung dieses Zertifikates liegt eine Prüfung zugrunde, deren Ergebnisse im Bericht Nr. 968/FSP 1259.00/16 vom 27.07.2016 dokumentiert sind.
Dieses Zertifikat ist nur gültig für Erzeugnisse, die mit dem Prüfgegenstand übereinstimmen. Es wird ungültig bei jeglicher Änderung der Prüfgrundlagen für den angegebenen Verwendungszweck.
The issue of this certificate is based upon an examination, whose results are documented in Report No. 968/FSP 1259.00/16 dated 2016-07-27.
This certificate is valid only for products which are identical with the product tested. It becomes invalid at any change of the codes and standards forming the basis of testing for the intended application.

0035 Notified Body

Berlin, 2016-07-27

Notified Body for Machinery, NB 0035

Dipl.-Ing. Jelena Stenzel

TÜV Rheinland Industrie Service GmbH, Alboinstr. 56, 12103 Berlin / Germany
Tel.: +49 30 7562-1370, Fax: +49 30 7562-1557, E-Mail: industrie-service@de.tuv.com

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# 8.4 Permits

Kuhnke's FIO Safety I/O module has been granted the following permits:

Certified for use in safety application by the German technical testing and inspection association (TÜV) to: EN ISO 13849-1:2015, EN 62061:2005 + AC:2010 + A1:2013 + A2:2015, EN 61131-2:2007, EN 60204-1:2006 + A1:2009 + AC: 2010 (extracts), IEC 61508 Parts 1-7:2010

CULUS

File number: E202287

Conformance and interoperability tests passed at an EtherCAT Test Center (ETC).

Conforms to RoHS Directive 2011/65/EU limiting the use of certain hazardous substances in electrical and electronic equipment

# 8.5 Order Specifications

## 8.5.1 Basic Units

| Technical Data | |
|---|---|
| **Kuhnke FIO Safety SDI4 / SDO2** | **694 430 00** |
| Safe input/output module<br>Safety protocol: FSoE<br>Safety standard: IEC 61508 SIL3 and DIN EN ISO 13849-1 Cat. 3 / PL e<br>Number of inputs: 4 safe inputs (configurable properties)<br>Number of outputs: 2 safe outputs (Imax = 2.0 A)<br>Test pulse outputs (OSSD): 4<br>Extended diagnostic information: Via CoE |  |

## 8.5.2 Accessories

| Technical Data | |
|---|---|
| **KUHNKE FIO Safety PLC** | **694 330 00** |
| Safety control unit<br>Safety protocol: FSoE<br>Safety standard: IEC 61508 SIL3 and DIN EN ISO 13849-1 Cat. 3 / PL e<br>permits CE, cULus (planned), TÜV Rheinland<br>Runtime system: CODESYS RT Safety<br>Programming tool: CODESYS v3.5 SP5 or higher with integrated safety function modules |  |

## 8.5.3 Spare Parts

There are no spare parts for the FIO Safety I/O module.

You are not allowed to repair Kuhnke's FIO Safety I/O module. Please return the defective module to Kendrion Kuhnke Automation GmbH in Malente → 9 Sales & Service.

# 9 Sales & Service

Please visit our Internet site to find a comprehensive overview of our sales and service network including all the relevant addresses. Feel free to also contact us at our headquarters in Malente/Germany:


## 9.1.1 Malente Headquarters

Kendrion Kuhnke Automation GmbH
Industrial Control Systems
Lütjenburger Straße 101
D-23714 Malente, Germany

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Fax +49 4523 402-201

Email sales-ics@kendrion.com
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