

# Installation Manual for Series KSM100



Installation instructions for basic devices KSM100-1, KSM100-2, KSM100-4, KSM121, KSM121-2, KSM122, KSM 122A, KSM122-2, KSM131 and KSM131R.

For information about KSM100 modules with communication interface, see manuals KSM 53, KSM 54 or KSM 55.

**Note:** The German version is the original version of the installation manual.

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Valid from FW release 2.1.0.6 for KSM100-x (basic devices)  
And from FW release 2.1.0.2 for KSM12x, KSM13x (Extension devices)

## **Subject to change without prior notification**

The contents of this documentation has been collated with greatest care and corresponds with our present status of information.

However, we would like to point out, that this document cannot always be updated at the same time as the technical further development of the products.

Information and specifications can be changed at any time. Please keep yourself informed about the current version under [www.kollmorgen.com](http://www.kollmorgen.com).

Devices of the

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## 1 Important notes

Definition of individual target groups

Project engineers for secure drive systems:  
Engineers and technicians

Assembling, electrical installation, maintenance and replacement of device plant electricians  
and service engineers

Commissioning, operation and configuration:  
Technicians and engineers

### 1.1 Definitions

The designation KSM100 is used as generic term for all derivatives from the KSM100 product range. Wherever this description refers to a certain derivative, the complete designation is used.

The term “safe” used in the following text in any case refers to the classification as a safe function for application up to PLe acc. to EN ISO 13849-1 or SIL3 acc. to EN 61508.

The system software “SafePLC 100” serves the purpose of configuring and programming KSM100 modules.

The modules of the KSM100 series are internally built up of two independent processing units. In the following these are referred to as system A and system B.

## 1.2 Co-valid documents

| <i>Description</i>  | <i>Reference</i>  |
|---|---|
| Configuration of the KSM module for stand-alone applications without field-bus interfacing with the program "SafePLC" | SafePLC programming manual (System CD)  |
| Validation report for implemented parameterization and PLC-program  | Safety inspection with acceptance protocol  |
| Acceptance test for general safety related applications   | Certificate for type approval test for fail-safe control system acc. to machine directive 2006/42/EC for the product groups<br><br>KSM100-1<br>KSM100-2<br>KSM100-4 |

Note:

- Thoroughly read the manuals before you start the installation and the commissioning of the KSM100 module.
- Paying attention to the documentation is a prerequisite for trouble-free operation and fulfilment of possible warranty claims.

## 1.3 Abbreviations used

| <i>Abbreviation</i> | <i>Meaning</i>  |
|---------------------|---|
| AC                  | Alternating voltage   |
| IL                  | Instruction list  |
| ELIA                | Employer's liability insurance association                            |
| CLK                 | Clock (cycle)   |
| CPU                 | Central Processing Unit   |
| DC                  | Direct voltage  |
| DI1..DI14           | Digital Input   |
| DIN                 | Deutsches Institut für Normung (German Institute for Standardization) |
| DO                  | Digital Output  |
| EMU                 | Emergency Monitoring Unit   |

| <b>Abbreviation</b> | <b>Meaning</b>   |
|---------------------|--|
| EMC                 | Electromagnetic compatibility  |
| ELC                 | Emergency Limit Control  |
| EN                  | European Standard  |
| HISIDE              | Output with 24VDC nominal level switching to plus  |
| IP20                | Degree of protection for housing   |
| ISO                 | International Organisation for Standardisation   |
| LED                 | Light Emitting Diode   |
| LOSIDE              | Output switching to reference potential  |
| OLC                 | Operational Limit Control  |
| PIA                 | Process image of outputs   |
| PII                 | Process image of inputs  |
| P1,P2               | Pulse outputs  |
| PLC                 | Programmable Logic Controller  |
| POR                 | Power on Reset   |
| PSC                 | Position Supervision Control   |
| SDDC                | Safe Device To Device Communication  |
| SELV                | Safety Extra Low Voltage   |
| SSI                 | Synchronous Serial Interface   |
| VDE                 | Verband der Elektrotechnik, Elektronik und Informationstechnik e. V.<br>(association for electrical engineering, electronics and information technology) |



## 2 Safety regulations

### 2.1 Intended use

Devices of the KSM100 series are programmable fail-safe control system intended for the establishment of emergency shut-down features and functions. The devices are intended for use in

- EMERGENCY STOP facilities,
- as safety component as defined by the EC machine directive 2006/42/EC,
- as PES for risk reduction as defined by EN 61508,
- in safety circuits acc. to EN 60204 and EN 60204-32,
- as PES for functional safety as defined by EN 62061,
- as SRP/CS as defined by EN 13849,
- as device for establishing the safety functions acc. to EN 61800-5-2,
- as logic unit for converting and processing signals in two-hand control acc. to EN 574.

### 2.2 General safety regulations

#### Safety note:

- In order to avoid damage to persons and property only qualified personnel is entitled to work on the device. The term qualified personnel refers to persons who have successfully completed electrotechnical training and are fully familiar with the applicable rules and standards of electrical engineering.

The qualified person must become familiar with the operating instructions (see IEC364, DIN VDE0100).

- The qualified must have profound knowledge of the national accident prevention regulations
- The use of the device must be strictly limited to the intended use as specified in the following list. The values of data listed under section “3.2 Characteristic device data” must also be observed.
- The contents of this installation manual is restricted to the basic function of the device or its installation. The “Programming instructions KSM100” contains a more detailed description of the programming and re-parameterization of the devices. Exact knowledge and understanding of these instructions is mandatory for a new installation or modification of device functions or device parameters.
- Commissioning (i.e. starting up the intended operation) is only permitted in strict compliance with the EMC-directive. The EMC-testing regulations EN55011:2007 + A2:2007 and EN 61000-6-2:2005 are used as basis.

- Compliance with the conditions acc. to EN 60068-2-6 related to the values specified under “Technical characteristics” is mandatory for storage and transport.
- The wiring and connecting instructions in chapter “Installation” must be strictly followed.
- The applicable VDE-regulations and other special safety regulations of relevance for the application must be strictly followed.
- Evidence of the configured monitoring functions as well as their parameters and links must be issued by means of a validation report.
- The implementation of the module must be coordinated with the demands of the responsible acceptance testing authority (e.g. TÜV or ELIA).
- Do not install or operate damaged products. Report damages immediately to the responsible forwarding agent.
- Never open the housing and/or make unauthorized conversions.
- Inputs and outputs for standard functions or digital and analog data transmitted via communication modules must not be used for safety relevant applications.

**WARNING:**

**Using our devices contrary to the rules and conditions specified hereunder can lead to injuries or fatalities as well as damage to connected devices and machines!  
This will also cause the loss of all warranty and compensation claims against Kollmorgen.**

## 2.3 Operation and service

The module must always be de-energized before installation and removal, or before disconnecting signal lines. For this purpose all live supply lines to the device must be checked for safe isolation from supply

When installing or removing the module appropriate measures must be applied to prevent electrostatic discharge to the externally arranged terminal and plug connections. Contact with such terminals should be reduced to a minimum and earthing should by means of e.g. an earthing strap should take place before and during these procedures.

## 2.4 Transport/storage

Information concerning transport, storage and proper handling must be strictly followed. The climate related specifications in chapter "Technical data" must be with complied.

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## 3 Device types

The series KSM100 consists of

- the basic devices KSM100-1/100-2/100-4
- the extension modules KSM121, KSM121-2, KSM122(A), KSM122-2(A), and KSM131

### Basic devices

The KSM100 series represents a modular fail-safe control system. The device is freely programmable for reliable processing of both EMERGENCY STOP button, two-hand control, light grid, operation mode switch, etc., but also of drive related safety functions. Pre-configured modules for safety relevant signal pre-processing are available for a vast number of input devices. The same applies for safety functions serving the purpose of drive monitoring. Detailed information can be found in the programming manual.

The basic version of the device has 14 secure inputs and 3 shut-down channels, which can be extended to max. 130 inputs, 65 of which are secure I/O's.

Single encoder solutions (incl. TTL/HTL, SIN(COS, Proxi-Sw.) as well as dual encoder solutions (e.g. 2 x Inc.-TTL or SSI and Inc..HTL) are supported for reliable speed and/or position detection.

### Extension modules:

Axis extension modules for the KSM100 series: KSM121, KSM121-2, KSM122(A), KSM122-2(A)  
 Digital I/O extension for the KSM100 series: KSM131.

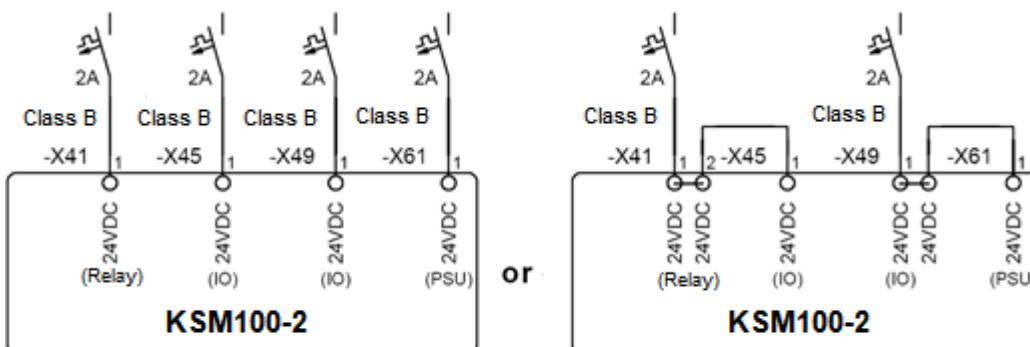
A maximum of 8 extension modules can be connected to a system.

The extension module has 12 secure inputs, 10 secure I/O for optional configuration as input or output and 2 signal outputs.

Extension module for the transfer of diagnostic and status data to an imposed control by means of standard field bus.

### ⚠ Safety note:

- The 24V-DC supply connections on the KSM module must be fused with an external 2A (24VDC) backup fuse.  
 Recommended fuse type:  
 2A miniature circuit breaker (class B) or melting fuse (quick-acting).
- Depending on the electric power demand the fusing can be connected in sum or per I/O group.



Connection example with separated I/O supply! When connecting I/Os with high current consumption.

Connection example with separated I/O supply! When connecting I/Os with high current consumption.


## 3.1 Module overview

| Basic Modules                      |  |             |             | Extension Modules       |            |            |            |            |
|------------------------------------|--|-------------|-------------|-------------------------|------------|------------|------------|------------|
| Designation                        | KSM 100-1  | KSM 100-2   | KSM 100-4   | KSM 121                 | KSM 121-2  | KSM 122    | KSM 122-2  | KSM 131    |
| Max. number of extension modules   | 6  | 6           | 6           | -                       | -          | -          | -          | -          |
| Secure digital I                   | 14   | 14          | 14          | 12                      | 12         | 12         | 12         | 12         |
| Secure digital I/O                 | -  | 20          | 40          | -                       | -          | -          | -          | 10         |
| Secure digital Out                 | 2  | 2           | 2           | -                       | -          | -          | -          | -          |
| Secure analog In                   | -  | -           | -           | -                       | -          | 2*         | 2*         | -          |
| Secure relay outputs               | 1  | 1           | 1           | -                       | -          | -          | -          | -          |
| Signal outputs                     | 2  | 6           | 10          | -                       | -          | -          | -          | -          |
| Pulse outputs                      | 2  | 2           | 2           | -                       | -          | -          | -          | -          |
| Memory Card                        | yes  | yes         | yes         | -                       | -          | -          | -          | -          |
| Integrated communication interface | Optional:<br>Profibus / Profinet / Devicenet /<br>CAN 2.0 / CANopen / EtherCAT |             |             |                         |            |            |            |            |
| Axis monitoring                    | -  |             |             | 1**                     | 1**        | max. 2***  | max. 2***  | -          |
| Encoder interfaces                 | -  |             |             | 1                       | 2          | 2          | 4          | -          |
|                                    |  |             |             | SSI                     | SSI        | SSI        | SSI        | -          |
|                                    |  |             |             | SIN/COS                 | SIN/COS    | SIN/COS    | SIN/COS    | -          |
|                                    |  |             |             | Incr. TTL               | Incr. TTL  | Incr. TTL  | Incr. TTL  | -          |
|                                    |  |             |             | Incr. HTL               | Incr. HTL  | Incr. HTL  | Incr. HTL  | -          |
| Proxi sw.                          | Resolver   | Proxi sw.   | Resolver    | -                       |            |            |            |            |
| Proxi sw.                          | Proxi sw.  | Proxi sw.   | Proxi sw.   | -                       |            |            |            |            |
| Supply voltage                     | 24 VDC/2A  |             |             | Supply via basic module |            |            |            |            |
| Rated voltage digital I/O          | 24VDC  |             |             | 24 VDC                  |            |            |            |            |
| Max. input voltage analog          | -  |             |             |                         |            |            |            |            |
| Max. load digital O                | 0.25 A   |             |             | 0.25 A                  |            |            |            |            |
| Max. load relay                    | 24 VDC/2A  |             |             | -                       |            |            |            |            |
|                                    | 230 VAC/2A   |             |             |                         |            |            |            |            |
| Dimensions (HxDxW [mm])            | 100x115x90   | 100x115x135 | 100x115x180 | 100x115x23              | 100x115x45 | 100x115x45 | 100x115x45 | 100x115x90 |

## 3.2 Characteristic data of device

### 3.2.1 Basic modules

#### 3.2.1.1 System module KSM 100-1

| <b>Type designation</b>  | <b>Device design</b>  |
|--|---|
|  | <p>Design of module with the following periphery:</p> <ul style="list-style-type: none"> <li>14 digital inputs</li> <li>2 digital outputs</li> <li>1 digital output relay</li> <li>2 signal outputs</li> <li>2 pulse generator outputs</li> </ul> |


#### Characteristics of the module:

- 14 secure inputs, 3 shut-down channels, 1 of these a secure relay output and 2 secure signal outputs provided by the basic device
- Extendable to max. 130 secure I/O and/or 12 secure axes by means of integrated backplane bus (connectors to snap on top-hat rail)
- Logic diagram oriented programming by means of SafePLC-SW
- Extensive library for pre-configured safety sensors and operator controls
- Complete speed and position related safety functions for drive monitoring in accordance with DIN EN 61800 integrated in firmware
- Three-dimensional functions for secure speed and area monitoring possible
- Parameter management for extension modules in the basic device
- Cross-shorting monitoring
- Possibility of contact multiplication or contact amplification by means of external contactors in connection with integrated monitoring
- Extensive diagnostics functions integrated in FW
- Encoded status display via 7-segment display and status LEDs in front panel
- Quit-/Start-/Reset buttons operable in front panel
- Optionally with connection to superimposed Master by means of standard field bus communication via CAN-Bus 2.0 interface, CANopen, PROFIBUS, PROFINET, EtherCAT, DeviceNet, or secure field bus communication by means of PROFIsafe V 2.0 or FSoE.

## Technical characteristic data KSM 100-1

|                                    |  |
|------------------------------------|--|
| Safety related characteristic data |  |
| PI acc. to EN 13849                | PI e   |
| PFH/architecture                   | Typical: $1,4 \cdot 10^{-9}$ /class 4                    |
| SIL acc. to EN 61508               | SIL 3  |
| Proof test interval                | 20 years = max. utilization period                       |
| General data                       |  |
| Max. number of extension modules   | 8  |
| Interface for extension modules    | T-bus connector, pluggable in top-hat rail               |
| Secure digital I                   | 14 incl. 8 OSSD  |
| Secure digital I/O                 | -  |
| Secure digital Out                 | 2  |
| Secure analog In                   | -  |
| Secure relay outputs               | 1  |
| Signal outputs                     | 2  |
| Pulse outputs                      | 2  |
| Type of connection                 | Clamp-type terminals                                     |
| Electrical data                    |  |
| Supply voltage                     | 24 VDC/2A  |
| Tolerance                          | -15 %, +20 %   |
| Power consumption                  | Max. 3.2 W   |
| Ratings digital I                  | 24 VDC; 20 mA, Type1 acc. to EN61131-2                   |
| Ratings digital O                  | 24 VDC; 250 mA   |
| Ratings relays                     | 24 VDC/2A and 230 VAC/2A                                 |
| Pulse outputs                      | Max. 250 mA  |
| Supply voltage fuse protection     | Max. 2 A   |
| Environmental data                 |  |
| Temperature                        | 0° to 50° operating temp.;<br>-10° to +70° storage temp. |
| Class of protection                | IP 52  |
| Climatic category                  | 3 acc. to DIN 50 178                                     |
| EMC                                | In accordance with EN 55011 and<br>EN 61000-6-2          |
| Mechanical data                    |  |
| Dimensions (HxDxW [mm])            | 100x115x114  |
| Weight                             | 460 g  |
| Fastening                          | To snap on standard rail                                 |
| Max. conductor size                | 1.5 mm <sup>2</sup>                                      |

## 3.2.1.2 System module KSM 100-2

| <b>Type designation</b>   | <b>Device design</b>  |
|---|---|
|  | <p>Design of module with the following periphery:</p> <ul style="list-style-type: none"> <li>20 secure digital I/O</li> <li>14 digital inputs</li> <li>2 pulse generator outputs</li> <li>1 digital output relay</li> <li>2 digital outputs LOSIDE</li> <li>2 digital outputs HISIDE</li> <li>6 signal outputs</li> </ul> |

### Characteristics of the module:


- 20 secure I/O – configurable as input or output, 14 secure inputs, 3 shut-down channels, 1 of these a secure relay output and 6 signal outputs provided by the basic device
- Extendable to max. 130 secure I/O and/or 12 secure axes by means of integrated backplane bus (connectors to snap on top-hat rail)
- Logic diagram oriented programming by means of SafePLC-SW
- Extensive library for pre-configured safety sensors and operator controls
- Complete speed and position related safety functions for drive monitoring in accordance with DIN EN 61800 integrated in firmware
- Three-dimensional functions for secure speed and area monitoring possible
- Parameter management for extension modules in the basic device
- Cross-shorting monitoring
- Possibility of contact multiplication or contact amplification by means of external contactors in connection with integrated monitoring
- Extensive diagnostics functions integrated in FW
- Encoded status display via 7-segment display and status LEDs in front panel
- Quit-/Start-/Reset buttons operable in front panel
- Optionally with connection to superimposed Master by means of standard field bus communication via CAN-Bus 2.0 interface, CANopen, PROFIBUS, PROFINET, EtherCAT, DeviceNet, or secure field bus communication by means of PROFIsafe V 2.0 or FSoE.



## Technical characteristic data KSM 100-2

|                                    |  |
|------------------------------------|--|
| Safety related characteristic data |  |
| PI acc. to EN 13849                | PI e   |
| PFH/architecture                   | Typically $1.6 \cdot 10^{-9}$ /class 4                   |
| SIL acc. to EN 61508               | SIL 3  |
| Proof test interval                | 20 years = max. utilization period                       |
| General data                       |  |
| Max. number of extension modules   | 8  |
| Interface for extension modules    | T-bus connector, pluggable in top-hat rail               |
| Secure digital I                   | 14 incl. 8 OSSD  |
| Secure digital I/O                 | 20   |
| Secure digital Out                 | 2  |
| Secure analog In                   | -  |
| Secure relay outputs               | 1  |
| Signal outputs                     | 6  |
| Pulse outputs                      | 2  |
| Type of connection                 | Clamp-type terminals                                     |
| Electrical data                    |  |
| Supply voltage                     | 24 VDC/2A  |
| Tolerance                          | -15 %, +20 %   |
| Power consumption                  | Max. 3.2 W   |
| Ratings digital I                  | 24 VDC; 20 mA, Type1 acc. to EN61131-2                   |
| Ratings digital O                  | 24 VDC; 250 mA   |
| Ratings relays                     | 24 VDC/2A and 230 VAC/2A                                 |
| Pulse outputs                      | Max. 250 mA  |
| Supply voltage fuse protection     | Max. 2 A   |
| Environmental data                 |  |
| Temperature                        | 0° to 50° operating temp.;<br>-10° to +70° storage temp. |
| Class of protection                | IP 52  |
| Climatic category                  | 3 acc. to DIN 50 178                                     |
| EMC                                | In accordance with EN 55011 and<br>EN 61000-6-2          |
| Dimensions (HxDxW [mm])            |  |
| Weight                             | 690 g  |
| Fastening                          | To snap on standard rail                                 |
| Max. conductor size                | 1.5 mm <sup>2</sup>                                      |

### 3.2.1.3 System module KSM 100-4

| <b>Type designation</b>   | <b>Device design</b>  |
|---|---|
|  | <p>Design of module with the following periphery:</p> <ul style="list-style-type: none"> <li>40 secure digital I/O</li> <li>14 digital inputs</li> <li>2 digital outputs</li> <li>1 digital output relay</li> <li>10 signal outputs</li> <li>2 pulse generator outputs</li> </ul> |

#### Characteristics of the module:


- 40 secure I/O – configurable as input or output, 14 secure inputs, 3 shut-down channels, 1 of these a secure relay output and 10 signal outputs provided by the basic device
- Extendable to max. 130 secure I/O and/or 12 secure axes by means of integrated backplane bus (connectors to snap on top-hat rail)
- Logic diagram oriented programming by means of SafePLC-SW
- Extensive library for pre-configured safety sensors and operator controls
- Complete speed and position related safety functions for drive monitoring in accordance with DIN EN 61800 integrated in firmware
- Three-dimensional functions for secure speed and area monitoring possible
- Parameter management for extension modules in the basic device
- Cross-shorting monitoring
- Possibility of contact multiplication or contact amplification by means of external contactors in connection with integrated monitoring
- Extensive diagnostics functions integrated in FW
- Encoded status display via 7-segment display and status LEDs in front panel
- Quit-/Start-/Reset buttons operable in front panel
- Optionally with connection to superimposed Master by means of standard field bus communication via CAN-Bus 2.0 interface, CANopen, PROFIBUS, PROFINET, EtherCAT, DeviceNet, or secure field bus communication by means of PROFI-safe V 2.0 or FSoE.

## Technical characteristic data KSM 100-4

|                                    |  |
|------------------------------------|--|
| Safety related characteristic data |  |
| PI acc. to EN 13849                | PI e   |
| PFH/architecture                   | Typical: $1.7 \cdot 10^{-9}$ /class 4                    |
| SIL acc. to EN 61508               | SIL 3  |
| Proof test interval                | 20 years = max. utilization period                       |
| General data                       |  |
| Max. number of extension modules   | 8  |
| Interface for extension modules    | T-bus connector, pluggable in top-hat rail               |
| Secure digital I                   | 14 incl. 8 OSSD  |
| Secure digital I/O                 | 40   |
| Secure digital Out                 | 2  |
| Secure analog In                   | -  |
| Secure relay outputs               | 1  |
| Signal outputs                     | 10   |
| Pulse outputs                      | 2  |
| Type of connection                 | Clamp-type terminals                                     |
| Electrical data                    |  |
| Supply voltage                     | 24 VDC/2A  |
| Tolerance                          | -15 %, +20 %   |
| Power consumption                  | Max. 3.2 W   |
| Ratings digital I                  | 24 VDC; 20 mA, Type1 acc. to EN61131-2                   |
| Ratings digital O                  | 24 VDC; 250 mA   |
| Ratings relays                     | 24 VDC/2A and 230 VAC/2A                                 |
| Pulse outputs                      | Max. 250 mA  |
| Supply voltage fuse protection     | Max. 2 A   |
| Environmental data                 |  |
| Temperature                        | 0° to 50° operating temp.;<br>-10° to +70° storage temp. |
| Class of protection                | IP 52  |
| Climatic category                  | 3 acc. to DIN 50 178                                     |
| EMC                                | In accordance with EN 55011 and<br>EN 61000-6-2          |
| Dimensions (HxDxW [mm])            |  |
| Dimensions (HxDxW [mm])            | 100x115x205  |
| Weight                             | 920 g  |
| Fastening                          | To snap on standard rail                                 |
| Max. conductor size                | 1,5 mm <sup>2</sup>                                      |

## 3.2.2 Extension modules

### 3.2.2.1 Extension module KSM 121

| <b>Type designation</b>  | <b>Device design</b>   |
|--|--|
|  | <p>Design of module with the following periphery:</p> <ul style="list-style-type: none"><li>12 digital inputs</li><li>1 axis</li></ul> |


#### Characteristics of the module:

- Parametrizable encoder interface for 1x incr.-TTL, SIN/COS and 1x HTL via terminal connection
- Cross-shorting monitoring by means of pulse outputs on the basic device
- Extensive diagnostics functions integrated in FW
- Power supply via basic module

## Technical characteristic data KSM 121

|                                    |  |
|------------------------------------|--|
| Safety related characteristic data |  |
| PI acc. to EN 13849                | PI e   |
| PFH/architecture                   | Typical: $1,2 * 10^{-9}$ /class 4                        |
| SIL acc. to EN 61508               | SIL 3  |
| Proof test interval                | 20 years = max. utilization period                       |
| General data                       |  |
| Secure digital inputs              | 12   |
| Type of connection                 | Clamp-type terminals                                     |
| Axis monitoring                    | 1 axis   |
| Encoder interface front number     | 1 SSI, SIN/COS, Incr. TTL                                |
| Max. frequency SIN/COS, Incr., TTL | 200 kHz  |
| Cycle frequency/mode SSI           | Master mode 150 kHz/Slave mode 250 kHz                   |
| Type of connection                 | D-SUB 9pole  |
| Encoder interface terminals        | 1Proxi / HTL   |
| Max. frequency HTL                 | 10 kHz   |
| Type of connection                 | Clamp-type terminals                                     |
| Electrical data                    |  |
| Power consumption                  | 24 VDC/2A  |
| Ratings digital inputs             | 24 VDC; 20mA, type1 acc. to EN61131-2                    |
| Environmental data                 |  |
| Temperature                        | 0° to 50° operating temp.;<br>-10° to +70° storage temp. |
| Class of protection                | IP 52  |
| Climatic category                  | 3 acc. to DIN 50 178                                     |
| EMC                                | In accordance with EN 55011 and EN 61000-6-2             |
| Dimensions (HxDxW [mm])            |  |
| Weight                             | 210 g  |
| Fastening                          | To snap on standard rail                                 |
| Max. conductor size                | 1,5 mm <sup>2</sup>                                      |
| Safety related characteristic data |  |
| PI acc. to EN 13849                | PI e   |
| PFH/architecture                   | Type $6.0 * 10^{-9}$ /class 4                            |
| SIL acc. to EN 61508               | SIL 3  |
| Proof test interval                | 20 years = max. utilization period                       |
| General data                       |  |

## 3.2.2.2 Extension module KSM 121-2

| <b>Type designation</b>   | <b>Device design</b>  |
|---|---|
|  A photograph of the KSM 121-2 extension module. It is a grey, rectangular industrial component with yellow terminal blocks on the top and bottom. The front panel features a label with 'KSM 121-2' and 'KOLLMORGEN' branding. There are two D-sub connectors on the front, labeled 'Encoder Interface 1' and 'Encoder Interface 2'. The top edge has terminals labeled X13, X14, X17, and X18. The bottom edge has terminals labeled X23, X24, X27, and X28. | <p>Design of module with the following periphery:</p> <ul style="list-style-type: none"><li>12 digital inputs</li><li>2 axes</li><li>1 encoder solution</li></ul> |

### Characteristics of the module:

- Parametrizable encoder interface for 2x Incr, SIN/COS, SSI, HTL and 1x Resolver
- Cross-shortening monitoring by means of pulse outputs on the basic device
- Extensive diagnostics functions integrated in FW
- Power supply via basic module


## Technical characteristic data KSM 121-2

|   |                      |  |
|---|----------------------|--|
| Safety related characteristic data              |                      |  |
| PI acc. to EN 13849                             |                      | PI e   |
| PFH / architecture                              |                      | Typical: $1.2 \cdot 10^{-9}$ / architecture class 4        |
| SIL acc. to EN 61508                            |                      | SIL 3  |
| Proof test interval                             |                      | 20 years = max. utilization period                         |
| General data                                    |                      |  |
| Interface for extension modules                 |                      | T-bus connector, pluggable in top-hat rail                 |
| Secure digital I                                |                      | 12 incl. 8 OSSD  |
| Secure digital I/O                              |                      | -  |
| Secure digital Out                              |                      | -  |
| Secure analog In                                |                      | -  |
| Secure relay outputs                            |                      | -  |
| Signal outputs                                  |                      | -  |
| Pulse outputs                                   |                      | -  |
| Type of connection                              |                      | Clamp-type terminals                                       |
| Axis monitoring                                 |                      | 1 axis   |
| Encoder interface front number / technology     |                      | 2 / SSI; SIN/COS; Incr.-TTL; Resolver                      |
| Max. frequency incremental (SIN/COS, TTL)       | KSM                  | 200 kHz  |
|   | Encoder ext. board   | 250 kHz  |
| Cycle frequency/mode SSI                        | KSM                  | Master mode 150 kHz / Slave mode max. 250 kHz              |
|   | Encoder ext. board   | Master mode 150 kHz / Slave mode 150-350 kHz               |
| Resolver (Encoder ext. board)                   | Signal frequency     | max. 600 Hz  |
|   | Input voltage        | max. 8 V <sub>ss</sub> (on 16 kΩ)                          |
|   | Reference frequency  | 6 kHz – 16 kHz   |
|   | Reference amplitude  | 8 V <sub>ss</sub> – 28 V <sub>ss</sub>                     |
|   | Number of pole pairs | 1..8   |
|   | Transformation ratio | 2:1; 3:1; 4:1  |
| Phase fault                                     |                      | max. 8°  |
| Type of connection                              |                      | D-SUB 9pole  |
| Max. frequency HTL                              | KSM (Proxi-Input)    | 10 kHz   |
|   | Encoder ext. board   | 200 kHz  |
| Encoder interface terminals number / technology |                      | 2 / Proxi-Sw.; Inc.-HTL                                    |
| Type of connection                              |                      | Clamp-type terminals                                       |
| Electrical data                                 |                      |  |
| Supply voltage                                  |                      | 24 VDC / 2A  |
| Tolerance                                       |                      | -15 %, +20 %   |
| Power consumption                               |                      | 2.4 W  |
| Ratings digital I                               |                      | 24 VDC; 20 mA, Type1 acc. to EN61131-2                     |
| Ratings digital O                               |                      | 24VDC; 250 mA  |
| Ratings relays                                  |                      | 24 VDC/2A<br>230 VAC/2A                                    |
| Pulse outputs                                   |                      | Max. 250 mA  |
| Supply voltage fuse protection                  |                      | Max. 2 A   |
| Environmental data                              |                      |  |
| Temperature                                     |                      | 0° to +50° operating temp.;<br>-10° to +70 ° storage temp. |
| Class of protection                             |                      | IP 52  |
| Climatic category                               |                      | 3 acc. to DIN 50 178                                       |
| EMC   |                      | In accordance with EN 55011 and EN 61000-6-2               |
| Mechanical data                                 |                      |  |
| Dimensions (HxDxW [mm])                         |                      | 100x115x45   |
| Weight  |                      | 390 g  |
| Fastening                                       |                      | To snap on standard rail                                   |
| Max. conductor size                             |                      | 1.5 mm <sup>2</sup>  |

1) When using 2 independent encoders

2) When using 1 encoder

### 3.2.2.3 Extension module KSM 122 (A)

| <b>Type designation</b>   | <b>Device design</b>  |
|---|---|
|  | <p>Design of module with the following periphery:</p> <ul style="list-style-type: none"> <li>12 digital inputs</li> <li>2 axes</li> <li>1 encoder solution</li> </ul> |

#### Characteristics of the module:

- Parametrizable encoder interface for 1 x Incr-TTL/SIN-COS/SSI in front panel and 1 x HTL via terminal connection
- 12 secure inputs
- Optionally 2 secure analog inputs (option “A”)
- Cross-shortening monitoring by means of pulse outputs on the basic device
- Extensive diagnostics functions integrated in FW
- Power supply via basic module




## Technical characteristic data KSM 122 (A)

|   |  |
|---|--|
| Safety related characteristic data              |  |
| PI acc. to EN 13849                             | PI e   |
| PFH/architecture                                | Typical: $1.2 \cdot 10^{-9}$ /incl. Basic group/class 4  |
| SIL acc. to EN 61508                            | SIL 3  |
| Proof test interval                             | 20 years = max. utilization period                       |
| General data                                    |  |
| Secure digital I                                | 12 incl. 8 OSSD  |
| Type of connection                              | Clamp-type terminals                                     |
| Secure analog inputs                            | 2 <sup>1)</sup>  |
| Axis monitoring                                 | 2 axes   |
| Encoder interface front number / technology     | 2 SSI; SIN/COS; Incr.-TTL                                |
| Max. frequency SIN/COS, Incr. TLL               | 200 kHz  |
| Cycle frequency/mode SSI                        | Master mode 150 kHz/Slave mode max. 250 kHz              |
| Type of connection                              | D-SUB 9pole  |
| Encoder interface terminals number / technology | 2/Proxi-Sw.; Incr.-HTL                                   |
| Max. frequency HTL                              | 10 kHz   |
| Type of connection                              | Clamp-type terminals                                     |
| Electrical data                                 |  |
| Power consumption                               | 2.4 W  |
| Ratings digital I                               | 24 VDC; 20 mA, Type1 acc. to EN61131-2                   |
| Environmental data                              |  |
| Temperature                                     | 0° to 50° operating temp.;<br>-10° to +70° storage temp. |
| Class of protection                             | IP 52  |
| Climatic category                               | 3 acc. to DIN 50 178                                     |
| EMC   | In accordance with EN 55011 and EN 61000-6-2             |
| Mechanical data                                 |  |
| Dimensions (HxDxW [mm])                         | 100x115x45   |
| Weight  | 310 g  |
| Fastening                                       | To snap on standard rail                                 |
| Max. conductor size                             | 1,5 mm <sup>2</sup>                                      |

1) Only for version KSM 122A

## 3.2.2.4 Extension module KSM 122-2

| <b>Type designation</b>   | <b>Device design</b>   |
|---|--|
|  | <p>Design of module with the following periphery:</p> <ul style="list-style-type: none"> <li>12 digital inputs</li> <li>2 axes</li> <li>2 encoder solutions</li> </ul> |


### Characteristics of the module

- Parametrizable encoder interface for 2 x 2 x Incr-TTL/SIN-COS/SSI and 2 x HTL/Resolver
- 12 secure inputs
- Cross-shorting monitoring by means of pulse outputs on the basic device
- Extensive diagnostics functions integrated in FW
- Power supply via basic module

## Technical characteristic data KSM 122 – 2

|   |                      |  |
|---|----------------------|--|
| Safety related characteristic data              |                      |  |
| PI acc. to EN 13849                             |                      | PI e   |
| PFH / architecture                              |                      | Typical: $1.2 \cdot 10^{-9}$ / architecture class 4        |
| SIL acc. to EN 61508                            |                      | SIL 3  |
| Proof test interval                             |                      | 20 years = max. utilization period                         |
| General data                                    |                      |  |
| Interface for extension modules                 |                      | T-bus connector, pluggable in top-hat rail                 |
| Secure digital I                                |                      | 12 incl. 8 OSSD  |
| Secure digital I/O                              |                      | -  |
| Secure digital Out                              |                      | -  |
| Secure analog In                                |                      | 2 optional   |
| Secure relay outputs                            |                      | -  |
| Signal outputs                                  |                      | -  |
| Pulse outputs                                   |                      | -  |
| Type of connection                              |                      | Clamp-type terminals                                       |
| Axis monitoring                                 |                      | 2 axes   |
| Encoder interface front number / technology     |                      | 4 / SSI; SIN/COS; Incr.-TTL; Resolver                      |
| Max. frequency incremental (SIN/COS, TTL)       | KSM                  | 200 kHz  |
|   | Encoder ext. board   | 250 kHz  |
| Cycle frequency/mode SSI                        | KSM                  | Master mode 150 kHz / Slave mode max. 250 kHz              |
|   | Encoder ext. board   | Master mode 150 kHz / Slave mode 150-350 kHz               |
| Resolver (Encoder ext. board)                   | Signal frequency     | max. 600 Hz  |
|   | Input voltage        | max. 8 V <sub>ss</sub> (on 16 k $\Omega$ )                 |
|   | Reference frequency  | 6 kHz – 16 kHz   |
|   | Reference amplitude  | 8 V <sub>ss</sub> – 28 V <sub>ss</sub>                     |
|   | Number of pole pairs | 1..8   |
|   | Transformation ratio | 2:1; 3:1; 4:1  |
| Phase fault                                     |                      | max. 8°  |
| Type of connection                              |                      | D-SUB 9pole  |
| Max. frequency HTL                              | KSM (Proxi-Input)    | 10 kHz   |
|   | Encoder ext. board   | 200 kHz  |
| Encoder interface terminals number / technology |                      | 2 / Proxi-Sw.; Inc.-HTL                                    |
| Type of connection                              |                      | Clamp-type terminals                                       |
| Electrical data                                 |                      |  |
| Supply voltage                                  |                      | 24 VDC / 2 A   |
| Tolerance                                       |                      | -15 %, +20 %   |
| Power consumption                               |                      | 2.4 W  |
| Ratings digital I                               |                      | 24 VDC; 20 mA, Type1 acc. to EN61131-2                     |
| Ratings digital O                               |                      | 24VDC; 250 mA  |
| Ratings relays                                  |                      | 24 VDC/2 A<br>230 VAC/2 A                                  |
| Pulse outputs                                   |                      | Max. 250 mA  |
| Supply voltage fuse protection                  |                      | Max. 2 A   |
| Environmental data                              |                      |  |
| Temperature                                     |                      | 0° to +50° operating temp.;<br>-10° to +70 ° storage temp. |
| Class of protection                             |                      | IP 52  |
| Climatic category                               |                      | 3 acc. to DIN 50 178                                       |
| EMC   |                      | In accordance with EN 55011 and EN 61000-6-2               |
| Mechanical data                                 |                      |  |
| Dimensions (HxDxW [mm])                         |                      | 100x115x90   |
| Weight  |                      | 470 g  |
| Fastening                                       |                      | To snap on standard rail                                   |
| Max. conductor size                             |                      | 1.5 mm <sup>2</sup>  |

## 3.2.2.5 Extension group KSM131

| <i>Type designation</i>   | <i>Device design</i>  |
|---|---|
|  | <p>Design of module with the following periphery:</p> <ul style="list-style-type: none"> <li>12 digital inputs</li> <li>10 I/O optionally configurable as input or output</li> <li>2 pulse outputs</li> <li>2 signal outputs</li> <li>12 status LEDs for inputs</li> <li>10 status LEDs for I/O</li> <li>1 backplane bus interface</li> </ul> |

### Characteristics of the module:

- 12 secure inputs; 8 of these OSSD compatible
- 10 secure I/O optionally configurable as input or output,
- Cross-shorting monitoring
- Possibility of contact multiplication or contact amplification by means of external contactors in connection with integrated monitoring
- Extensive diagnostics functions integrated in FW
- Power supply via basic module
- Assembly on top hat rail

**Technical characteristic data:**








|                                    |   |
|------------------------------------|---|
| Safety related characteristic data |   |
| PI acc. to EN 13849                | PI e  |
| PFH / architecture                 | Typical: $1.1 \cdot 10^{-9 \text{ (1)}}$ / Class 4        |
| SIL acc. to EN 61508               | SIL 3   |
| Proof test interval                | 20 years = max. utilization period                        |
| General data                       |   |
| Secure digital I                   | 12 incl. 8 OSSD   |
| Secure digital I/O                 | 10  |
| Secure digital Out                 | -   |
| Secure analog In                   | -   |
| Secure relay outputs               | -   |
| Signal outputs                     | 2   |
| Pulse outputs                      | 2   |
| Type of connection                 | Clamp-type terminals                                      |
| Electrical data                    |   |
| Power consumption                  | Max. 3.8 W  |
| Ratings digital I                  | 24 VDC; 20 mA, Type1 acc. to EN61131-2                    |
| Ratings digital O                  | 24VDC; 250 mA   |
| Pulse outputs                      | Max. 250 mA   |
| Environmental data                 |   |
| Temperature                        | 0° to 50° operating temp.;<br>-10° to +70 ° storage temp. |
| Class of protection                | IP 52   |
| Climatic category                  | 3 acc. to DIN 50 178                                      |
| EMC                                | In accordance with EN 55011 and<br>EN 61000-6-2           |
| Mechanical data                    |   |
| Dimensions (HxDxW [mm])            | 100x115x45  |
| Weight                             | 300 g   |
| Fastening                          | To snap on standard rail                                  |
| Max. conductor size                | 1.5 mm <sup>2</sup>                                       |

## 3.3 Identification

The type plate is located on the left side wall of the module and contains the following information:

- Type designation
- Part number
- Serial number
- Identification of hardware release
- Identification of software release
- Safety category
- Input characteristics
- Output characteristics
- Date of manufacture (week/year)

### 3.3.1 Basic device

| P/N  S/N <br><b>0610100 000101</b> |  | Typ <b>KSM 100-1</b> <br> |   |       |        |  |   |  |  |
|--|--|---|---|-------|--------|--|---|--|--|
| HW-Release <br>07-02-07  |  | 35/13<br>Cat. 4 and PLe acc. to EN ISO 13849-1<br>SIL3 acc. to IEC 61508/ IEC 62061<br>EN 50178   |   |       |        |  |   |  |  |
| SW-Release <br>02-01-00-06  |  |    |   |       |        |  |   |  |  |
| <b>KOLLMORGEN</b><br>Kollmorgen Europe GmbH<br>Pempelfurtstr. 1<br>40880 Ratingen<br>Germany<br>www.kollmorgen.com   |  | Supply<br>U = 24 V DC +20%/-15%<br>I = 2A DC<br>T = 0...50°C  | <table border="1"> <thead> <tr> <th>Input</th> <th>Output</th> </tr> </thead> <tbody> <tr> <td>                     Digital Input<br/>                     Type1/ EN61131-2<br/>                     U = 24V DC<br/>                     I<sub>max</sub> = 20mA                 </td> <td>                     Safety Relay<br/>                     U = 24V DC I = 2A<br/>                     U = 230V AC I = 2A                 </td> </tr> <tr> <td></td> <td>                     Digital Output<br/>                     I = 250mA<br/>                     Auxiliary Output<br/>                     I = 100mA                 </td> </tr> </tbody> </table> | Input | Output | Digital Input<br>Type1/ EN61131-2<br>U = 24V DC<br>I <sub>max</sub> = 20mA | Safety Relay<br>U = 24V DC I = 2A<br>U = 230V AC I = 2A |  | Digital Output<br>I = 250mA<br>Auxiliary Output<br>I = 100mA |
| Input  | Output   |   |   |       |        |  |   |  |  |
| Digital Input<br>Type1/ EN61131-2<br>U = 24V DC<br>I <sub>max</sub> = 20mA   | Safety Relay<br>U = 24V DC I = 2A<br>U = 230V AC I = 2A      |   |   |       |        |  |   |  |  |
|  | Digital Output<br>I = 250mA<br>Auxiliary Output<br>I = 100mA |   |   |       |        |  |   |  |  |
| Reaktionszeiten siehe Installationshandbuch<br>See installation manual for response time   |  | Made in Germany   |   |       |        |  |   |  |  |

Type plate KSM100-1 (image enlarged)

### 3.3.2 Extension device

|   |  |   |  |
|---|--|---|--|
| P/N  S/N <br><b>06101009 000101</b> |  | Typ <b>KSM 121</b> <br> |  |
| HW-Release <br>07c   |  | 35/13<br>Cat. 4 and PLe acc. to EN ISO 13849-1<br>SIL3 acc. to IEC 61508/ IEC 62061<br>EN 50178   |  |
| SW-Release <br>02-01-00-02   |  |   |  |
| <b>KOLLMORGEN</b><br>Kollmorgen Europe GmbH<br>Pempelfurtstr. 1<br>40880 Ratingen<br>Germany<br>www.kollmorgen.com  |  | Input<br>Digital Input<br>Type1/ EN61131-2<br>U = 24V DC<br>I <sub>max</sub> = 20mA<br>T = 0...50°C   | Reaktionszeiten siehe Installationshandbuch<br>See installation manual for response time |
|   |  | Made in Germany   |  |

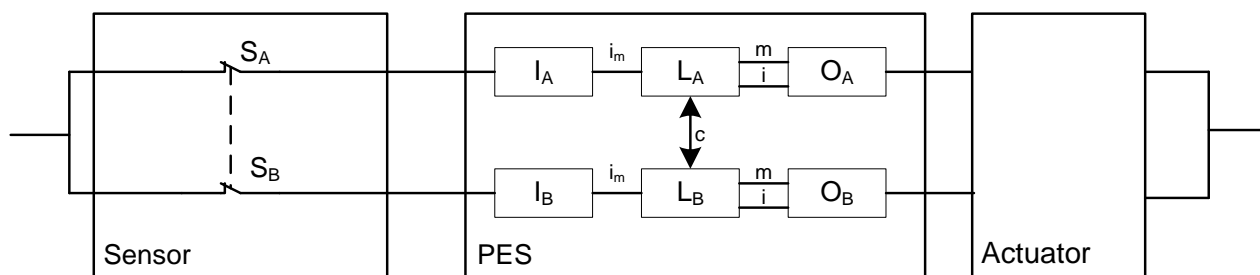
Type plate KSM121 (image enlarged)

## 4 Safety related characteristics

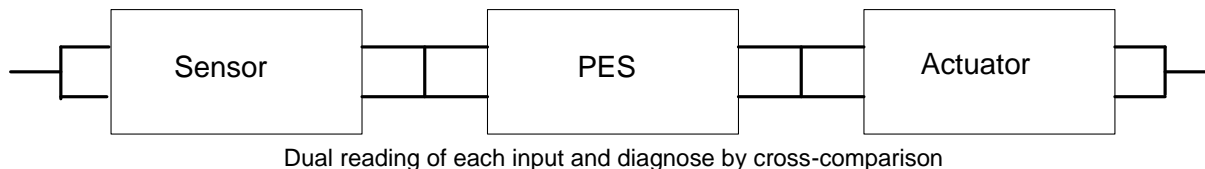
### 4.1 General design, safety related architecture and characteristic data

The internal structure of all modules of the KSM100 series consists of two separate channels with reciprocal comparison of results, except the communication module. High quality diagnoses for fault detection are made in each of the two channels.

With respect to architecture and function the internal structure corresponds with category 4 of EN 13849-1.



The overall architecture of the basic module KSM100-1, -2, -4 has the following structure:



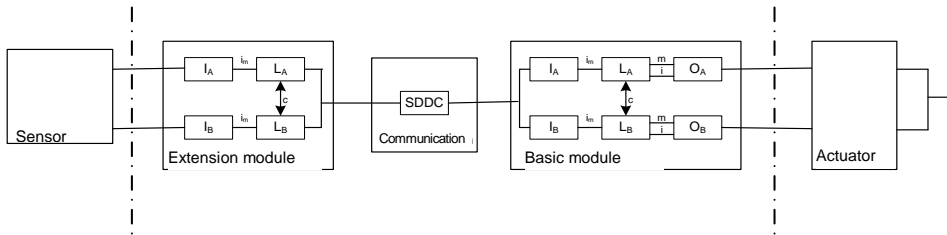
The specific safety related characteristic data of the corresponding module can be taken from the technical characteristic data in chapter 3.

The combination with the extension modules results in a complex structure. In this case one must also consider the bus communication, alongside the structures of the extension modules. The safety related equivalent circuit diagram / architecture must for each case be determined with respect to the application related structure.

In detail one must differentiate between the following cases:

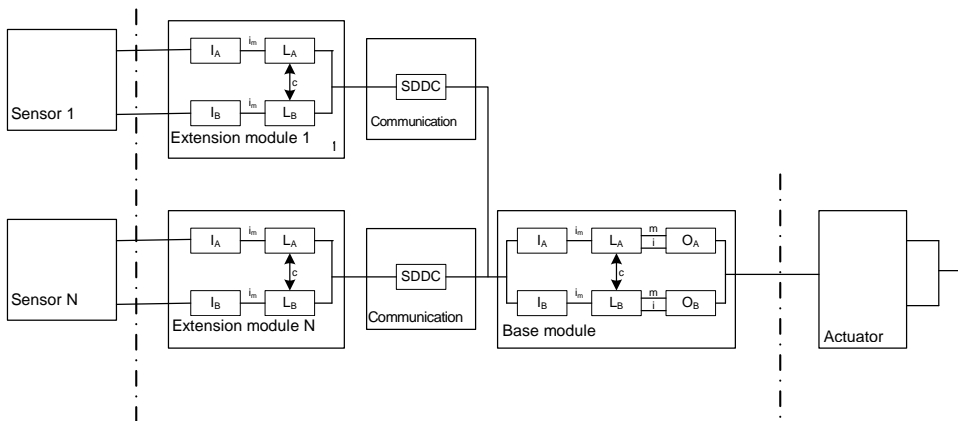
# Installation Manual

- a) Axis modules with safety functions related to one axis or use of secure inputs on an extension module and shut-down channel via outputs on the basic module



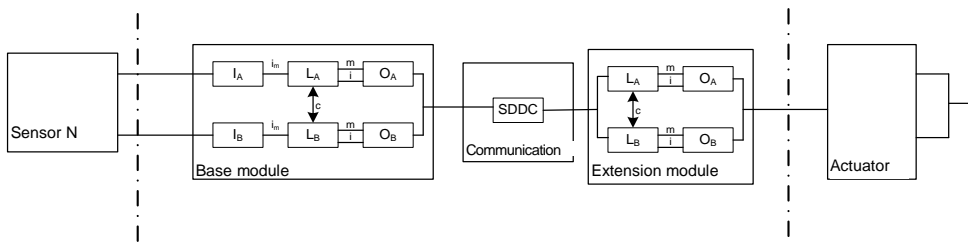
$$PFH_{KSM100} = PFH_{KSM100-X} + PFH_{KSM1XX\_IN} + PFH_{SDDC}$$

- b) 1..N axis modules with safety functions for inter axes functionality (e.g. X/Y range protection) or use of secure inputs on several extension modules with effect on one individual safety function and shut-down channel via outputs on the basic module



$$PFH_{KSM100} = PFH_{KSM100-X} + N * PFH_{KSM1XX\_IN} + N * PFH_{SDDC}$$

- c) Inputs on basic group and shut-down channel via outputs on an extension module

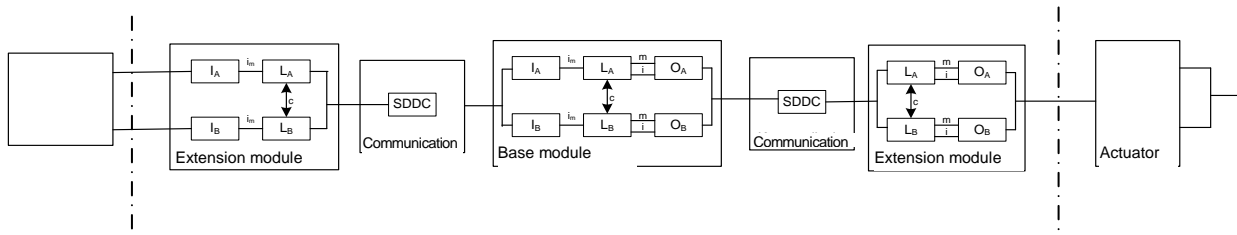


$$PFH_{KSM100} = PFH_{KSM100-X} + PFH_{KSM1XX\_OUT} + PFH_{SDDC}$$



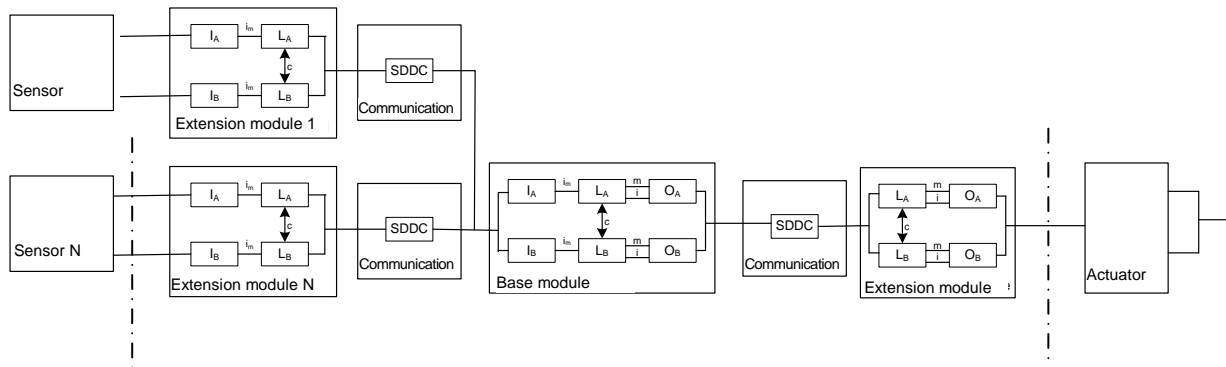
# Installation Manual

- d) Axis module with safety functions related to one axis or use of secure inputs on an extension module and shut-down channel via outputs on the basic module



$$PFH_{KSM100} = PFHKSM_{100-X} + PFH_{KSM1XX\_IN} + PFH_{KSM1XX\_OUT} + 2 * PFH_{SDDC}$$

- e) 1..N axis modules with safety functions for inter axes functionality (e.g. X/Y range protection) or use of secure inputs on several extension modules with effect on one individual safety function and shut-down channel via outputs on one extension module



$$PFH_{KSM100} = PFHKSM_{100-X} + N * PFH_{KSM1XX\_IN} + PFH_{KSM1XX\_OUT} + (N+1) * PFH_{SDDC}$$

The characteristic data from chapter 3 must be used for the partial systems  $PFHKSM_{100-X}$ ,  $PFH_{KSM1XX\_IN}$ ,  $PFH_{KSM1XX\_OUT}$  and  $PFH_{SDDC}$  to determine the  $PFH_{KSM100}$  for the KSM100 system.

**Characteristic data:**

|   |   |
|---|---|
| <b>Max. obtainable safety class</b>                               | <ul style="list-style-type: none"> <li>• SIL 3 acc. to EN61508</li> <li>• Category 4 acc. to EN945-1</li> <li>• Performance-Level e acc. to EN ISO 13849-1</li> </ul> |
| <b>System structure</b>   | 2-channel with diagnose (/1002) acc. to EN 61508<br>Architecture category 4 acc. to EN 13849  |
| <b>Rating of operating mode</b>                                   | “high demand” acc. to EN 61508 (high demand rate)   |
| <b>Probability of an endangering failure per hour (PFH-value)</b> | Specific values as per table “Techn. characteristic data” to be determined application related for the KSM100 system.   |
| <b>Proof-Test-Interval (EN61508)</b>                              | 20 years, after this time the module must be replaced   |

 **Safety note:**

- The specific safety related characteristic data of the corresponding module can be taken from the technical characteristic data in chapter 3.
- When using several sensors with different functions (e.g. position indicator access door + speed detection) for a safety function (e.g. secure reduced speed when access door is open), these must be assumed as being connected in series for the safety related assessment of the overall system. See also exemplary calculation in appendix.
- The safety regulations and EMC-directives must be strictly followed.
- Concerning the applicable fault exclusions please refer to the tables under D in the appendix of EN 13849-2.
- The characteristic data specified in chapter 3 for the partial system PES (e.g. PI e and PFH-value acc. to table as evidence acc. to EN 13849) can be used for the safety related assessment of the overall system.

The following examples and their characteristic architecture are mainly responsible for the assignment to a category acc. to EN ISO 13849-1.

**The maximum possible Performance Levels acc. to EN 13849 resulting from this still depend on the following factors of the external components:**

- Structure (simple or redundant)
- Detection of common cause faults (CCF)
- Degree of diagnostic coverage on request ( $DC_{avg}$ )
- Mean time to dangerous failure of a channel ( $MTTF_d$ )

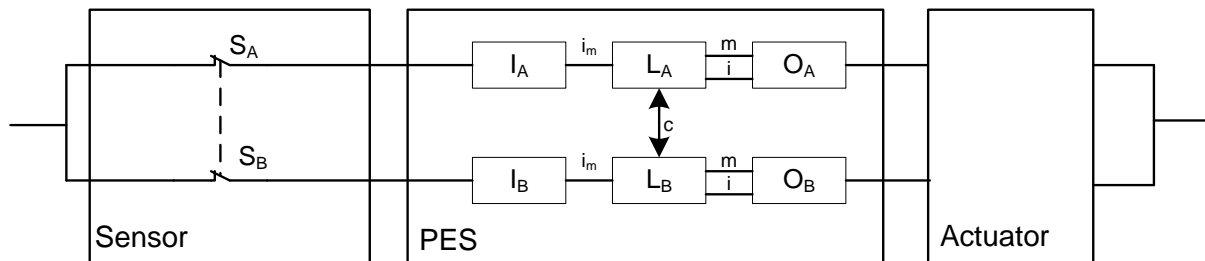
## 4.2 Safety related characteristic data and wiring for the connected sensors

The KSM100 modules have completely redundant signal processing paths for each safety input. This applies for both the digital and the analog inputs. Furthermore, measures for achieving the highest possible DC-values have been implemented.

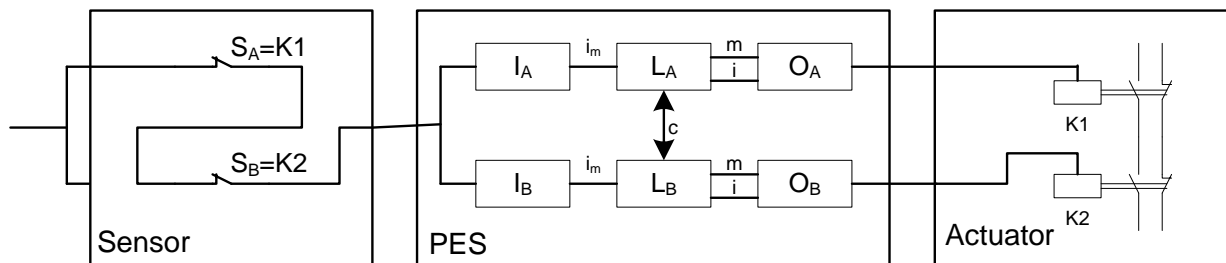
### 4.2.1 Digital sensors

Digital inputs and outputs are generally of a completely redundant design, except the electro-magnetic input terminal. The following list contains details for classification, the DC and the achievable PI or SIL.

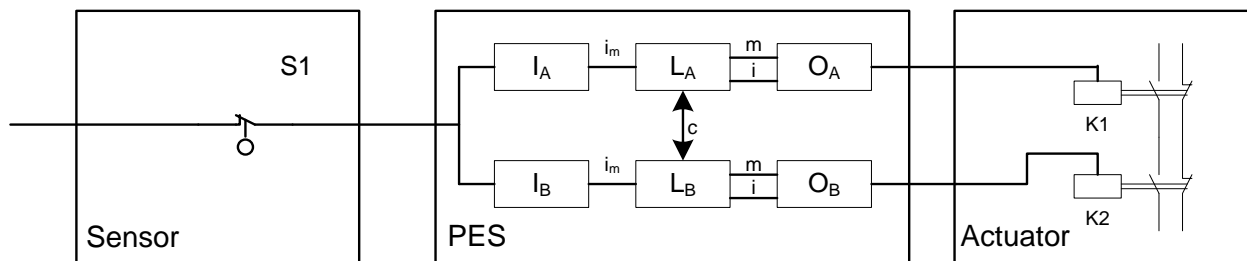
#### 4.2.1.1 Characteristics of sensors / input elements



Two-channel input element in parallel connection (Cat. 4, fault tolerance 1) with high DC caused by signal processing in two channels and diagnose by means of cross-comparison in the PES



Two-channel input element in series connection (Cat. 4, fault tolerance 1) with low to medium DC caused by signal processing in two channels and diagnose by means of cyclic testing



Single channel input element and dual channel processing with low to medium DC by signal processing in two channels and diagnose by means of cyclic testing, PI / SIL depending on permissible fault exclusions and test rate for input element.

## 4.2.1.2 DC digital sensors/inputs

The KSM100 modules ensure far reaching diagnostics functions for the partial input system. These are carried out permanently, or optionally (cross-shorting monitoring by means of pulse identifier, cross-comparison, 2- or multi-channel sensor with/without time-out, start-up test).

### Permanently active diagnostics functions:

#### Cross-comparison:

KSM module inputs are in general internally designed with two channels. The status of input signals is permanently compared crosswise. Only with High signals in both partial input systems the input is considered a High input, should the signal level deviate between both channels, the input is set to Low state.

#### Dynamic test of the partial input system switching threshold:

The switching thresholds for detecting the High level are tested cyclically with a high cycle rate. Falling below the defined threshold value a module triggers a module alarm.

#### Dynamic test of the input system's switchability:

The switchability of the input system to Low level is tested for all inputs with a high rate, except DI5 -- DI8. Falling below the defined threshold value a module triggers a module alarm.

### Diagnostics functions to be activated by parameterization:

#### Cross-shorting test:

The KSM modules have pulse signal outputs, identified by an unambiguous signature. When performing the cross-shorting test the switching elements of the digital sensors / input elements are supplied with auxiliary voltage by the KSM-module via the pulse signal outputs. The signature is thus stamped on the High signal level of the sensors / input elements and checked by the KSM module. With the signature test short-circuits and cross-shorting to High signals can be recognized. With alternating use of the pulse signals of multi-contacts, parallel signal lines or adjacent terminal assignment, cross-shorting between the respective input elements is detected.

#### Sensors / input elements with 2- or multi-pole contacts without time-out.

Several contacts can be assigned to the sensors / input elements. These are therefore compatible with at least 2-channel elements. A High level of the sensor/input element requires a logic series connection of both contacts.

#### Example 1:

Input element with 2 normally closed contacts: High level when both contacts are closed.

#### Example 2:

Input element with 1 normally closed and 1 normally open contact: High level when normally open contact is actuated and normally closed contact is not actuated.

Sensors / input elements with 2- or multi-pole contacts with time-out.

Same test as before, but additional monitoring of the input signals for compliance with the defined level connections within a time window of 0.5 seconds. Defining the levels over a time period of > 0.5 seconds triggers a module alarm.

Start test:

Each time the safety module (=KSM module) is switched on, the input element must be tested in direction of the Low signal status (defined Safe State), e.g. by actuating the Emergency Stop button or a door lock after the system has been started.

Operational / organizational tests:

Apart from the previously mentioned diagnostic measures for the KSM modules, cyclic testing can be performed within the application. These tests can also be used when assessing the DC.

The following diagnoses for input sensors can generally be used for the safety related assessment of the entire system:

| Input element characteristic | Parameterized / operational tests |               |            |                              | DC    | Definition of measure   | Note   |
|------------------------------|-----------------------------------|---------------|------------|------------------------------|-------|---|--|
|                              | Cross-shorting test               | With time-out | Start test | Cyclic test during operation |       |   |  |
| Single-channel               |                                   |               | O          | O                            | >60   | Cyclic test pulse by dynamic change of input signals  | A sufficiently high test rate must be ensured.   |
|                              | X                                 |               |            |                              | 90    | Cyclic test pulse by dynamic change of input signals  | Only effective if pulse assignment is active   |
|                              | X                                 |               | O          | O                            | 90-99 | Cyclic test pulse by dynamic change of input signals  | DC depending on frequency of start / cyclic test<br>DC = 90 test only in > 4 weeks<br>DC = 99 test at least 1 x day / or 100-time request rate |
| Dual channel                 |                                   |               |            |                              | 90    | Cross-comparison of input signals with dynamic test, if short-circuits cannot be detected (for multiple inputs/outputs)   | For fault exclusion short-circuit up to DC=99 possible   |
|                              |                                   |               | O          | O                            | 90-99 | Cyclic test pulse by dynamic change of input signals  | DC depending on frequency of start / cyclic test   |
|                              | X                                 |               |            |                              | 99    | Cross-comparison of input signals with immediate and intermediate results in the logic (L) and temporal as well as logic program sequence monitoring and detection of static failures and short circuits (for multiple inputs/outputs). | Only effective if pulse assignment is active   |
|                              |                                   | X             |            |                              | 99    | Plausibility test, e.g. use of normally open and normally closed contacts = non-equivalent signal comparison of input elements.   | Only effective in connection with activated time-out function for input element  |

X: Diagnostic measure activated

O: min. 1 diagnostic measure activated

 **Safety note:**

- The manufacturer's data (MTTFD, FIT-numbers, etc.) must be used for a safety related assessment of the partial system "Sensors".
- The DC-values listed in the table must be used conservatively and compliance with the boundary conditions (see table under "Remarks") must be ensured.
- According to the applicable standards, fault exclusions are permitted. The boundary conditions mentioned in this context must permanently be met.
- If several sensor systems are required for the correct function of a single safety function, their partial values must be correctly merged by following the chosen method.

## 4.2.1.3 Classification of digital safety inputs

### 4.2.1.3.1 Basic inputs DI1 ... DI14

| Digital inputs              | Achievable performance level | Comment  |
|-----------------------------|------------------------------|--|
| DI1 ... DI4<br>DI9 ... DI12 | PL e                         | Suitable for any kind of input elements, with / without pulse, achievable PI depending on the $MTTF_d$ of the input element, as well as fault exclusions in the external wiring.   |
| DI5 ... DI8                 | PL e                         | Single-channel with pulse: <ul style="list-style-type: none"> <li>- Mainly High level required (<math>T_{High} &gt; 100 * T_{Low}</math>)</li> <li>- At least one request/day required by application</li> <li>- Fault detection upon request</li> </ul> |
|                             | PL d                         | Single-channel without pulse: <ul style="list-style-type: none"> <li>- Fault exclusion short-circuit between signals and to VCC</li> <li>- Fault detection upon request</li> </ul>   |
|                             | PL e                         | Dual channel: <ul style="list-style-type: none"> <li>- At least one request/day required by application</li> <li>- Fault detection upon request</li> </ul>   |
| DI13, DI14                  | PL e                         | Use of pulse1 and pulse2   |
|                             | PI d                         | Without pulse / with pulse1 or 2 on both inputs<br>Fault detection upon request  |

### 4.2.1.3.2 Expansion inputs EAE1 ... EAE40

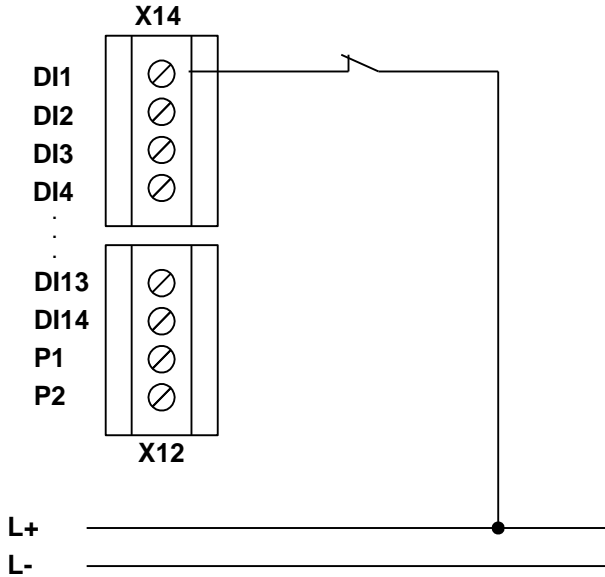
| Digital inputs | Achievable Performance Level | Comment  |
|----------------|------------------------------|--|
| EAE1 ... EAE40 |                              | Without pulse, single channel static signal<br>-> auxiliary input  |
|                | PL e                         | Without pulse, dual channel static signal <ul style="list-style-type: none"> <li>- At least one request/day required by application</li> <li>- Fault detection only upon request</li> </ul>  |
|                | PL d                         | Without pulse, dual channel static signal <ul style="list-style-type: none"> <li>- Less than one request/day required by application</li> </ul>  |
|                | PL e                         | Single-channel with pulse <ul style="list-style-type: none"> <li>- Mainly High level required (<math>T_{High} &gt; 100 * T_{Low}</math>)</li> <li>- At least one request/day required by application</li> <li>- Fault detection only upon request</li> </ul> |
|                | PL d                         | Single-channel with pulse <ul style="list-style-type: none"> <li>- Less than one request/day</li> </ul>  |
|                | PL e                         | Dual channel with pulse1 and pulse2  |



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## 4.2.1.4 Exemplary connections of digital sensors/input elements

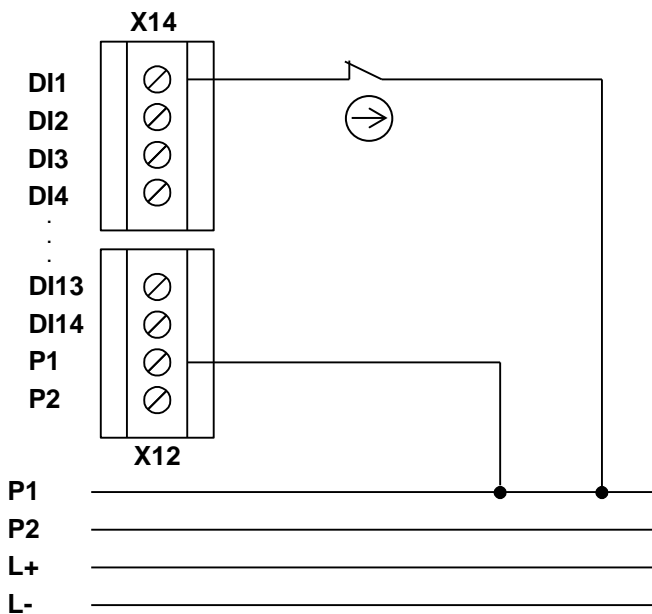
### 4.2.1.4.1 Single-channel input element, without cross-shorting test



*Fig.: Single-channel sensor, without cross-shorting test*

The single-channel sensor is connected to the KSM100 without clocking or without cross-shorting test. This design is not recommended for safety applications. PI b acc. To EN ISO 13849-1 can maximally be reached.

### 4.2.1.4.2 Single-channel sensor with cross-shorting test



*Fig.: Single-channel sensor with cross-shorting test*

When using a single-channel sensor with clock one supply connection is connected to the clock output P1 or P2. The clock must subsequently be assigned to the KSM100.

The use of a single-channel sensor with clock detects:

short-circuit to supply voltage DC 24 V  
short-circuit to DC 0 V  
cable interruption (current interruption is secure state!)

However, be cautious in case of a cable short between the two sensor connections, because this is not detected! A short-circuit between P1 and DI1 is also not detected.

Due to the single-channel character of the switching element / sensor its failure requires an fault exclusion. This is permissible when using positively disconnecting switches with correct constrained actuation.

A series connection of 2 switching elements with corresponding fault exclusion of a double fault is on equal footing with the application. These may be e.g. the safety outputs of an electronic monitoring device (light curtain, switching mat) with internal dual-channel switch-off.

PL d acc. to EN ISO 13849-1 can be achieved by using a suitable switching element and with cautious wiring of the sensor. In special cases, i.e. in connection with suitable switching elements and permissible fault exclusions one may also achieve PL e as per EN ISO 13849-1.

 **Safety note:**

- PL e or higher acc. to EN ISO 13849-1 is achieved if the short-circuit between input and associated pulse output as well as the short-circuit between the sensor connections can be excluded. Here one must take care that in a fault scenario the switch must be positively opening in accordance with EN 60947-5-1.. The sensor must additionally be triggered in regular intervals and the safety function requested. Fault exclusions can be achieved in accordance with EN ISO 13849-2, table D8. In case of single-channel use of the inputs, the achievable safety level must be limited to SIL 2 or PL d, if the safety function is demanded at regular intervals.
- A series connection of 2 switching elements with fault exclusion for double fault requires testing of the suitability in accordance with the intended safety level of this element. We would like to draw your attention to the applicable regulations in the EC machine directive 2006/42/EC.
- For single-channel sensors a safety related use of the inputs is only intended in connection with the pulse outputs.

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## 4.2.1.4.3 Dual-channel sensor with time-out and cross-shorting test

Faults are at least detected when requested. The DC is medium and by using cyclic tests (start test, operational/organizational tests) can be changed up to high level. depending on the test frequency.

For safety applications only normally closed contacts are permitted for requesting the safety function.

PI d acc. to EN 13849-1 can be achieved when using sensors / switching elements with fault exclusion for not opening the switch contacts. This is permissible when using positively disconnecting switches with correct constrained actuation. The use of sensors with self-monitoring output contacts is also permitted.

PI e in accordance with EN 13849-1 can be achieved when using heterogeneous sensors / input elements with sufficiently high MTTFd in connection with temporal plausibility monitoring and a sufficiently high change of the switching state = dynamic testing.

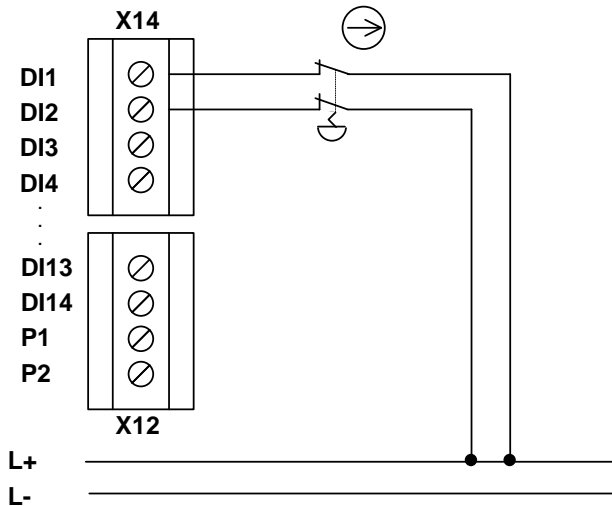


Figure: dual-channel sensor homogeneous without cycling, with positive disconnection

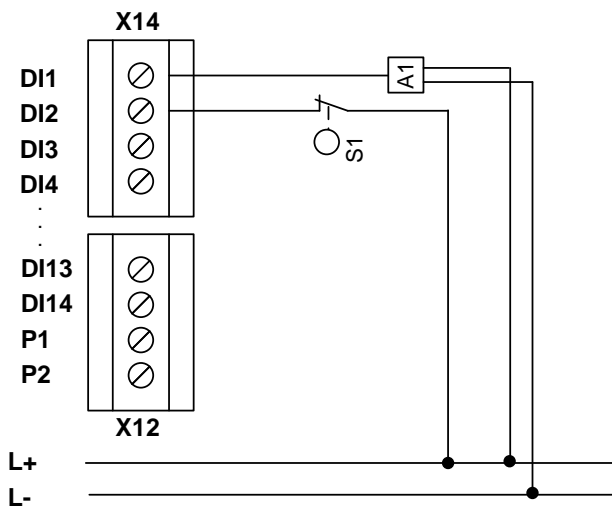


Figure: dual-channel input element heterogeneous, without cycling

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**⚠ Safety note:**

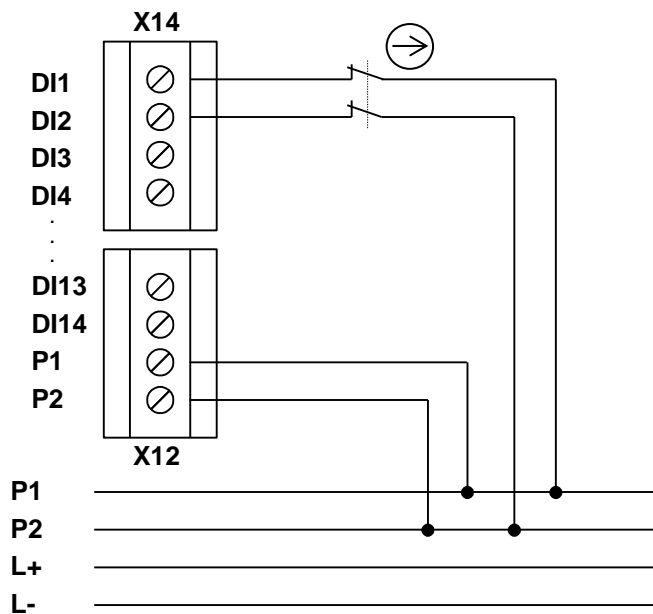
- PI d in accordance with EN ISO 13849-1 is achieved by using switching elements / sensors with positively opening contacts or positive actuation acc. to EN 60947-5-1
- PI e in accordance with EN ISO 13849-1 is achieved by using diverse input elements with appropriately high MTTFd and sufficient testing by operationally ensured dynamizing of the switching state in connection with temporal plausibility monitoring.
- For the temporal plausibility monitoring one must choose a duration of less than the switching state in operation.

### 4.2.1.4.4 Dual-channel sensor without timeout with cross-shorting test

Cross-shorting as well as connections to DC 24 V and DC 0 V can be detected by using two independent clock signals on the homogeneous sensor.

Only normally closed contacts should be used for safety related applications.

PI d or higher acc. to EN 13849-1 can be achieved when using sensors / switching elements with fault exclusion for not opening the switch contacts. This is permissible when using positively disconnecting switches with correct constrained actuation. The use of sensors with self-monitoring output contacts is also permitted.



*Figure: two-channel sensor, homogeneous with clock*

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**⚠ Safety note:**

- PI d or higher in accordance with EN ISO 13849-1 is achieved by using switching elements / sensors with positively opening contacts or positive actuation acc. to EN 60947-5-1
- Using devices for which the fault exclusion double fault for the intended safety level can be specified for the switching elements, is permitted. We would like to draw your attention to the applicable regulations in the EC machine directive 2006/42/EC.

### 4.2.1.4.5 Dual-channel sensor with time-out and cross-shorting test

Cross-shorting as well as connections to DC 24 V and DC 0 V can be detected by using two independent clock signals on the homogeneous sensor.

PI d or higher acc. to EN 13849-1 can be achieved when:

- using sensors / switching elements with positive actuation.
- using 2 sensors / switching elements with independent actuation.
- dto. However, with actuation through a common actuating device in connection with an fault exclusion for this device.

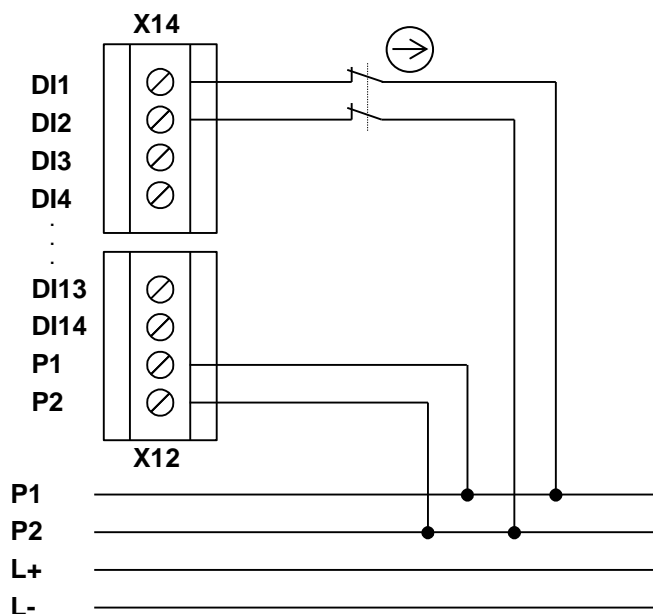


Figure: two-channel sensor, homogeneous with clock

**⚠ Safety note:**

- PI d or higher in accordance with EN ISO 13849-1 is achieved by using switching elements / sensors with positively actuation
- When using two independent sensors with independent actuation, PI d or higher acc. to EN ISO 13849-1 can be achieved.
- When using common elements in the actuation chain, an fault exclusion is required for this purpose. The corresponding limitations and criteria acc. to EN 13849-1 must be observed.

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## 4.2.1.5 Overview of achievable PI for digital safety inputs

| Type of sensor / input element | InPort               | Parameterized / operational tests |               |            |                              | Achievable PI acc. to EN 13849-1 | Fault exclusion for input element                                     | Condition for input element  |
|--------------------------------|----------------------|-----------------------------------|---------------|------------|------------------------------|----------------------------------|---|--|
|                                |                      | Cross-shorting test               | With time-out | Start test | Cyclic test during operation |                                  |   |  |
| Single-channel                 | DI1..D14             |                                   |               |            |                              | b                                |   | Operation proven input element   |
|                                |                      |                                   |               | O          | O                            | d                                | All faults at the input element<br>Short-circuit at input/signal line | MTTF <sub>D</sub> = high<br>Connection in control cabinet or protected routing   |
|                                | DI1..D4<br>DI9..DI12 |                                   |               |            |                              | e                                | All faults at the input element<br>Short-circuit at input/signal line | Input element does not comply with min. PIr<br>Connection in control cabinet or protected routing  |
|                                |                      | X                                 |               |            |                              | d                                | Getting caught<br>Short-circuit at input/signal line                  | Mainly High level required (T <sub>High</sub> > 100 * T <sub>Low</sub> ). Positively disconnecting<br>MTTF <sub>D</sub> = high<br>Connection in control cabinet or protected routing |
|                                | All                  | X                                 |               | O          | O                            | e                                | All faults at the input element<br>Short-circuit at input/signal line | Input element does not comply with min. PIr<br>Connection in control cabinet or protected routing<br>MTTF <sub>D</sub> = high  |
|                                |                      |                                   |               |            |                              |                                  |   |  |
| Dual-channel parallel          | All                  |                                   |               |            |                              | d                                | Short-circuit between input/signal line                               | Connection in control cabinet or protected routing<br>MTTF <sub>D</sub> = medium   |
|                                |                      | X                                 |               |            |                              | e                                |   | MTTF <sub>D</sub> = high   |

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| Type of sensor / input element | InPort               | Parameterized / operational tests |               |            |                              | Achievable PI acc. to EN 13849-1 | Fault exclusion for input element  | Condition for input element  |
|--------------------------------|----------------------|-----------------------------------|---------------|------------|------------------------------|----------------------------------|--|--|
|                                |                      | Cross-shorting test               | With time-out | Start test | Cyclic test during operation |                                  |  |  |
| Dual-channel parallel          | All                  |                                   | X             |            |                              | e                                | Short-circuit between input/signal line (only with common switching elements = 2xNO or 2xNC) | Connection in control cabinet or protected routing<br><br>MTTF <sub>D</sub> = high   |
| Dual-channel                   | DI1..D4<br>DI9..DI12 |                                   |               |            |                              | d                                | Short-circuit at input/signal line<br><br>Getting caught / positively disconnecting          | Connection in control cabinet or protected routing<br><br>MTTF <sub>D</sub> = medium |
|                                |                      |                                   |               | O          | O                            | e                                | Short-circuit at input/signal line   | Connection in control cabinet or protected routing<br><br>MTTF <sub>D</sub> = high   |
|                                | All                  |                                   |               | O          | O                            | d                                | Short-circuit at input/signal line   | Connection in control cabinet or protected routing<br><br>MTTF <sub>D</sub> = medium |
|                                |                      | X                                 |               | O          | O                            | e                                |  | MTTF <sub>D</sub> = high   |

X: Diagnostic measure activated

O: min. 1 diagnostic measure activated

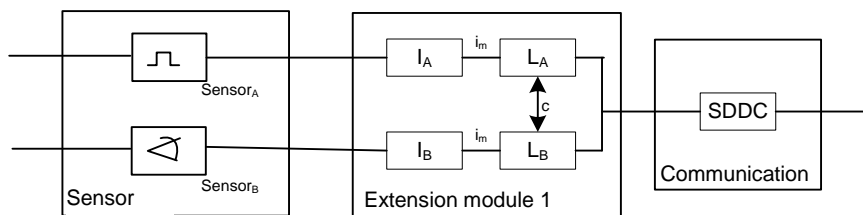
# Installation Manual

## 4.2.2 Sensors for speed and/or position detection

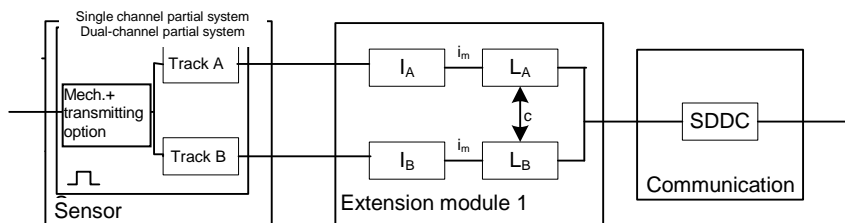
### 4.2.2.1 General safety related structure of the sensor interface for position and/or speed

The extension modules of the KSM100 series can be optionally equipped with one (KSM121, KSM122) or two encoder interfaces (KSM121-2, KSM122-2) per axis.

Depending on encoder type and combination, different safety levels can be reached. The following system reflection results for the corresponding partial system:



Dual-channel sensor system with separate signal processing in two channels, diagnose by cross-comparison in the PES



Sensor system with single and dual-channel partial system (example incremental encoder). Diagnose by separate signal processing in two channels and cross-comparison in the PES as well as further specific diagnoses.



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## 4.2.2.2 General diagnostic measures for encoder interface

For fault detection in the sensor system the KSM series has a number of diagnostic measures implemented, depending on the chosen encoder type or its combination. These are automatically activated when choosing the encoder type.

With respect to their type and effectiveness diagnostic measures can generally be classified using the following table:

Diagnoses for sensors for position and/or speed detection:

| <b>Measure</b>  | <b>DC</b> | <b>Note</b>  | <b>Use</b>  |
|---|-----------|--|---|
| Cross-comparison of input signals with immediate and intermediate results in the logic (L) and temporal as well as logic program sequence monitoring and detection of static failures and short circuits (for multiple inputs/outputs). | 99        | Only to be used for:<br>- dual-channel sensor systems (2 separate sensors),<br>- the dual channel partial system of single channel sensors (incremental encoder)<br>- Diagnose for the single and dual channel partial system of specially suitable sensor systems (SIN/COS-encoder, resolver)<br>- Dynamic operation / no standstill monitoring | Monitoring of 2-channel sensor systems or the corresponding partial system of sensors for dynamic operation<br>Not to be used for standstill monitoring!            |
| Cross-comparison of input signals without dynamic test  | 80-95%    | DC depends on the frequency of the dynamic condition, i.e. standstill or movement, as well as on the quality of the monitoring measure (80 - 90% for incremental encoder, 95 % for SIN/COS-encoder)  | Monitoring of 2-channel sensor systems or the corresponding partial system of sensors for non-dynamic operation<br>To be used especially for standstill monitoring! |
| Monitoring of some features of the sensor (response time, the area of analog signals, e.g. electric resistance, capacity)   | 60        | Diagnose of specific features of sensors, only to be used for speed and position sensors as per chapter 4.3.   | Monitoring of the single-channel partial system in single-channel sensor systems  |

# Installation Manual

## 4.2.2.3 Encoder types and their combination, diagnostic data

| Type<br><i>Encoder to interface X31/32</i> | Type<br><i>Encoder to interface X33/34</i> | Type<br><i>Encoder to X 23</i> | Secure speed | Secure direction | Secure position | Fault exclusion  | DC                       |                                  |  |
|--|--|--------------------------------|--------------|------------------|-----------------|--|--------------------------|----------------------------------|--|
|  |  |                                |              |                  |                 |  | 1-channel partial system | 2-channel partial system dynamic | 2-channel partial system non-dynamic (standstill monitoring) |
| NC   | NC   | 1 x Bero + 1 x Bero            | X            |                  |                 | Fault exclusion mech. shaft breakage, positive encoder shaft connection required, if common elements are in use. | n.a.                     | 99%                              | 80-90%   |
| Incremental                                | NC   | NC                             | X            |                  |                 | Fault exclusion mech. shaft breakage, positive encoder shaft connection required                                 | 60%                      | 99%                              | 80-90%   |
| Incremental                                | Incremental                                | NC                             | X            | X                |                 |  | n.a.                     | 99%                              | 95%  |
| Incremental                                | NC   | 1 x Bero                       | X            |                  |                 |  | n.a.                     | 99%                              | 90-95%   |
| Incremental                                | NC   | 2 x Bero 90°                   | X            | X                |                 |  | n.a.                     | 99%                              | 90-95%   |
| Incremental                                | SIN/COS                                    | NC                             | X            | X                |                 |  | n.a.                     | 99%                              | 99%  |
| Incremental                                | HTL  | NC                             | X            | X                |                 |  | n.a.                     | 99%                              | 90-95%   |

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| Type<br>Encoder to<br>interface<br>X31/32 | Type<br>Encoder to<br>interface<br>X33/34 | Type<br>Encoder to<br>X 23 | Secure<br>speed | Secure<br>direction | Secure<br>position | Fault exclusion  | DC                             |   |   |
|---|---|----------------------------|-----------------|---------------------|--------------------|--|--------------------------------|---|---|
|   |   |                            |                 |                     |                    |  | 1-channel<br>partial<br>system | 2-channel<br>partial<br>system<br>dynamic | 2-channel<br>partial<br>system<br>non-<br>dynamic<br>(standstill<br>monitoring) |
| Incremental                               | Resolver                                  | NC                         | X               | X                   |                    |  | n.a.                           | 99%                                       | 99%   |
| Incremental                               | SSI                                       | NC                         | X               | X                   | X                  |  | n.a.                           | 99%                                       | 90-95%  |
| SIN/COS                                   | NC  | NC                         | X               | X                   |                    | Fault exclusion mech. shaft breakage, positive encoder shaft connection required | 90%                            | 99%                                       | 90-95%  |
| SIN/COS                                   | Incremental                               | NC                         | X               | X                   |                    |  | n.a.                           | 99%                                       | 95-99%  |
| SIN/COS                                   | NC  | 1 x Bero                   | X               | X                   |                    |  | n.a.                           | 99%                                       | 90-95%  |
| SIN/COS                                   | NC  | 2 x Bero 90°               | X               | X                   |                    |  | n.a.                           | 99%                                       | 95-99%  |
| SIN/COS                                   | HTL                                       | NC                         | X               | X                   |                    |  | n.a.                           | 99%                                       | 95-99%  |
| SIN/COS                                   | Resolver                                  | NC                         | X               | X                   |                    |  | n.a.                           | 99%                                       | 99%   |

| Type<br>Encoder to<br>interface<br>X31/32 | Type<br>Encoder to<br>interface<br>X33/34 | Type<br>Encoder to<br>X 23 | Secure<br>speed | Secure<br>direction | Secure<br>position | Fault exclusion  | DC                             |   |   |
|---|---|----------------------------|-----------------|---------------------|--------------------|--|--------------------------------|---|---|
|   |   |                            |                 |                     |                    |  | 1-channel<br>partial<br>system | 2-channel<br>partial<br>system<br>dynamic | 2-channel<br>partial<br>system<br>non-<br>dynamic<br>(standstill<br>monitoring) |
| SIN/COS                                   | SSI                                       | NC                         | X               | X                   | X                  |  | n.a.                           | 99%                                       | 95-99%  |
| SSI                                       | NC  | 2 x Bero 90°               | X               | X                   | X                  |  | n.a.                           | 99%                                       | 90-95%  |
| SSI                                       | SIN/COS                                   | NC                         | X               | X                   | X                  |  | n.a.                           | 99%                                       | 95-99%  |
| SSI                                       | Resolver                                  | NC                         | X               | X                   | X                  |  | n.a.                           | 99%                                       | 95-99%  |
| SSI                                       | SSI                                       | NC                         | X               | X                   | X                  |  | n.a.                           | 99%                                       | 90-95%  |
| NC  | SIN/COS                                   | NC                         | X               | X                   |                    | Fault exclusion mech. shaft breakage, positive encoder shaft connection required | 90%                            | 99%                                       | 90-95%  |
| NC  | Resolver                                  | NC                         | X               | X                   |                    | Fault exclusion mech. shaft breakage, positive encoder shaft connection required | 90%                            | 99%                                       | 90-95%  |

| <i>Type</i><br><i>Encoder to interface</i><br><i>X31/32</i> | <i>Type</i><br><i>Encoder to interface</i><br><i>X33/34</i> | <i>Type</i><br><i>Encoder to X 23</i> | <i>Secure speed</i> | <i>Secure direction</i> | <i>Secure position</i> | <i>Fault exclusion</i>   | <i>DC</i>                |                                  |  |
|---|---|---------------------------------------|---------------------|-------------------------|------------------------|--|--------------------------|----------------------------------|--|
|   |   |                                       |                     |                         |                        |  | 1-channel partial system | 2-channel partial system dynamic | 2-channel partial system non-dynamic (standstill monitoring) |
| NC  | HTL   | NC                                    | X                   |                         |                        | Fault exclusion mech. shaft breakage, positive encoder shaft connection required | 60%                      | 99%                              | 80-90%   |
| NC  | SSI   | 2 x Bero 90°                          | X                   | X                       | X                      |  | n.a.                     | 99%                              | 90-95%   |

## 4.2.2.4 Specific diagnostic measures with regard to the encoder type used

| Encoder type           |                         | Supply voltage monitoring | Difference level monitoring | SIN/COS plausibility monitoring | Signal level input monitoring | Monitoring of the permissible quadrants | Monitoring of the counting signal separated for track A/B | Monitoring of the transfer ratio reference signal / measured signal | Frequency monitoring of the reference signal | Voltage monitoring of the reference signal | Form factor analysis of the measured signal | Plausibility test position signal versus speed | Monitoring of Clk-frequency |
|------------------------|-------------------------|---------------------------|-----------------------------|---------------------------------|-------------------------------|---|---|---|--|--|---|--|-----------------------------|
| Interface X 31/32, X23 | Incremental             | X                         | X                           |                                 |                               |   | X   |   |  |  |   |  |                             |
|                        | SIN/COS                 | X                         |                             | X                               |                               |   |   |   |  |  |   |  |                             |
|                        | SSI                     | X                         | X                           |                                 |                               |   |   |   |  |  |   |  |                             |
|                        | Bero 2 x counting input | X                         |                             |                                 |                               |   |   |   |  |  |   |  |                             |
|                        | Bero 1 x counting input | X                         |                             |                                 |                               |   |   |   |  |  |   |  |                             |
| Interface X 33/34      | Incremental             | X                         | X                           |                                 | X                             |   | X   |   |  |  |   |  |                             |
|                        | HTL                     |                           | X                           |                                 | X                             |   |   |   |  |  |   |  |                             |
|                        | Resolver                |                           |                             | X                               |                               | X                                       |   | X   | X  | X  | X   |  |                             |
|                        | SIN_COS                 | X                         |                             | X                               |                               | X <sup>1)</sup>                         |   |   |  |  |   |  |                             |
|                        | SSI                     | X                         | X                           |                                 |                               |   |   |   |  |  |   | X  | X                           |

1) Only in High-Resolution Mode

## 4.2.2.5 Safety relevant cut-off thresholds encoder systems for position and speed detection

Plausibility tests with the current position and speed values are performed between both measuring channels A and B of the KSM100 module as a basic measure, which are then checked against parametrizable thresholds.

The **incremental shut-down threshold** describes the tolerable deviation of position between both sensing channels A and B in the unit of the measuring distance.

The **speed shut-down threshold** describes the tolerable deviation in speed between both sensing channels A and B.

Diagnostic functions for the determination of optimal parameter values for the applications are available within the SCOPE-dialog of the parameterization tool.

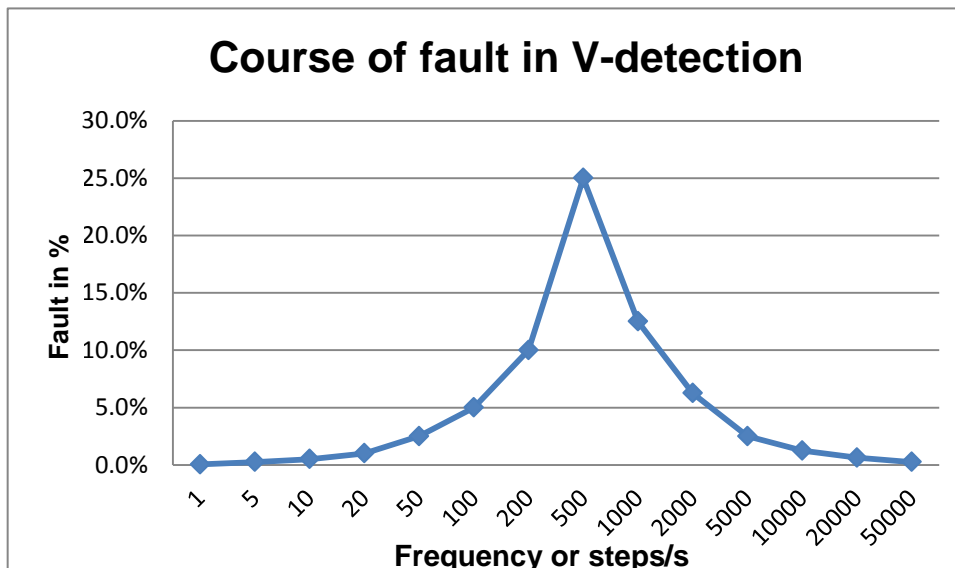
### Note:

Speed and acceleration are detected values with a minimal digital resolution.

This fact limits the smallest possible detection of speed or acceleration and determines the digital step width for the input values.

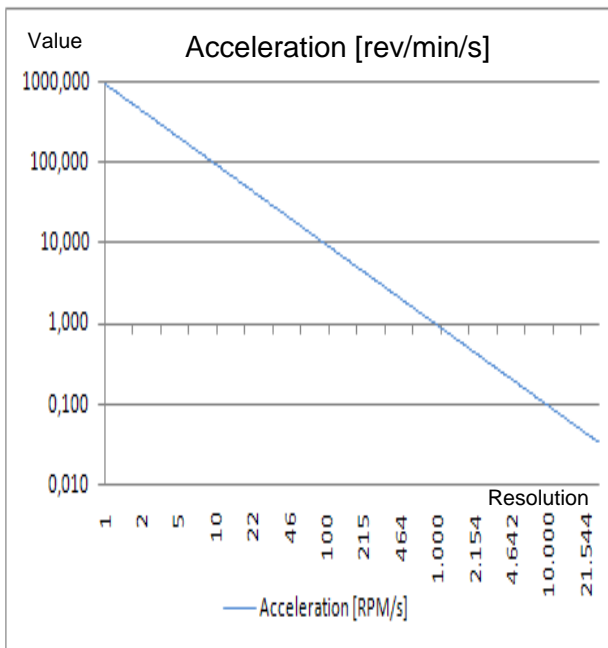
### Speed resolution:

Up to a frequency of 500 Hz or 500 steps/s speed is detected with the frequency measuring method, below this it is measured with a time measuring method. This results in the following course of the sensing fault:

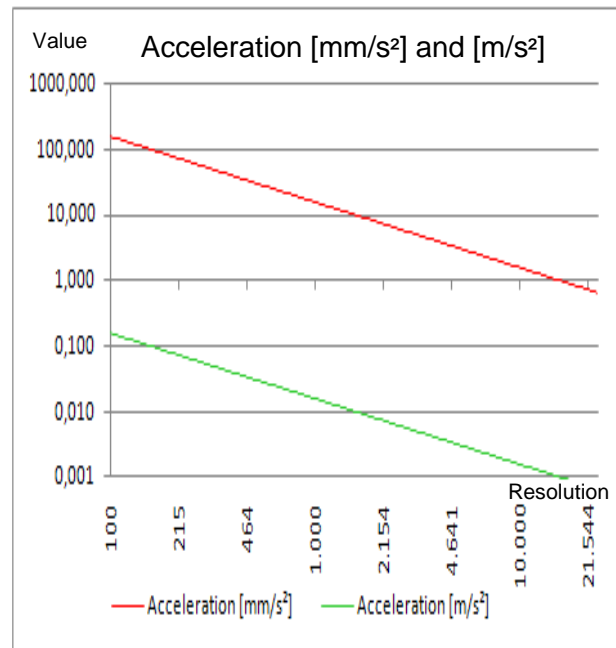


### Acceleration resolution

The digital acceleration resolution is limited by a maximum peak time of 256 ms and the encoder resolution. The graphs below show the lowest measurable acceleration in dependence on the resolution in revolutions/min, mm/s<sup>2</sup> and m/s<sup>2</sup>.



**Graph acceleration, rotary**  
(Values in rev/min/s)



**Graph acceleration, linear**  
(Values in mm/s and m/s²)

**⚠ Safety note:**

- The fault can be optimized by choosing a suitable sensor resolution for the corresponding application.
- For applications with limited resolution and/or time variance of the sensing signal, the functional performance of the monitoring function used can be improved by using an average filter. The average filter “smoothes” digital spurious components of the sensors. However, this is achieved at the cost of a longer response time of the overall system.
- The filter time can be variably set between 0 and 64 in steps of 8. The dimension is “msec”. In order to determine the response time of the overall system, the filter times must be added to the specified response times of the KSM systems (see chapter 11).

**⚠ Safety note:**

- The manufacturer's data (MTTFD, FIT-numbers, etc.) must be used for a safety related assessment of the partial system “Sensors”.
- If the manufacturer demands specific diagnoses to be able to guarantee the specified safety related characteristic values, these must be checked with respect to the specific encoder as specified in the table “Specific diagnostic measures for position and speed sensors”. If in doubt, the matter must be clarified by the manufacturer.
- The DC-values listed in the table must be used conservatively and compliance with the boundary conditions (see table under “Remarks”) must be ensured.
- in order to determine the DC-value for safety functions with standstill monitoring a frequency assessment of the dynamic status may be required. A DC of 90 % may here be used as a guide value.



- According to the applicable standards, fault exclusions are permitted. The boundary conditions mentioned in this context must permanently be met.
- If several sensor systems are required for the correct function of a single safety function, their partial values must be correctly merged by following the chosen method. This applies also for a combination of digital and analog sensors (e.g. securely reduced speed with open safety door = door contact + encoder for speed detection)
- By choosing a suitable resolution of the sensor system a sufficiently low tolerance with regard to the corresponding cut-off thresholds for the individual safety functions must be ensured.
- When using the encoder input filter one must consider the extension of the response time when assessing the safety related function.

## 4.2.2.6 Safety related assessment of encoder types or there combination

Due to the monitoring functions implemented in the KSM-series, no special demands are initially made on the internal design of the encoder electronics in applications with encoder systems, i.e. standard encoders can normally be used.

A safety related assessment of the overall arrangement must generally be made. Data issued by the encoder manufacturer (FIT, MTTF) as well as the DC from the table in 4.2.2 must in this case be used.

When using individual encoders at least an fault exclusion for the mechanical actuating chain, as well as for the single-channel part of must be made under due consideration of the applicable specification in EN 13849-1. Furthermore, the information in 4.2.2 must also be observed.

PI d and higher acc. to EN 13849-1 is normally reached by a combination of two encoders with prioritized different technology and separated mechanical linking.

The use of compact encoders with internal 2-channel structure of different technology is also suitable for applications up to PI e acc. to EN 13849-1, however, under due consideration of the specifically required fault exclusions and their permissibility. Normally one should use encoders with proven safety related characteristics, the safety level of which meets the demanded level.

### **Safety note:**

- The use of standard encoders or a combination of standard encoders is permitted. For the overall arrangement consisting of encoder, further sensors/switching elements for triggering the safety function, the KSM-module and their cut-off channel a safety related assessment is strictly required. For determining the achieved safety level one needs, among others, information from the manufacturer (FIT, MTTF) and the DC as specified under 4.2.2.
- If only one encoder is used, the fault exclusion “shaft breakage / fault in the mechanical encoder connection” is required. Suitable measures must be applied for this purpose, e.g. a positive connection of the encoder by means of slot shim or locking pin. The applicable information issued by the manufacturer as well as EN 138549-1 with respect to requirements and permissibility of the fault exclusion must strictly be followed.
- Encoders with proven safety related characteristics must preferably be used as individual encoders. The safety level of these encoders must at least meet the intended safety level of the overall arrangement. The information of the manufacturer with respect to diagnostic measures, mechanical connection and measures for the voltage supply must be strictly followed.
- SIN/COS encoder: The internal structure of the sensor system must be designed in such a way, that output signals for both tracks can be generated independently from each other and Common-Cause faults can be ruled out. Evidence of the mechanical design, e.g. fastening of the code disc on the shaft, must also be provided. Encoders with proven safety related characteristics should preferably be used.
- When using compact encoders with internal dual-channel structure, such as e.g. SSI + incremental/SinCos, you must strictly follow the instructions of the manufacturer concerning safety related characteristics, diagnostic measures, mechanical connection and measures concerning the electric power supply. The safety level of the encoder must at least meet the intended safety level of the overall arrangement. Encoders with proven safety related characteristics should preferably be used.

**The KSM100 module generally detects the following faults in the external encoder system:**

- Short-circuits between safety relevant signal lines
- Interruptions in safety relevant signal lines
- Stuck at 0 or 1 on one or all safety relevant signal lines

Each encoder type has further specific diagnoses for fault detection in the external encoder system assigned. The following list shows the respective diagnostic measures for the individual encoders, together with the limiting parameters.

 **Safety note:**

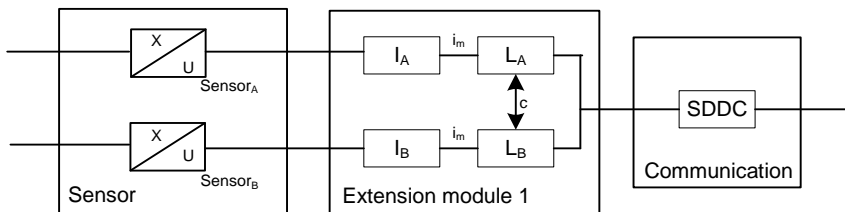
- The diagnostic measures obviously have tolerances because of measuring inaccuracies. These tolerances must be accounted for in the safety related assessment.
- The limiting values for the corresponding diagnostic measures are partly parametrizable or fixed. The diagnostic coverages resulting from this must be assessed in relation to the application and included in the safety related overall assessment.

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## 4.2.3 Analog sensors

The basic modules KSM12A have two analog inputs with two input channels each. Only dual-channel sensors can generally be connected to this interface.

The internal signal processing takes place separately in the two channels with cross-comparison of the results.



Dual-channel sensor system with separate signal processing in two channels, diagnose by cross-comparison in the PES

As with other sensor systems, a vast number of diagnostic measures has been implemented.

With respect to their type and effectiveness diagnostic measures can generally be classified using the following table:

Diagnoses for sensors for position and/or speed detection:

| Measure   | DC | Note  | Use   |
|---|----|---|---|
| Cross-comparison of input signals with dynamic test, if short-circuits cannot be detected (for multiple inputs/outputs)   | 90 | Comparison of the analog input values with identical characteristics for both channels                                | Monitoring of dual-channel systems with identical characteristic of the input signals |
| Cross-comparison of input signals with immediate and intermediate results in the logic (L) and temporal as well as logic program sequence monitoring and detection of static failures and short circuits (for multiple inputs/outputs). | 99 | Comparison of the analog input values with diverse characteristic for both channels. E.g. inverse signal course, etc. | Monitoring of dual-channel systems with diverse characteristic of the input signals   |

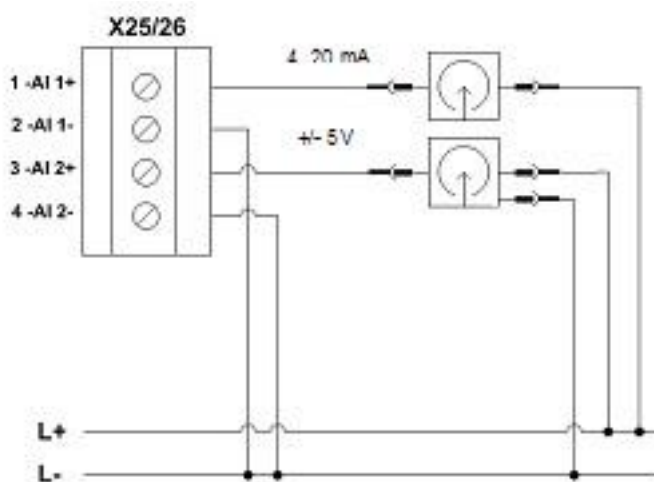
## Safety note:

- The manufacturer's data (MTTFD, FIT-numbers, etc.) must be used for a safety related assessment of the partial system "Sensors".
- The DC-values listed in the table must be used conservatively and compliance with the boundary conditions (see table under "Remarks") must be ensured.
- According to the applicable standards, fault exclusions are permitted. The boundary conditions mentioned in this context must permanently be met.
- If several sensor systems are required for the correct function of a single safety function, their partial values must be correctly merged by following the chosen method. This applies also for a combination of digital and analog sensors (e.g. securely reduced speed with open safety door = door contact + encoder for speed detection)

### 4.2.3.1 Exemplary connection of analog sensors

PI d acc. to EN ISO 13849-1 can be achieved by using suitable sensors and with cautious wiring of the sensor.

The analog current inputs are all equipped with the fixed loading resistor of 500Ohm. For analog voltage inputs this resistor is omitted.



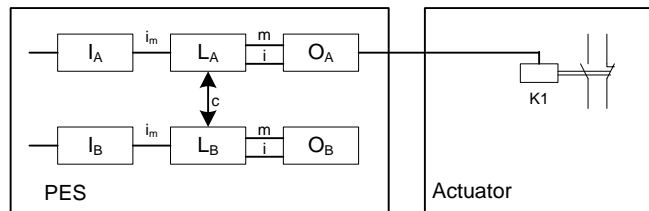
## Safety note:

- PI e acc. to EN ISO 13849-1 is achieved when using two non-reactive sensors, for which Common Cause faults can be ruled out.

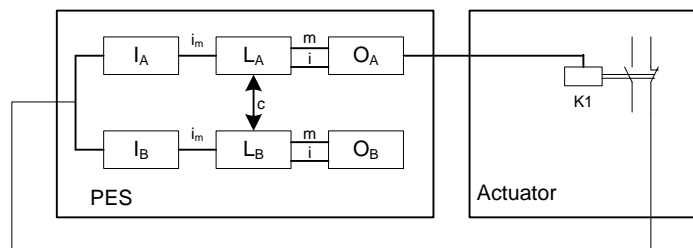
## 4.3 Safety related characteristic data and wiring of the outputs

KSM100 modules all have secure outputs of various types. For wiring, the corresponding characteristic as specified in the following description, must be accounted for

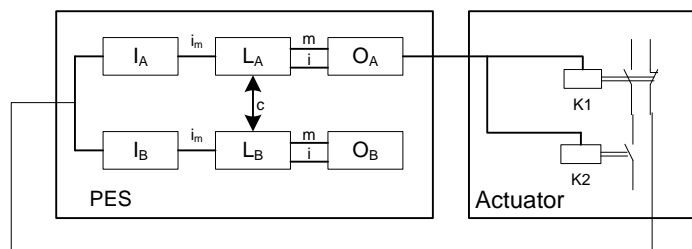
### 4.3.1 Characteristic of the output elements



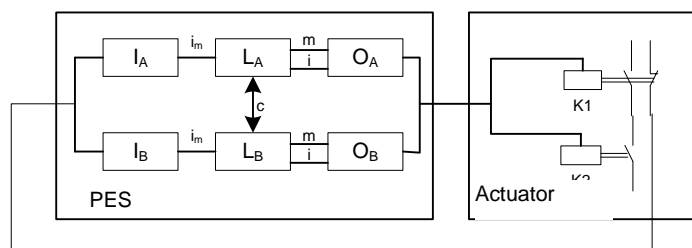
Single-channel output KSM and single-channel actuator without diagnostics



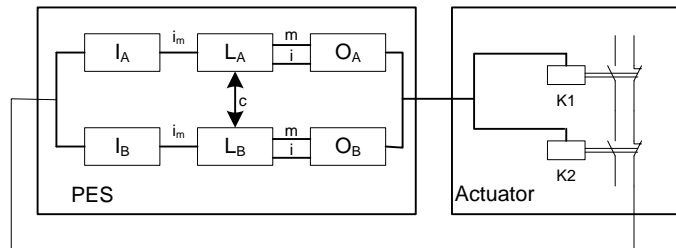
Single-channel output KSM and single-channel actuator with diagnostics



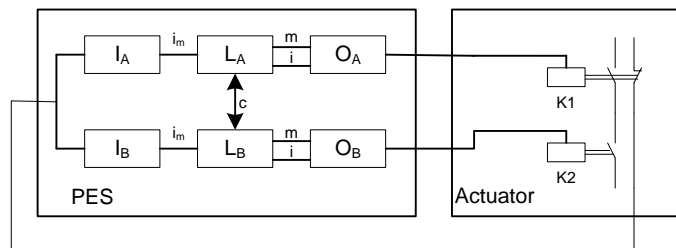
Single-channel output KSM (Rel 1 / 2 DO 0/1P, DO 0/1M) and dual-channel actuator with at least single-channel diagnostics.



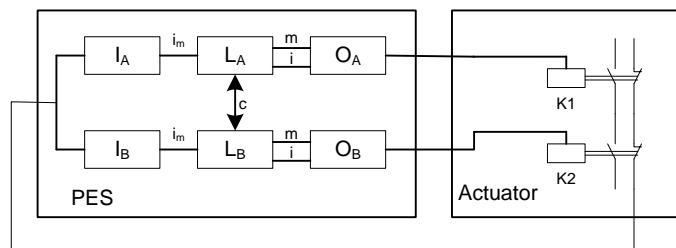
Single-channel output KSM with internal dual-channel processing (EAA1..40) and dual-channel actuator with at least single-channel diagnose



Single-channel output KSM with internal dual-channel processing (EAA1..40) and dual-channel actuator with dual-channel diagnose



Dual-channel output KSM and dual-channel actuator with single-channel diagnose



Dual-channel output KSM and dual-channel actuator with dual-channel diagnose

## 4.3.2 Diagnoses in the cut-off circuit

The cut-off circuit is equipped with durably implemented and parametrizable diagnostics functions. Certain diagnostics functions also include the external part of the cut-off channel. Depending on the use of these diagnostics functions, different DC-values will arise.

### 4.3.2.1 Diagnostic Functions

#### Durably implemented diagnostics functions:

Cross-wise readback of outputs:

All safety outputs are read back in the complementary channel. Faults in the internal cutout circuit of the KSM module are thus detected with DC = High.

Test of shut-down ability for Rel 1 and 2 (only control of relay), DO 0P, DO 0M, DO 1P, DO 1M: The cutout ability of these outputs is cyclically tested. Failure of the cutout possibility is clearly detected.

Parametrizable diagnostics functions:

Readback of the actuator status via auxiliary contacts, position indicators, etc.:

The current status of the actuator is detected by correspondingly suitable auxiliary contacts or position indicators and compared with the nominal status. Any deviation is thereby clearly recognized.

Note: The DC depends on a single-channel or dual-channel diagnose as well as on the switching frequency.

Testing the cutout ability for EAA1..40:

Once this function has been activated, the cutout ability of these outputs is cyclically tested.

Failure of the cutout possibility is clearly detected.

#### 4.3.2.2 Overview DC with respect to the chosen diagnostics functions

| Measure   | DC    | Note  | Use  |
|---|-------|---|--|
| Monitoring of outputs b a channel without dynamic test.   | 0-90% | DC depending on switching frequency<br><br>When using elements for switching amplification external relays or contactors) only effective in connection with the readback function of the switching contacts   | Monitoring of electro-mechanical, pneumatic or hydraulic actuators / outputs   |
| Redundant cutout path with monitoring one of the drive elements   | 90%   | When using elements for switching amplification external relays or contactors) only effective in connection with the readback function of the switching contacts  | Monitoring of the outputs with direct functions as safety circuit or monitoring of safety circuits with elements for switching amplification of pneumatic / hydraulic control valves in connection with readback functions from their switching status |
| Cross-comparison of input signals with immediate and intermediate results in the logic (L) and temporal as well as logic program sequence monitoring and detection of static failures and short circuits (for multiple inputs/outputs). | 99%   | When using elements for switching amplification external relays or contactors) only effective in connection with the readback function of the switching contacts<br><br>For applications with frequent safety shut-down requests these tests should be performed more frequently, e.g. at the beginning of the shift, 1 x per week. However, a test should at least be carried out cyclically 1 x year. | Monitoring of the outputs with direct functions as safety circuit or monitoring of safety circuits with elements for switching amplification of pneumatic / hydraulic control valves in connection with readback functions from their switching status |



## 4.3.3 Basic outputs

The following modules all have basic outputs of identical design:

- KSM100-1, KSM100-2, KSM100-4

### 4.3.3.1 Characteristic data of the basic outputs

The basic outputs provide a total of 8 outputs, which can be interconnected individually or in groups.

| <b>Output</b>   | <b>Architecture acc. to EN ISO 13849-1</b> | <b>Comment</b>   |
|-----------------|--|--|
| K1 and K2       | 4  | Complete shut-down channel in compliance with architecture category 4 acc. to EN ISO 13849-1 |
| K1              | up to 2                                    | Observe diagnose request and signal output   |
| K2              | up to 2                                    |  |
| DO0_P and DO0_M | 4  | Complete tripping channel in compliance with architecture category 4 acc. to EN ISO 13849-1  |
| DO0_P           | up to 2                                    | Observe diagnose request and signal output   |
| DO0_M           | up to 2                                    |  |
| DO1_P and DO1_M | 4  | Complete tripping channel in compliance with architecture category 4 acc. to EN ISO 13849-1  |
| DO1_P           | up to 2                                    | Observe diagnose request and signal output   |
| DO1_M           | up to 2                                    |  |
| O.1             | Not safe                                   | Signalling/auxiliary output  |
| O.2             | Not safe                                   | Signalling/auxiliary output  |

The HISIDE and LOWSIDE outputs are subjected to a plausibility test in all operating states. In switched on state the correct function of all outputs is tested with a cyclic test pulse. For this purpose the output is switched to the corresponding inverse value for a test period  $TT < 300\mu s$ , i.e. one P-output is switched instantaneously to 0 VDC potential, while one M-output is switched to 24 VDC potential.

The relay outputs are monitored for plausibility during each switching cycle. The relay outputs must be switched cyclically and thus tested to maintain the safety function. The switching/test cycle is determined in dependence on the application.

 **Safety note:**

- For applications with frequent safety shut-down requests these tests should be performed more frequently, e.g. at the beginning of the shift, 1 x per week. However, a test should at least be carried out cyclically 1 x year.
- The test function for the outputs is performed for groupes and individual control. The auxiliary outputs are not tested.
- **The single use of High-Side (DO.0\_P, DO.1\_P) and Low-Side (DO.0\_M, DO.1\_M) outputs for safety applications is only possible with limitations. Only the combination of High-Side/Low-Side is generally recommended.**

The outputs can be loaded as follows:

| <b>Output</b>     | <b>Voltage</b> | <b>Current</b> |
|-------------------|----------------|----------------|
| K1, K2            | 24 VDC         | 2.0 A          |
| K1, K2            | 230VAC         | 2.0 A          |
| O.1, O.2          | 24 VDC         | 100 mA         |
| DO.0_P,<br>DO.1_P | 24 VDC         | 250 mA         |
| DO.0_M,<br>DO.1_M | GNDEXT         | 250 mA         |

 **Safety note:**

- For safety relevant applications only external switching elements with a minimum withstand current of > 1.2mA may be used.
- For the output system a vast number of diagnostic measures have been implemented. Special attention must be paid to the inclusion of elements for switching amplification, such as relays, contactors, etc. in the cutout circuit.

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## 4.3.3.2 Wiring examples basic outputs

### 4.3.3.2.1 Single-pole switching relay or semi-conductor output without test

For the connection of multi-phase applications or for higher current demands external contactors may be used. For a single-pole connection without external test please bear in mind that the KSM100 module will not recognize bonding of one or several external contacts. The following circuit example is only limited suitable for safety applications, PI b acc. to EN 13849-1 can maximally be achieved!

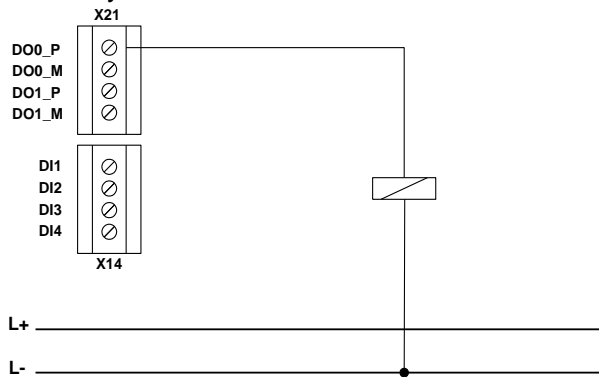


Fig.: Single-pole switching P-output.

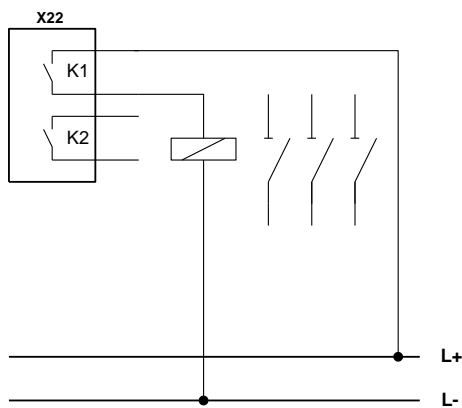


Fig.: Single-pole switching relay output.

**⚠ Safety note:**

- Not recommended for safety applications! In this context see also the notes in EN 13849-1 concerning the application and the required fault exclusions.

### 4.3.3.2.2 Single-pole switching relay or semi-conductor output with external switching amplifier and testing

When using external switching amplifiers or downstream electro-mechanical, pneumatic or hydraulic components, the setup for testing the complete chain and a message/warning feature for detected faults is required in order to achieve PI c or higher.

Positively guided auxiliary contacts are especially needed for electro-mechanical devices and message contacts for the valve position are required for hydraulic or pneumatic components. The message/warning device must ensure that the operator recognizes the dangerous situation immediately.

The achievable PI is mainly depending on the test rate, PI d acc. to EM 13849-1 can maximally be achieved.

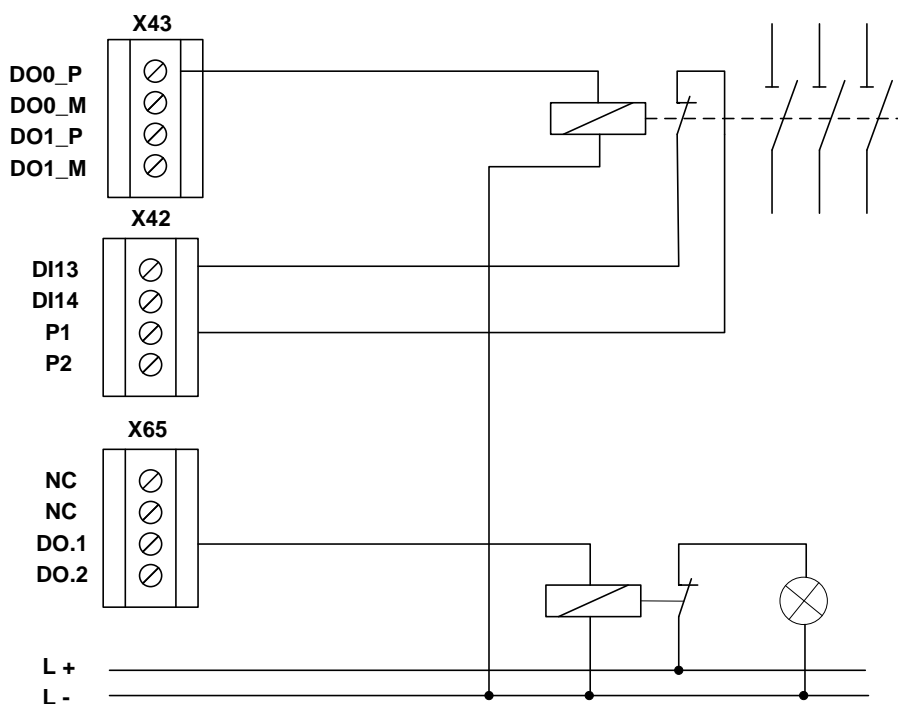


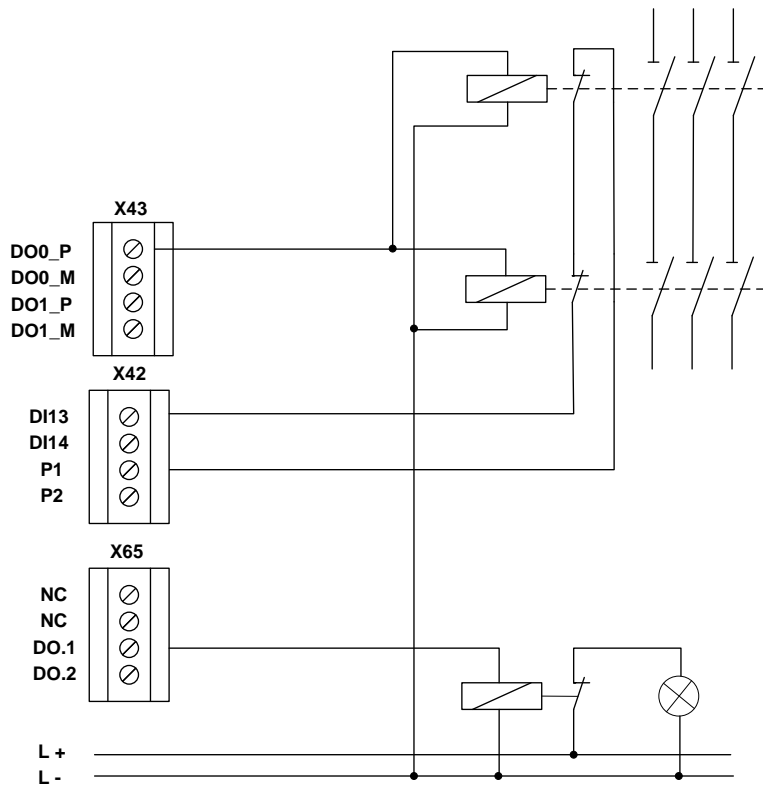
Fig.: Single-pole relay output with testing

**⚠ Safety note:**

- Only conditionally recommended for safety applications! In this context see also the notes in EN 13849-1 concerning the application and the required fault exclusions.
- For PI c or higher a test rate of  $> 100 \cdot$  the request rate is required.
- For PL c and higher a message/warning feature is required, which informs the operator immediately about a dangerous situation

### 4.3.3.2.3 Single-pole switching relay or semi-conductor output with dual-channel external circuit with testing

For safety applications from PI c and higher acc. to EN ISO 13849-1 we strongly recommend or even demand the control of two external cutout elements. Furthermore, the setup for testing the complete chain and a message/warning device for an detected fault is required for achieving PI c or higher - see also remarks under 4.3.3.2.2.



*Fig.: Single-channel switching output DO0\_P with dual-channel external circuit and monitoring at output 1 as group feedback*

The two external monitoring contacts are switched in series, supplied by the clock signal P1 and read via input 1. Input 1 was chosen as readback input, but any other input can be assigned for this purpose.

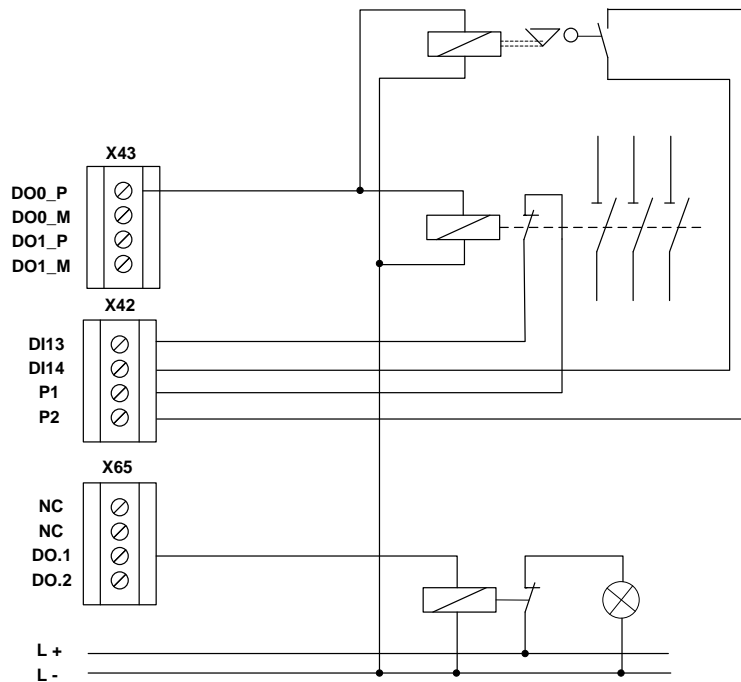


Fig.: Single-channel switching output DO0\_P with dual-channel external circuit as combination of electro-mechanical element and hydraulic/pneumatic valve and monitoring at two inputs

**⚠ Safety note:**

- Only conditionally recommended for safety applications! In this context see also the notes in EN 13849-1 concerning the application and the required fault exclusions.
- For PL c and higher a message/warning feature is required, which informs the operator immediately about a dangerous situation
- For higher requirements you must make sure that at least 1 switching operation must take place every 24 hours, in order to test the switching ability of the external power contactor.

### 4.3.3.2.4 Dual-channel switching relay output with external monitoring - group feedback

For safety related applications from PI d acc. to EN ISO 13849-1 two relays on the KSM100 module and two external power contactors are used.

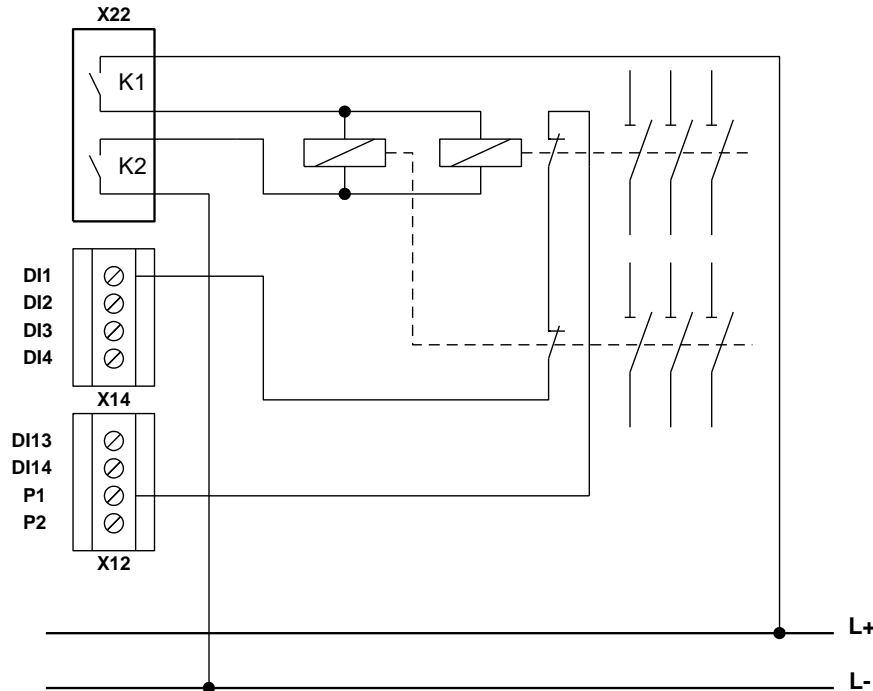


Fig.: Two-channel switching relay output with external monitoring – group feedback

The two external monitoring contacts are switched in series, supplied by the clock signal P1 and read in from DI1 (configured as EMU-input). In case of higher demands one must consider that at least 1 switching process must take place every 24 hours.

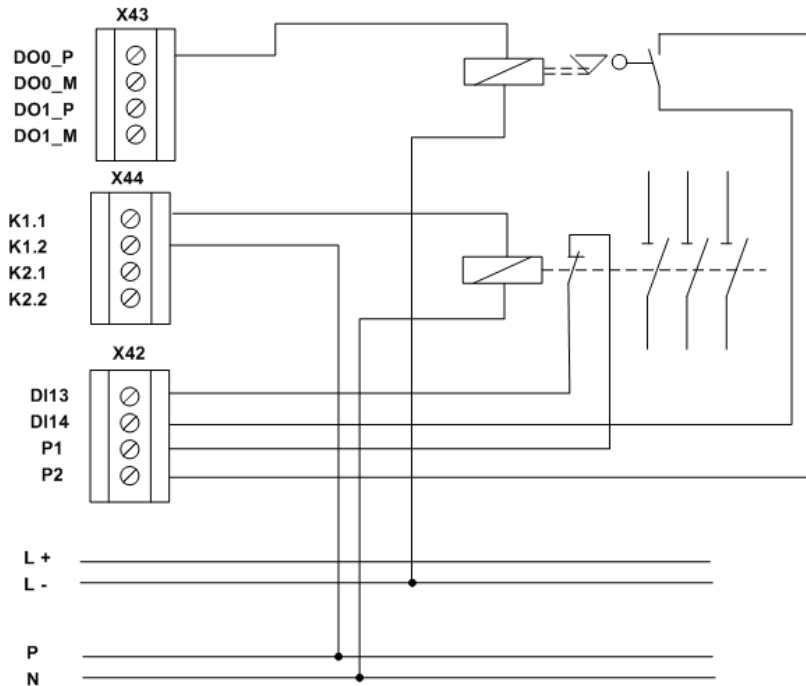
#### **⚠ Safety note:**

- For achieving PI e acc. to EN ISO 13849-1 a sufficiently high testing rate is required.
- For applications with frequent safety shut-down requests these tests should be performed more frequently, e.g. at the beginning of the shift, 1 x per week. However, a test should at least be carried out cyclically 1 x year.

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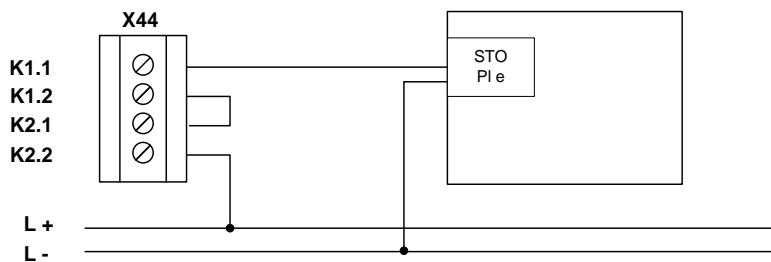
## 4.3.3.2.5 Dual-channel output with relay output and semi-conductor output – external control circuit with monitoring

For safety applications from PI d and higher acc. to EN ISO 13849-1. The external circuit is controlled in dual-channel mode via a relay and a semi-conductor output. Each of the two external cutout paths is monitored. For PL e acc. to EN ISO 13849-1 a sufficiently high testing rate and  $MTTF_D = \text{high}$  is demanded for the external circuit.



## 4.3.3.2.6 Dual-channel output with relay output and external control circuit in PI e

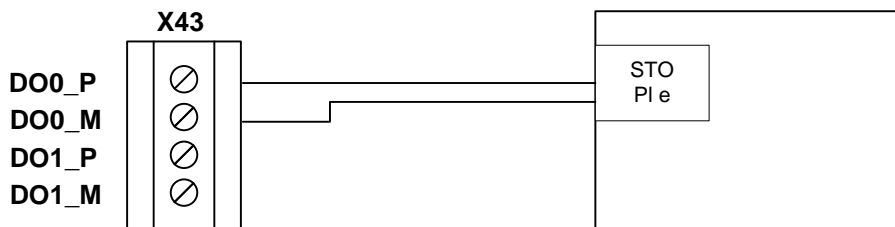
For safety applications from PI d and higher acc. to EN ISO 13849-1. The external circuit is controlled in dual-channel mode via the relay outputs. For PL e acc. to EN ISO 13849-1 a sufficiently high testing rate and PI e is demanded for the external circuit.





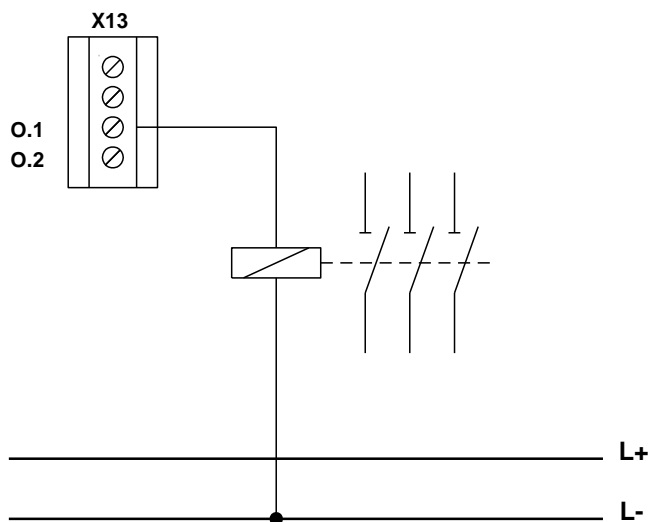
### 4.3.3.2.7 Dual-channel output with semi-conductor output and external control circuit in PI e

For safety applications from PI d and higher acc. to EN ISO 13849-1. The external circuit is controlled in dual-channel mode via the semi-conductor outputs. For PL e acc. to EN ISO 13849-1 PI e is demanded for the external circuit



### 4.3.3.2.8 Wiring of an auxiliary output

Both semi-conductor outputs implemented on the KSM100 module can be wired for functional applications. These outputs are not pulse-commutated.



*Fig.: Wiring of an auxiliary output*

Applications with auxiliary outputs are not accepted for safety related applications!

## 4.3.4 Configurable I/O as outputs

The modules

KSM100-2, KSM100-4

KSM131, KSM132

all have different quantities of configurable I/O's (see chapter 3, module overview). Parameterized as an output this connection acts as a secure digital Hi-Side output (DO\_P).

### 4.3.4.1 Classification of the I/O when used as output

| Classification             | Achievable PI acc. to EN ISO 13849-1 | Comment   |
|----------------------------|--------------------------------------|---|
| Static single-channel      | PL c                                 | - Fault detection or fault reaction acc. to cat. 2  |
|                            | PL e                                 | - Different group   |
| Static two-channel         | PL d                                 | Same group:<br>- Time-shifted triggering on PLC level<br>- Fault approach short-circuit on both outputs<br>Different group:<br>- Nom further requirements necessary |
|                            | PL e                                 | - Different group required  |
| Dynamically single-channel | PL e                                 | Nom further requirements necessary  |
| Dynamically dual-channel   | PL e                                 | Nom further requirements necessary  |

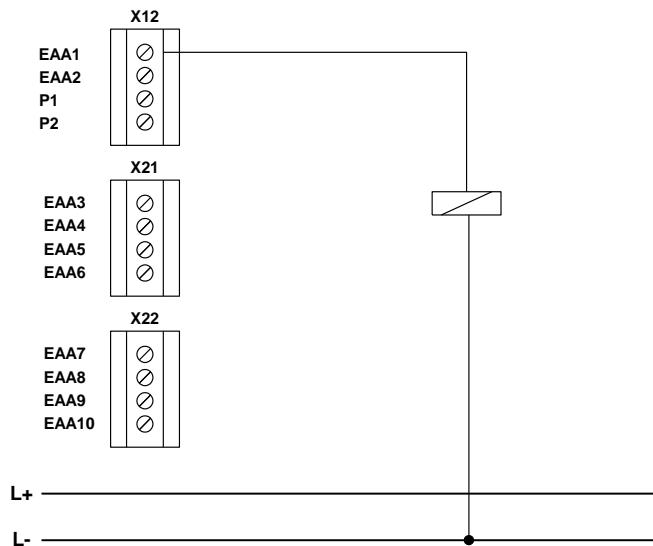
Note:

- 1) Group 1: EAA1 ... EAA6  
Group 2: EAA7 ... EAA10
- 2) Static: no pulse test on output  
Dynamic: Pulse test on output with  $t_{\text{Test}} \leq 500 \mu\text{s}$

## 4.3.4.2 Wiring example for outputs of extension module

### 4.3.4.2.1 Wiring single-channel without testing

For a single-pole connection without external test please bear in mind that the KSM100 module will not recognize bonding of one or several external contacts. The following circuit example is only limited suitable for safety applications, PI b acc. to EN 13849-1 can maximally be achieved!



#### Safety note:

- Not recommended for safety applications! In this context see also the notes in EN 13849-1 concerning the application and the required fault exclusions.

## 4.3.4.2.2 Wiring single-channel with testing

Use of one output EAA1...40 in connection with a single-channel external wiring for testing. Positively guided auxiliary contacts are especially needed for electro-mechanical devices and message contacts for the valve position are required for hydraulic or pneumatic components. Furthermore, a message/warning device for indicating a failure is required. The message/warning device must ensure that the operator recognizes the dangerous situation immediately. The achievable PI is mainly depending on the test rate, PI d acc. to EM 13849-1 can maximally be achieved.

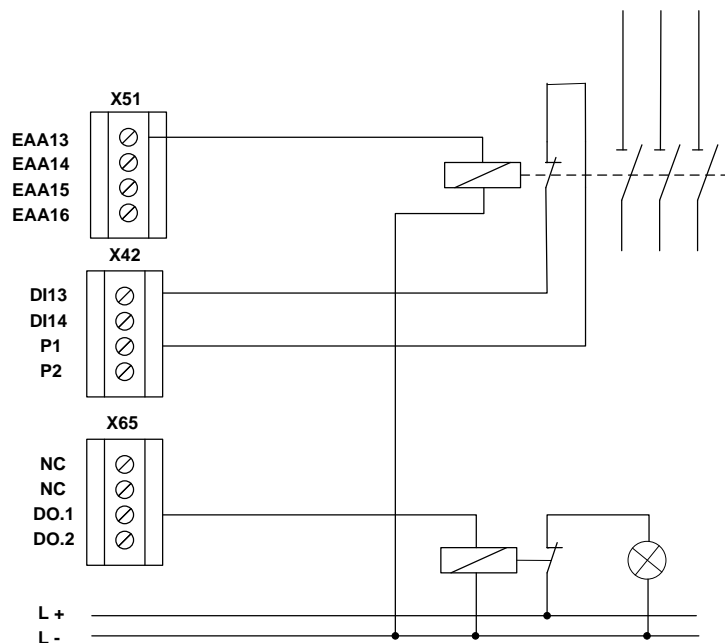


Fig.: Single-pole relay output with testing

### **⚠ Safety note:**

- Only conditionally recommended for safety applications! In this context see also the notes in EN 13849-1 concerning the application and the required fault exclusions.
- For PI c or higher a test rate of  $> 100 \cdot$  the request rate is required.
- For PL c and higher a message/warning feature is required, which informs the operator immediately about a dangerous situation

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## 4.3.4.2.3 Single-channel output in connection with a secure shut-down circuit

For safety applications from PI c and higher acc. to EN ISO 13849-1. The external circuit is controlled directly via an output. The achievable PL acc. to EN ISO 13849-1 depends on the use of dynamic testing (see 4.3.2.1 DC) and the PL of the downstream device.

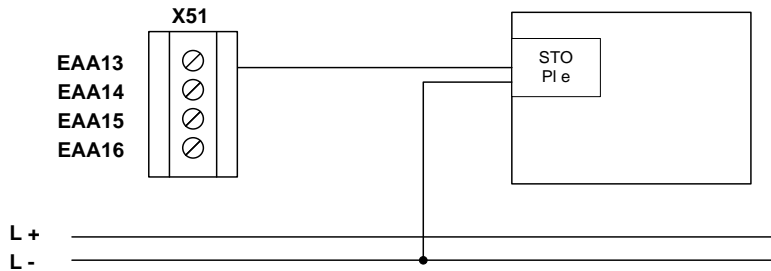


Fig.: Single-pole semi-conductor output in connection with device with tested shut-down.

## 4.3.4.2.4 Single-channel output in connection with a dual-channel shut-down circuit

Suitable for PI d and higher acc. to EN ISO 13849-1. Use of one output EAA1...40 in connection with a dual-channel external wiring with testing. Positively guided auxiliary contacts are especially needed for electro-mechanical devices and message contacts for the valve position are required for hydraulic or pneumatic components.

The achievable PI depends on the use of dynamic testing as well as MTTF<sub>D</sub>-value of the external channel. PI e acc. to EN ISO 13849-1 can maximally be reached.

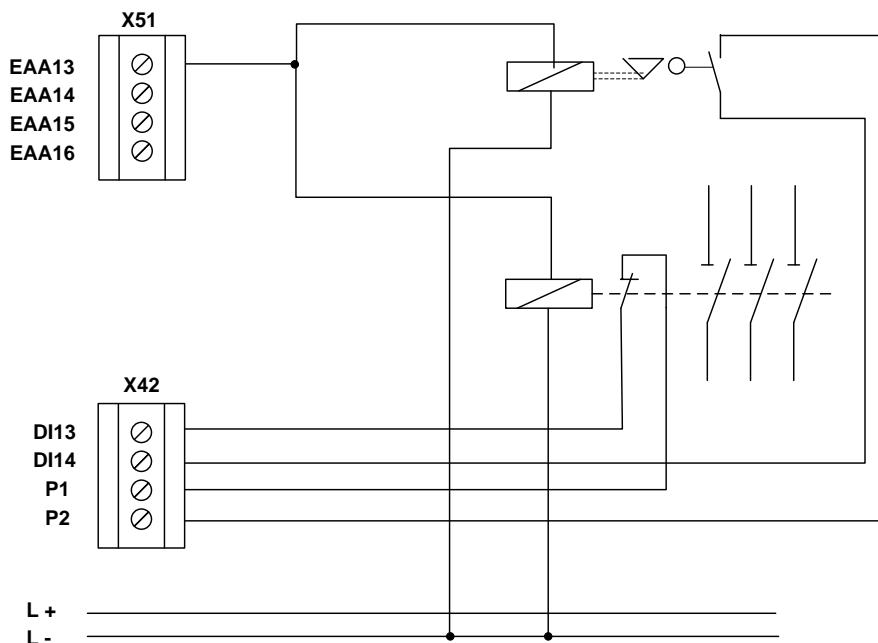


Fig.: Single-pole semi-conductor output in connection with dual-channel shut-down circuit with testing.

**⚠ Safety note:**

- For a safety related assessment of the partial system output the data issued by the respective manufacturer (MTTFD, FIT-numbers, B10d-value, etc.) must be used when using external elements, e.g. for switching amplification, in the shut-down circuit.
- The DC-values listed in the table must be used conservatively and compliance with the boundary conditions (see table under “Remarks”) must be ensured.
- According to the applicable standards, fault exclusions are permitted. The boundary conditions mentioned in this context must permanently be met.
- When using elements for switching amplification in safety circuits, their function must be monitored by means of suitable readback contacts, etc. (see circuitry examples). Suitable readback contacts are contacts which are linked with the contacts in the shut-down circuit in a positively switching way.
- The switching ability of the external switching amplifier must be cyclically tested. The time between 2 tests must be determined in accordance with the requirements of the application and ensured by suitable measures. Suitable measures may be of organizational (On and Off switching at the beginning of a shift, etc.) or technical (automatic, cyclic switching) nature.

#### 4.3.4.2.5 Dual-channel output

Suitable for PI d and higher acc. to EN ISO 13849-1. Use of two outputs EAA1...40 in connection with a dual-channel external wiring.

##### 4.3.4.2.5.1 Output in same group

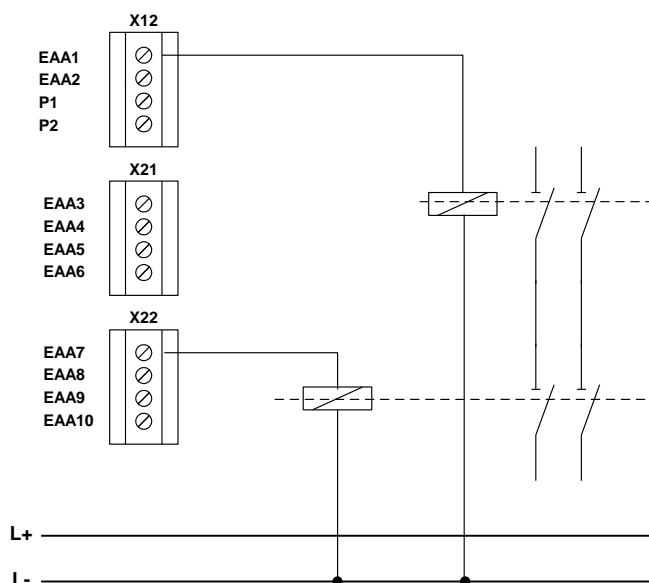


Fig.: Two-pole semiconductor output in the same group in connection with a dual-channel shut-down circuit

## 4.3.4.2.5.2 Output in different group

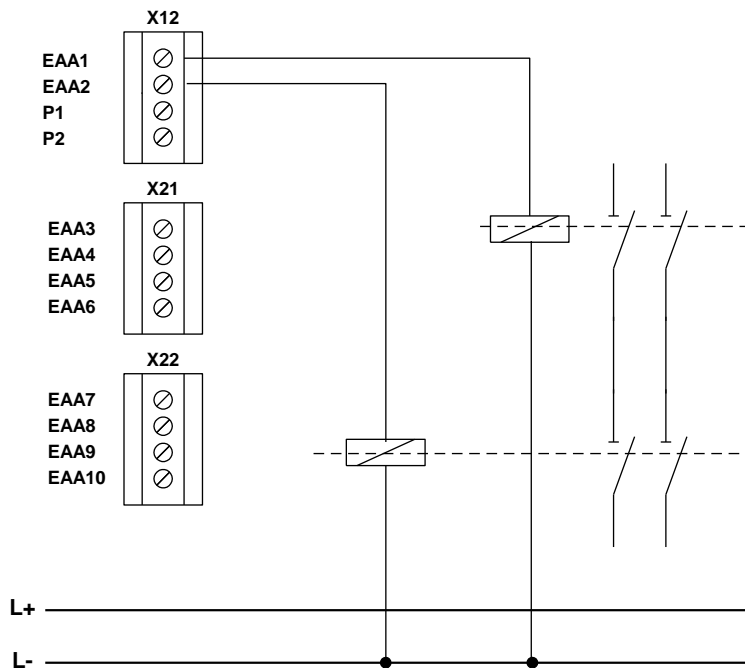


Fig.: Two-pole semi-conductor output in different group in connection with a dual-channel shut-down circuit

### Safety note:

- For a safety related assessment of the partial system output the data issued by the respective manufacturer (MTTFD, FIT-numbers, B10d-value, etc.) must be used when using external elements, e.g. for switching amplification, in the shut-down circuit.
- The DC-values listed in the table must be used conservatively and compliance with the boundary conditions (see table under “Remarks”) must be ensured.
- According to the applicable standards, fault exclusions are permitted. The boundary conditions mentioned in this context must permanently be met.
- When using elements for switching amplification in safety circuits, their function must be monitored by means of suitable readback contacts, etc. (see circuitry examples). Suitable readback contacts are contacts which are linked with the contacts in the shut-down circuit in a positively switching way.
- The switching ability of the external switching amplifier must be cyclically tested. The time between 2 tests must be determined in accordance with the requirements of the application and ensured by suitable measures. Suitable measures may be of organizational (On and Off switching at the beginning of a shift, etc.) or technical (automatic, cyclic switching) nature.

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## 4.3.4.3 Overview of achievable PI for digital safety outputs

| Output KSM   | Actuator / external shut-down circuit  | Category acc. to EN13849-1 | DC     |  | MTTF <sub>D</sub> Actuator | Achievable PI acc. to EN ISO 13849-1 | Boundary conditions   | Fault exclusion                   |
|--|--|----------------------------|--------|--|----------------------------|--------------------------------------|---|-----------------------------------|
| Single-channel without dynamic output test<br>Rel 1 or 2<br>DO 0P, DO 0M, DO 1P, DO 1M<br>EAA1..EAA40          | Single-channel<br>Contactor, valve, brake, etc. without direct feedback for diagnostics.   | Cat. B                     | 0 %    |  | Medium                     | b                                    | Contactor and downstream actuators appropriately designed for safety application  |                                   |
|  | Single-channel<br>Contactor, valve, brake, etc. with monitored and positively guided auxiliary contact   | Cat. 2                     | 60-90% | Depending on switching frequency                 | Medium                     | b                                    | Message output required for warning in case of detected malfunction<br><br>Contactor and downstream actuators appropriately designed for safety application   |                                   |
|  |  |                            |        |  | High                       | c                                    | As before   |                                   |
|  |  |                            |        |  |                            | d                                    | As before<br>DC = 90% due to a sufficiently high test rate with reference to the application  |                                   |
| Single-channel without dynamic output test<br>Rel 1 or 2<br>or<br>Single-channel<br>DO 0P, DO 0M, DO 1P, DO 1M | Dual channel<br>Contactor, valve, brake, etc. with direct feedback to diagnostics in at least one channel<br>or<br>actuator single channel controlled with safety function cat. 3 (e.g. STO) | Cat. 2                     | 90%    | Monitoring only in an external shut-down circuit | Medium                     | c                                    | Message output required for warning in case of detected malfunction   | Short circuit on external control |
|  |  |                            |        |  | High                       | d                                    | Contactor and downstream actuators appropriately designed for safety application  |                                   |
| Single-channel without dynamic output test<br>EAA1..EAA40  | Dual channel<br>Contactor, valve, brake, etc. with direct feedback to diagnostics in at least one channel<br>or<br>actuator single channel controlled with safety function cat. 3 (e.g. STO) | Cat. 3                     | 90 %   | Monitoring only in an external shut-down circuit | Medium or High             | d                                    | Contactor and downstream actuators appropriately designed for safety application  | Short circuit on external control |
| Single-channel with dynamic output test<br>EAA1..EAA40   | Dual channel<br>Contactor, valve, brake, etc. with direct feedback to diagnostics in both channels<br>or<br>actuator with safety function cat. 4 (e.g. STO)                                  | Cat. 4                     | 99%    | Monitoring in both external shut-down circuits   | High                       | e                                    | Contactor and downstream actuators appropriately designed for safety application<br><br>Monitoring of electro-mechanical components by means of positively guided switches, position monitoring of control valves, etc. |                                   |



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| Output KSM   | Actuator / external shut-down circuit   | Category acc. to EN13849-1 | DC  |  | MTTF <sub>D</sub> Actuator | Achievable PI acc. to EN ISO 13849-1 | Boundary conditions   | Fault exclusion                                    |
|--|---|----------------------------|-----|--|----------------------------|--------------------------------------|---|--|
|  |   |                            |     |  |                            |                                      |   |  |
| Dual-channel without dynamic output test<br>Rel 1 and Rel 2<br>2 x EAA1..EAA40   | Dual-channel Contactor, valve, brake, etc. with direct feedback to diagnostics in at least one channel<br>or<br>actuator with safety function cat. 4 (e.g. STO) | Cat. 3                     | 90% | Monitoring in both external shut-down circuits | Medium or High             | d                                    | <p>Contactor and downstream actuators appropriately designed for safety application</p> <p>Monitoring of electro-mechanical components by means of positively guided switches, position monitoring of control valves, etc.</p> <p>Outputs EAA1..40, 1 x each from different groups (groups of 6/4 contiguous EAA-ports each, e.g. EAA1..6, EAA7..10)</p> <p>or</p> <p>Time-shifted triggering on PLC level</p>  | Short circuit on external control                  |
| Dual-channel Rel 1 and Rel 2<br><br>or<br><br>Dual-channel with dynamic output test<br>DO 0P and, DO 0M,<br>DO 1P and DO 1M<br>2 x EAA1..EAA40 | Dual-channel Contactor, valve, brake, etc. with direct feedback to diagnostics in both channels<br>or<br>actuator with safety function cat. 4 (e.g. STO)        | Cat. 4                     | 99% | Monitoring in both external shut-down circuits | High                       | e                                    | <p>Contactor and downstream actuators appropriately designed for safety application</p> <p>Monitoring of electro-mechanical components by means of positively guided switches, position monitoring of control valves, etc.</p> <p>For applications with frequent safety shut-down requests these tests should be performed more frequently, e.g. at the beginning of the shift, 1 x per week. However, a test should at least be carried out cyclically 1 x year.</p> | Short-circuit in external control in both channels |

## 5 Connection and installation

### 5.1 General notes on installation

Strictly follow the safety regulations when installing!

Degree of protection IP52.

Route all signal lines for the interfacing of digital inputs and contact monitoring separately. In any case isolate 230 VAC voltages from low voltage lines, if these voltages are used in connection with the application.

The cable lengths for digital inputs and outputs must normally not exceed **30m**.

If the cable lengths exceeds 30m you must apply appropriate measures for fault exclusion concerning impermissible overvoltage. Appropriate measures include e.g. lightning protection for outdoor lines, overvoltage protection of the indoor system, protected routing of cables.

Measures concerning the electromagnetic compatibility (EMC)

The KSM100 module is intended for use in the drive environment and meets the EMC-requirements mentioned above.

It is also assumed that the electromagnetic compatibility of the overall system is ensured by application of appropriate measures.

#### Safety note:

- Electric power supply lines of the KSM100 and “discontinuous-action lines” of the power converter must be isolated from each other.
- Signal lines and power lines of the power converter must be routed through separate cable ducts. The distance between the cable ducts should be minimum 10 mm.
- Only shielded cables must be used to connect the position and speed sensors. The signal transmission cable must be RS-485-standard compliant (lines twisted in pairs).
- Care must be taken to ensure that the shielding is correctly connected in the 9-pin SUB-D plugs of the position and speed sensors. Only metal or metal coated plugs are permitted.
- The shielding on the sensor side must comply with appropriate methods.
- EMC-compliant installation of the power converter technology in the environment of the KSM100 module must be assured. Special attention must be paid to the routing of cables, the shielding of motor cables and the connection of the braking resistor. Strict compliance with the installation instructions of the power converter manufacturer is mandatory.
- All contactors in the environment of the power converter must be equipped with appropriate suppressor circuits.
- Suitable measures to protect against overvoltages must be applied.

## 5.2 Installation and assembly of the KSM100 module

The module is solely to be installed in control cabinets with a degree of protection of at least IP54.

The modules must be vertically fastened on a top hat rail

The ventilation slots must be kept unobstructed, to ensure adequate air circulation inside the module.

## 5.3 Installation of backplane bus system

Mounting several KSM100 modules (KSM100-1, KSM100-2, KSM100-4) on one top hat rail in connection with the backplane bus system is also possible. These modules can be combined with a communication extension. In this case the backplane bus system needs to be configured by Kollmorgen when placing the order and delivered in accordance with the application in question.

The backplane bus system consists of a 5-pin plug connector with snap-in contacts. In these plug connectors all 5 contacts are equipped by standard. In this case the component is not specially marked. On a second variant of the plug connector only 3 contacts are equipped.

### **Note:**

Expansion modules have no own power supply unit and depend on a DC power supply via the backplane bus system. Basic modules (KSM100-1, KSM100-2, KSM100-4) are equipped with a reinforced power supply unit and always feed in to the backplane bus.

There are two different types of backplane bus connectors:

- **TB1:** Standard design (all contacts are present)
- **TB2:** Circuit breaker design (The two live conductors are not present and are marked with a green dot).

### **Using the backplane bus connector TB1:**

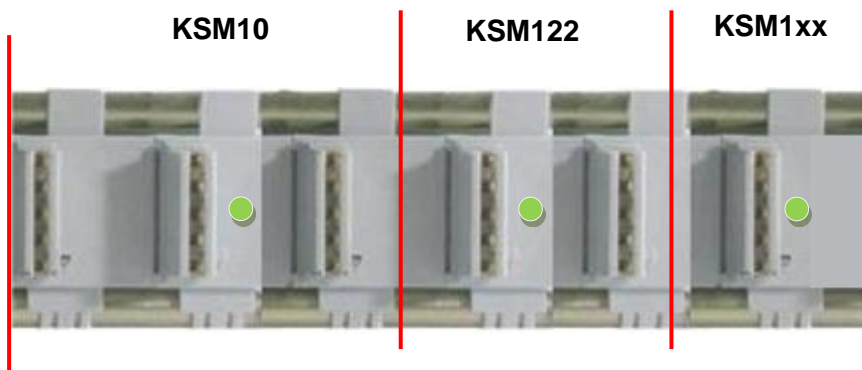
The backplane bus connector TB1 can only be installed in connection with expansion modules without their own power supply. Connection of several standalone modules is not possible.

### **Using the backplane bus connector TB2:**

The backplane bus connector TB2 is used for combining several base modules with expansion modules. A detailed description can be found under point 4.3.1.

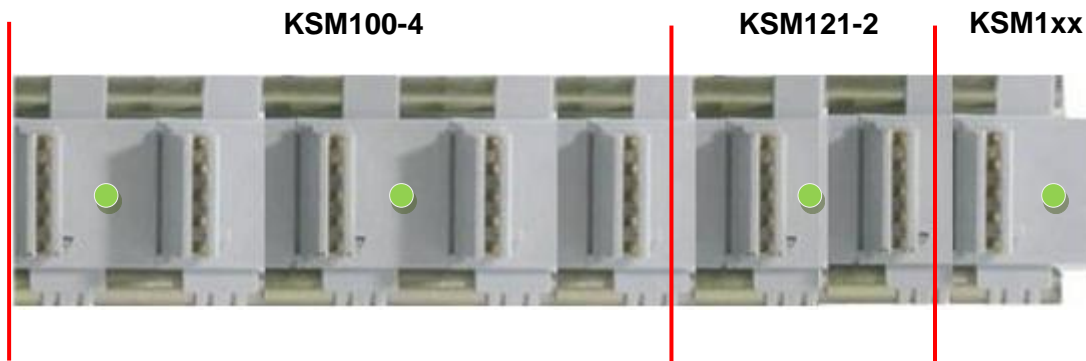
## 5.3.1 Arrangement examples

### 5.3.1.1 KSM100-1 + KSM122 + KSM1xx



There is no TB2 between the KSM121 module and the communication module KSM1xx, because the power supply for the KSM1xx is fed in through the backplane bus system.

### 5.3.1.2 KSM100-4 + KSM121-2 + KSM1xx



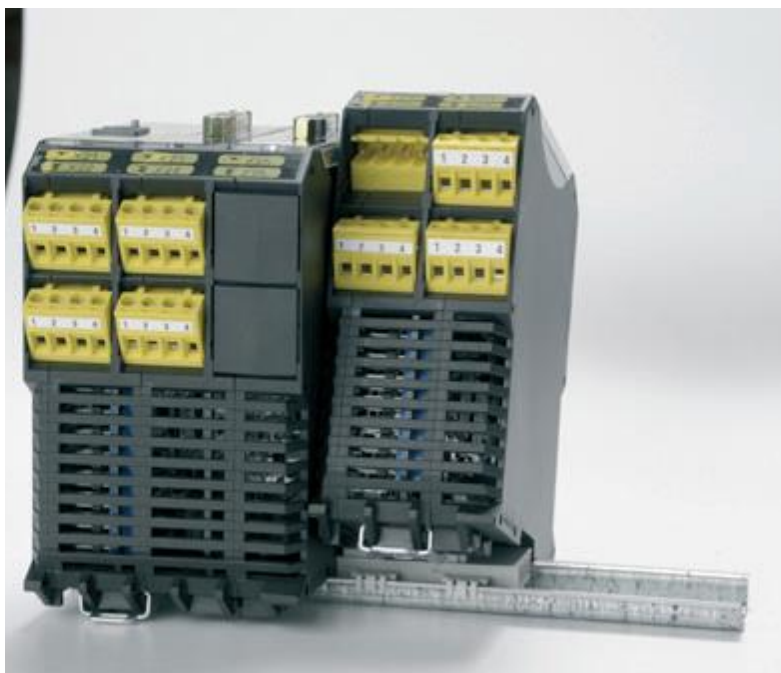
There is no TB2 between the KSM121-2 module and the communication module KSM1xx, because the power supply for the KSM1xx is fed in through the backplane bus system.

## 5.4 Assembling the modules

The modules are mounted on C-standard rails by means of snap-on latches.

### 5.4.1 Assembly on C-rail

The devices are inserted into the rail under an oblique angle and then snapped on downwards. For disassembling use a screwdriver, insert it into the slot of the downwards pointing latch and then move it up.



## 5.4.2 Assembly on backplane bus

After assembling the backplane bus the device can be installed. For this purpose insert the module from above into the plug connection under an oblique angle and snap it onto the C-rail.



Insert the module from above under an oblique angle.



Snap-on downwards on to the C-rail.

The backplane plug connection can later be extended. The system configuration can thus be extended by additional modules.

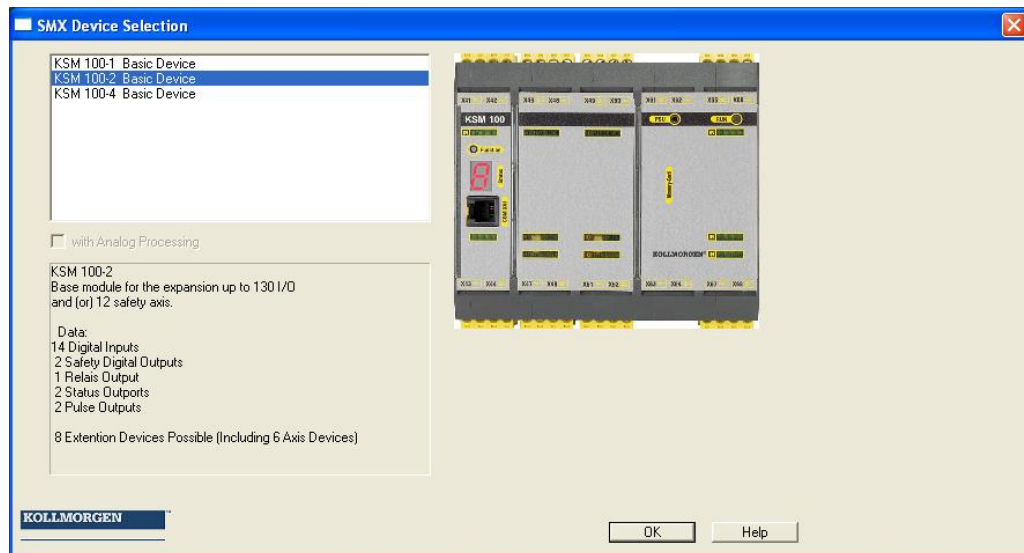


Snap the backplane bus element into the C-rail and insert it into the counter-piece by sliding it sideways.

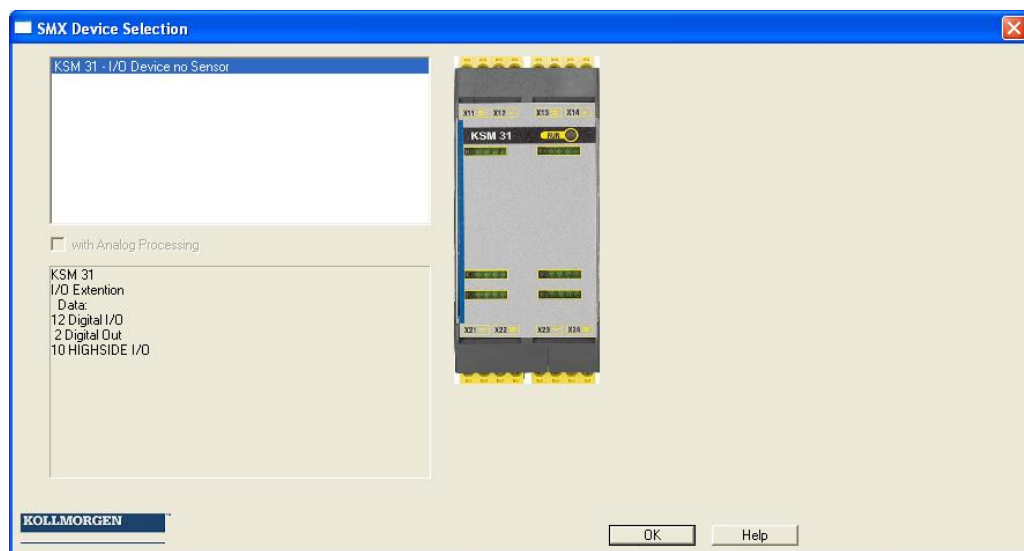
## 5.5 Installation and configuration I/O-extension KSM131

### 5.5.1 Log on KSM131 to basic group

After starting the program “SafePLC” the basic unit is active first.



With this additional button one can subsequently choose the KSM131 module.



**Note:** Max. two KSM131 modules can be operated with one basic unit.

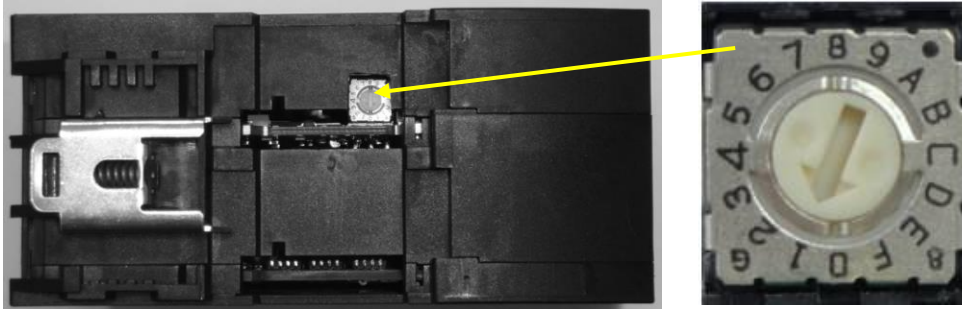


# Installation Manual

## 5.5.2 Physical address configuration KSM131

On the KSM31 module the bus address must be set with the help of the address switch.

This setting is made on the back of the module

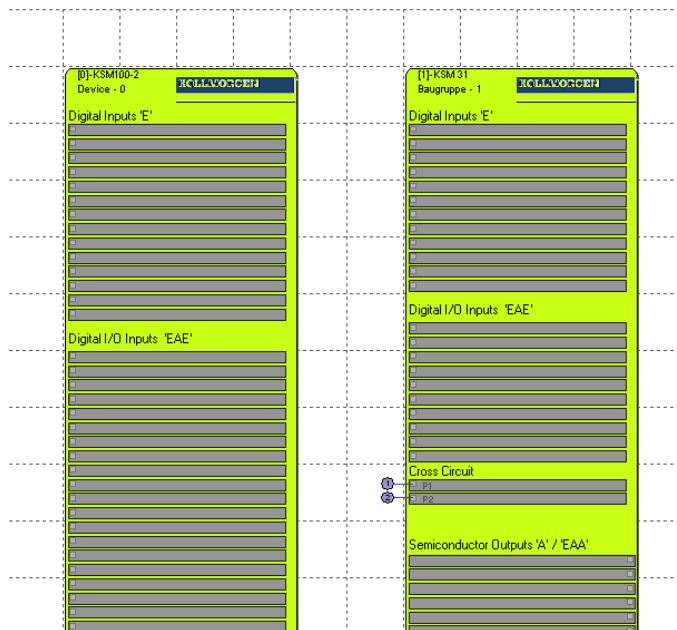


**Note:**

- Address range of the KSM131 module from 1...15.
- Address "0" is reserved for the basic device.

## 5.5.3 Configuration of the I/O-assignment KSM131

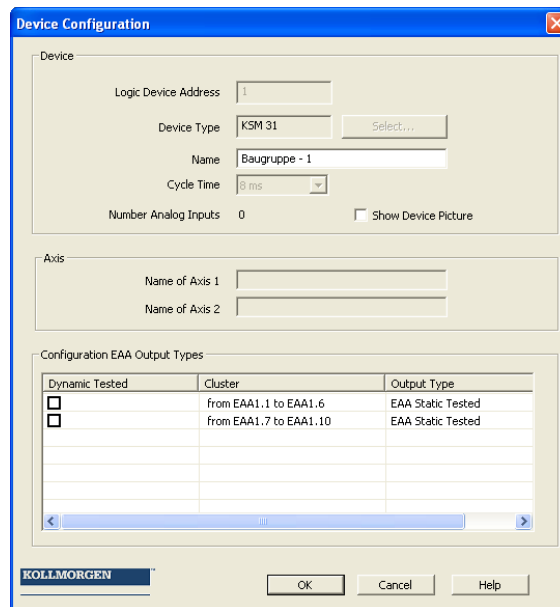
In the main menu of the "Safe PLC" program one can open the configuration dialog for the KSM131 module by "double-clicking" on the extension module.



## 5.5.4 Logic address configuration KSM131

The following settings must be made in the KSM131 configuration dialogue:

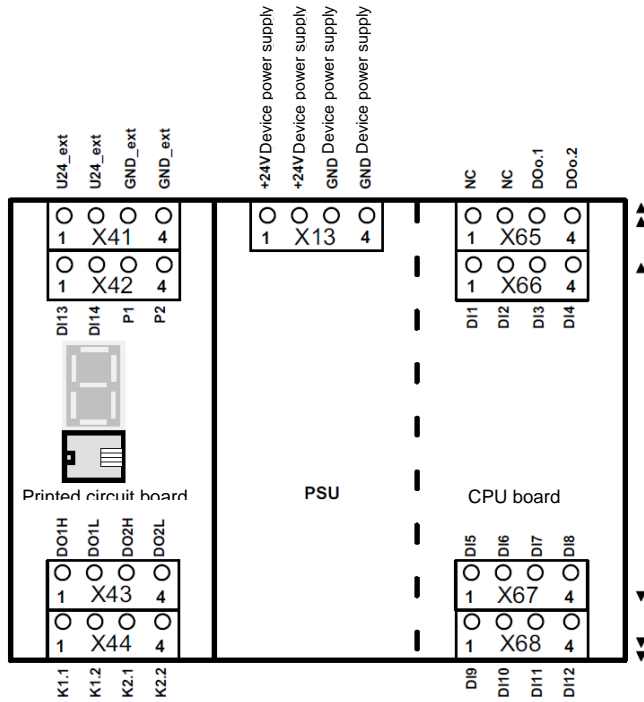
- Logic address KSM131 device x: Setting the address switch of the KSM131 module x
- Group1 EAAx.1-EAAx.6 or group1 EAAx.7-EAAx.10: When using these outputs one can choose between safety and standard outputs.



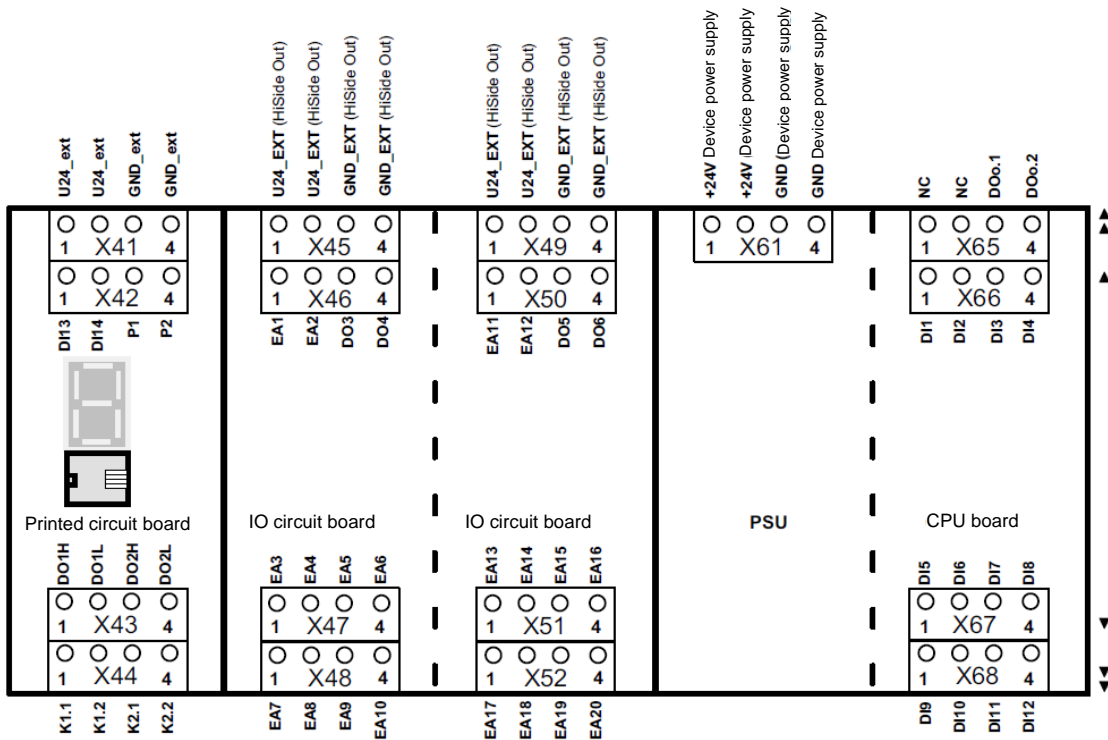
# Installation Manual

## 5.6 Terminal assignment

### 5.6.1 Terminal assignment KSM 100-1

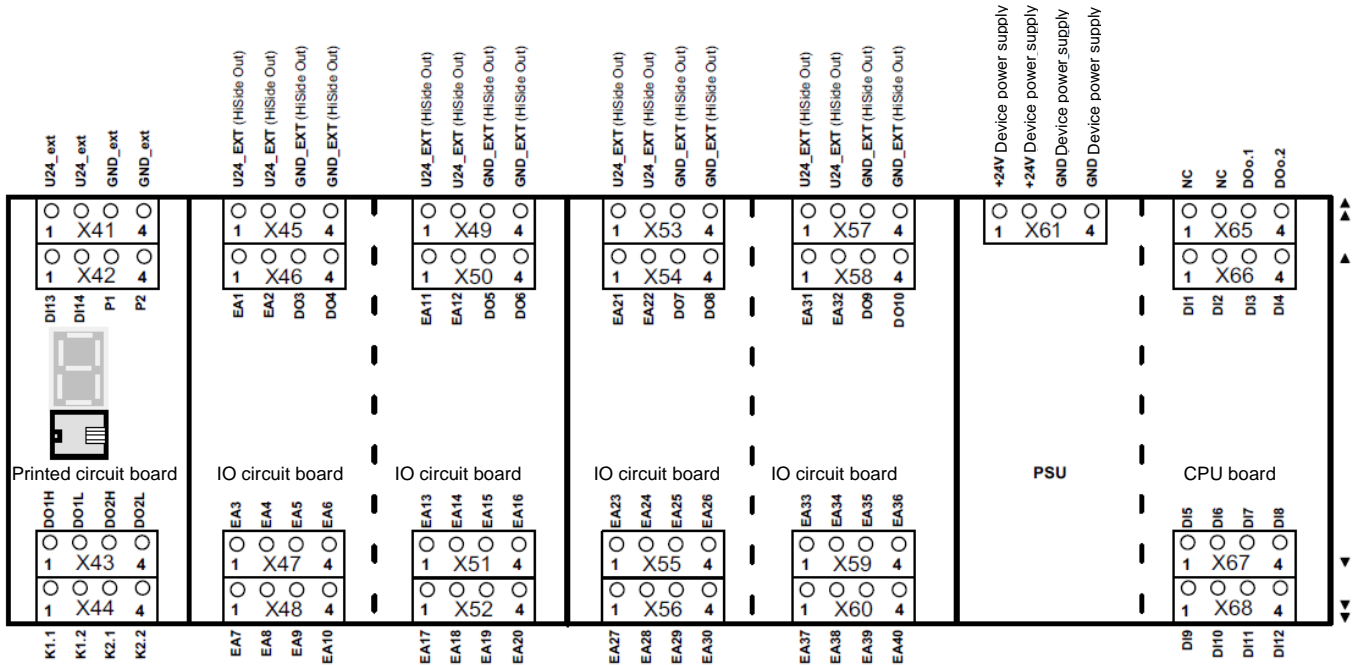


### 5.6.2 Terminal assignment KSM 100-2

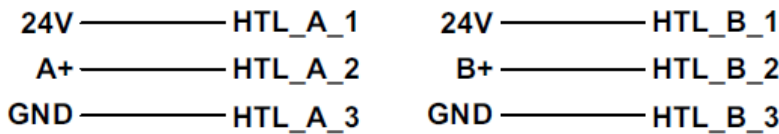


# Installation Manual

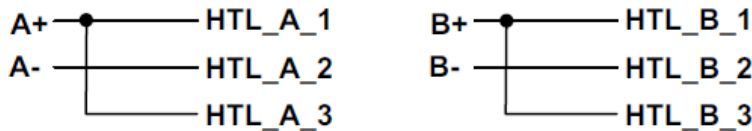
## 5.6.3 Terminal assignment KSM 100-4



HTL encoder connection: A+/B+

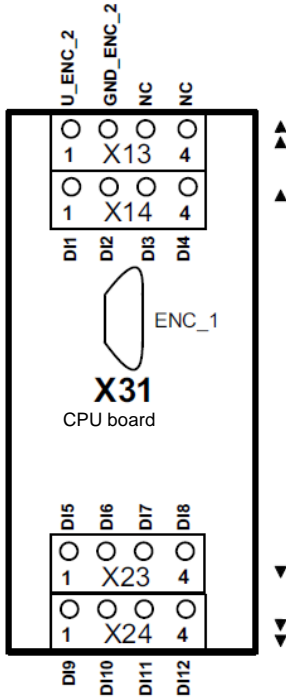


HTL encoder connection: A+,A-/B+,B-

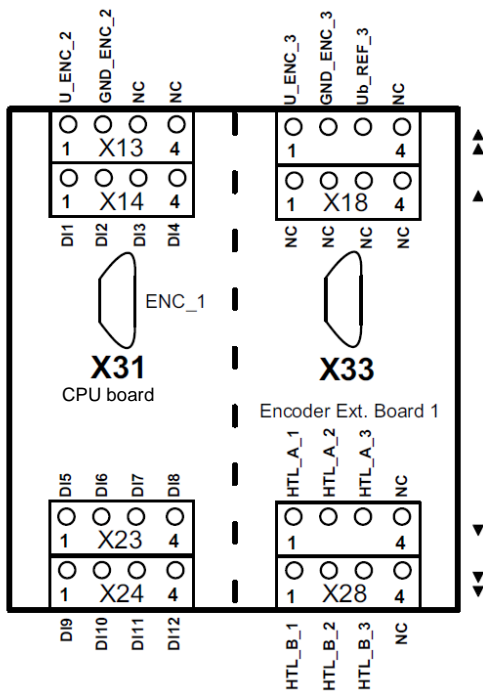


# Installation Manual

## 5.6.4 Terminal assignment KSM 121

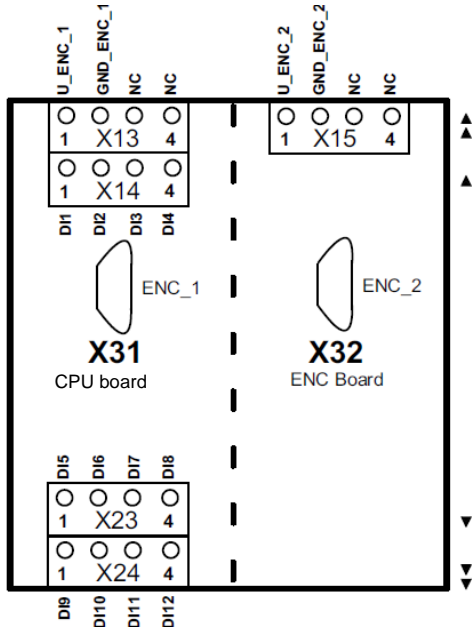


## 5.6.5 Terminal assignment KSM 121-2

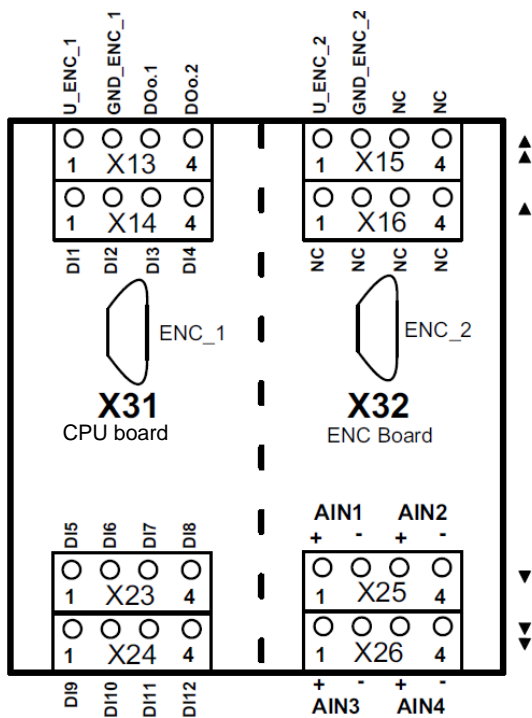


# Installation Manual

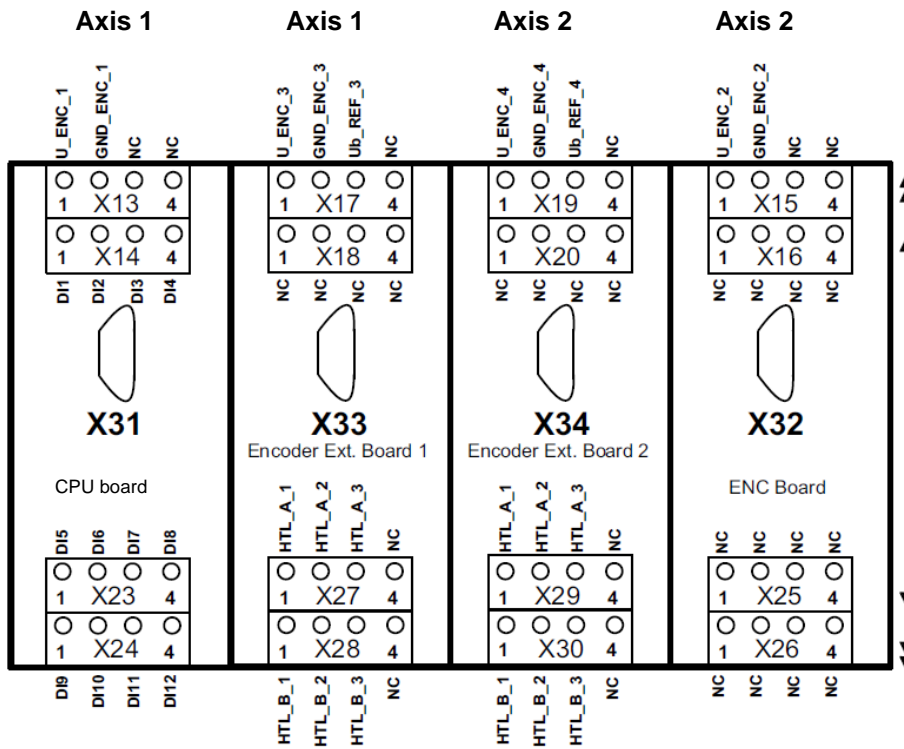
## 5.6.6 Terminal assignment KSM 122



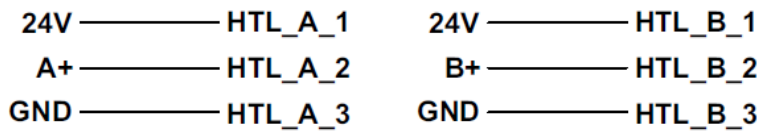
## 5.6.7 Terminal assignment KSM 122A



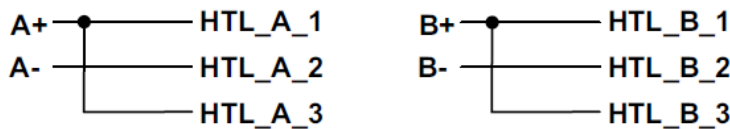
## 5.6.8 Terminal assignment KSM 122-2



HTL encoder connection: A+/B+

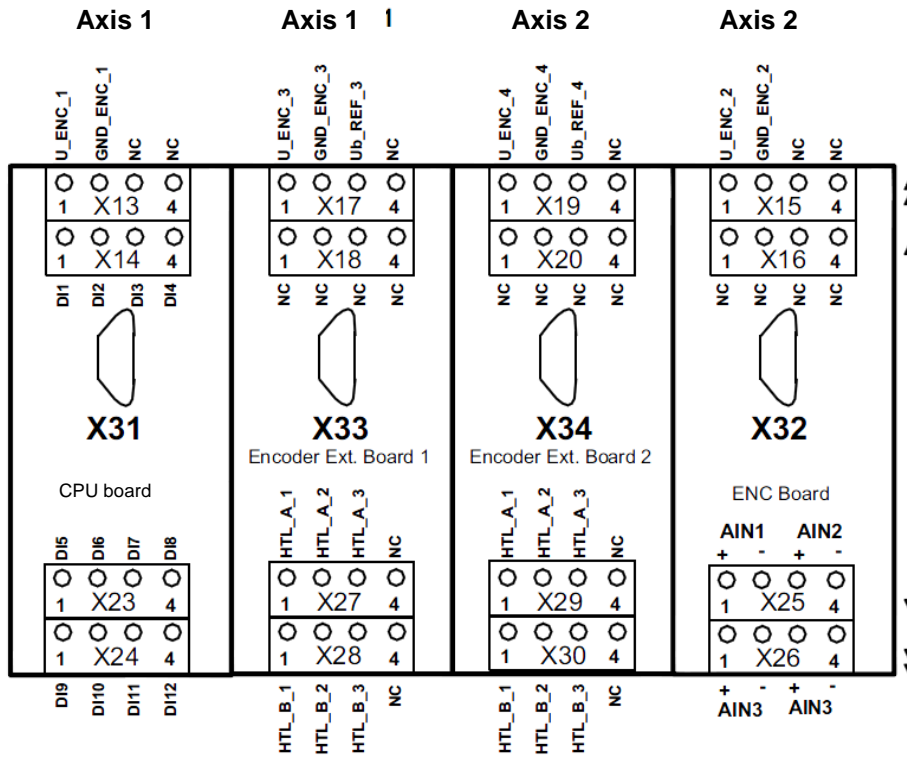


HTL encoder connection: A+,A-/B+,B-

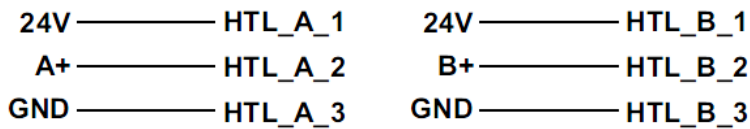


# Installation Manual

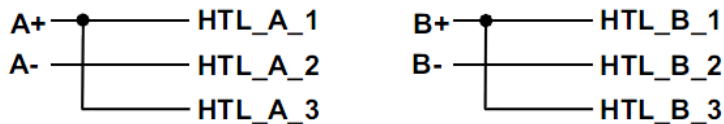
## 5.6.9 Terminal assignment KSM 122-2A



HTL encoder connection: A+/B+

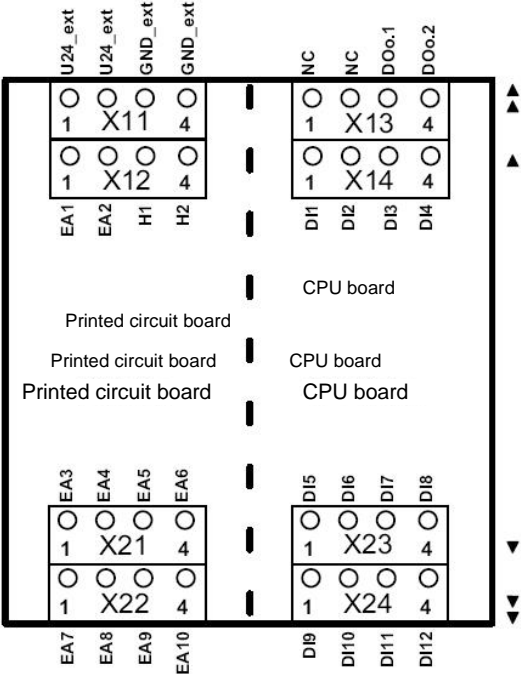


HTL encoder connection: A+,A-/B+,B-





## 5.6.10 Terminal assignment KSM 131



# Installation Manual

## 5.7 External 24 VDC – power supply

The KSM100 module requires a 24 VDC power supply (see also SELV or PELV, EN50178). Please comply with the following boundary conditions when planning and installing the specified power supply unit:

Strictly comply with the minimum and maximum supply voltage tolerance.

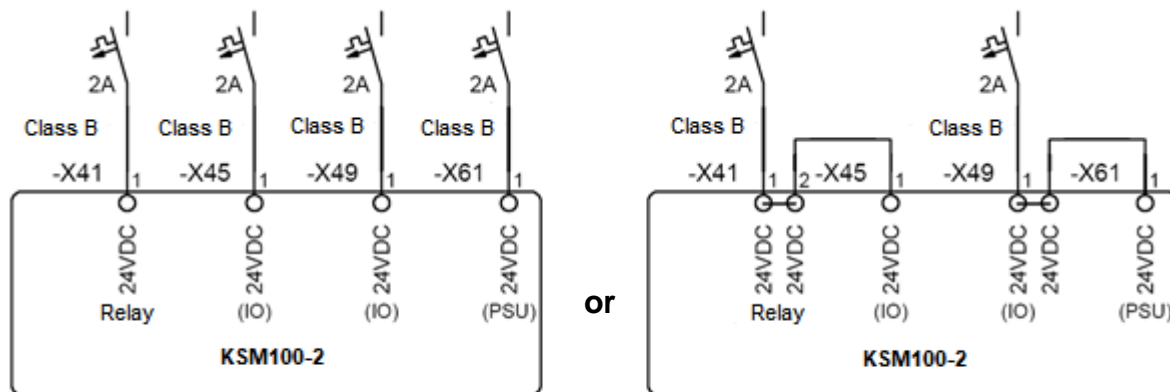
| <b>Nominal voltage</b> | <b>DC 24 V</b> |
|------------------------|----------------|
| Minimum: 24 VDC – 15 % | 20.4 VDC       |
| Maximum: 24 VDC + 20 % | 28.8 VDC       |

We recommend the use of a 3-phase power supply unit or an electronically controlled device to achieve an as little as possible residual ripple of the supply voltage. The power supply unit must meet the requirements acc. to EN61000-4-11 (voltage dip). Connecting cables must comply with local regulations.

The interference voltage resistance of the KSM100 module is 32 VDC (protected by suppressor diodes at the input).

**⚠ Safety note:**

- The 24V-DC supply connections on the KSM module must be fused with an external 2 A (24VDC) backup fuse.  
Recommended fuse type:  
2 A miniature circuit breaker (class B) or melting fuse (quick-acting).
- Depending on the electric power demand the fusing can be connected in sum or per I/O group.



Connection example with separated I/O supply!  
(when connecting I/Os with high current consumption)

Connection example with separated I/O supply!  
(when connecting I/Os with high current consumption)

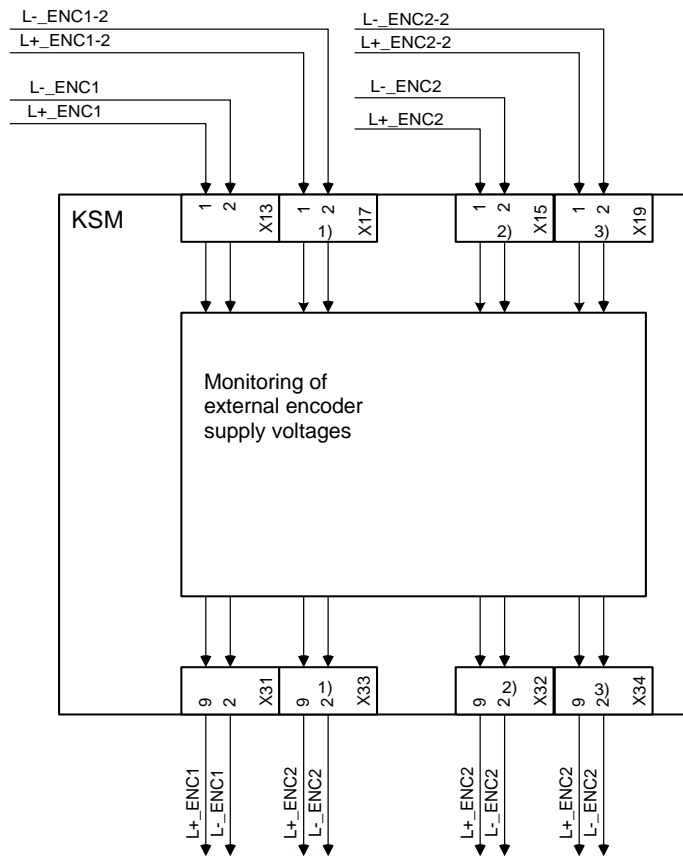
**Comments:**

Reliable galvanic isolation from the 230 VAC or 400 VAC network must be guaranteed in any case. This requires the selection of power supply units complying with the regulations DIN VDE 0551, EN 60 742 and DIN VDE 0160. Besides choosing a suitable device you must also ensure equipotential bonding between PE and 0-VDC on the secondary side.

# Installation Manual

## 5.8 Connection of the external encoder supply

### 5.8.1 Incremental, HTL, SIN/COS, SSI

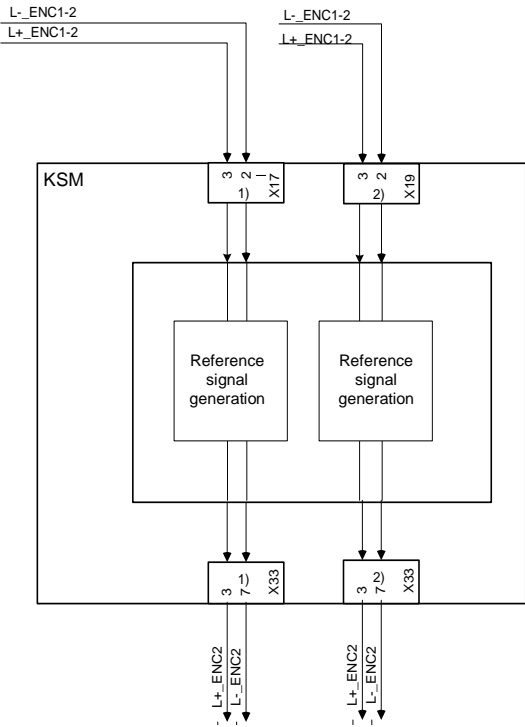


The KSM100 module supports encoder voltages of 5V, 8V, 10 V, 12V and 24V, which are internally monitored in accordance with the chosen configuration. If an encoder system is not supplied through the KSM100 module, a supply voltage still needs to be connected to terminal X13 or X15 and configured accordingly. The encoder supply must be protected with a fuse of max. 2A.

Monitoring of the supply voltage in accordance with the chosen nominal voltage:

| <b>Nominal voltage</b> | <b>Minimum voltage</b> | <b>Maximum voltage</b> |
|------------------------|------------------------|------------------------|
| 5 VDC                  | 4.4 VDC                | 5.6 VDC                |
| 8 VDC                  | 7 VDC                  | 9 VDC                  |
| 10 VDC                 | 8 VDC                  | 12 VDC                 |
| 12 VDC                 | 10 VDC                 | 14 VDC                 |
| 24 VDC                 | 20 VDC                 | 29 VDC                 |

## 5.8.2 Resolver



When using resolvers in Master-Mode an additional 24V DC power supply is required for generating the reference signal.

The encoder supply must be protected with a fuse of max. 2A.

Supply voltage monitoring:

| <b>Nominal voltage</b> | <b>Minimum voltage</b> | <b>Maximum voltage</b> |
|------------------------|------------------------|------------------------|
| 24 VDC                 | 20 VDC                 | 29 VDC                 |

## 5.9 Connection of digital inputs

The modules of the KSM100 system have 14 (KSM100-1/100-2/100-4) or 12 (KSM121, KSM121-2, KSM122, KSM122-2, KSM131) secure digital inputs. These are suitable for connecting single or two-channel signals with and without cycling, or without cross-shorting test.

The connected signals must have a “High”-level of DC 24 V (DC +15 V...+ DC 30 V ) and a “Low”-level of (DC -3 V...DC +5 V, type 1 acc. to EN61131-2). 24 VDC; +5 V, Type1 acc. to EN61131-2 The inputs are provided with internal input filters.

A device internal diagnostic function cyclically tests the correct function of the inputs including the input filters. A detected fault will set the KSM100 into an alarm status. At the same time all outputs of the KSM100 are rendered passive.

Besides the actual signal inputs, the KSM100 module holds two clock inputs P1 and P2 available. The clock outputs are switching-type 24 VDC outputs.

The clock outputs are solely intended for monitoring the digital inputs (DI1...DI14) and cannot be used for any other function within the application.

The switching frequency is 125 Hz for each output. In the planning stage one must bear in mind that the outputs may only be loaded with a total current of max. 250 mA.

Furthermore, approved OSSD-outputs can be connected to the inputs DI1-DI4 and DI9-DI14 without limitation

### **Note:**

**Digital inputs DI5 to DI8 are not suitable for OSSDs, because there is no compliance with EN 61131-2 Type 2 requirements.**

In case of single-channel use of the inputs, the achievable safety level must be limited to SIL 2 or PL d, if the safety function is demanded at regular intervals.

A safety related use of the inputs is generally only intended in connection with the pulse outputs.

If pulse outputs are not used, short circuits in the external wiring between different inputs and against the supply voltage for the KSM100 must be ruled out by external measures, appropriate routing of cables in particular.

**Each input of the KSM100 module can be configured individually for the following signal sources:**

Input assigned to pulse P1

Input assigned to pulse P2

Input assigned to continuous voltage DC 24 V

## 5.10 Connection of analog inputs

With versions KSM122A with analog processing max. 2 analog signals can be securely processed.

The analog inputs can be connected as follows:

|                | <i>min</i> | <i>max</i> |
|----------------|------------|------------|
| <b>Voltage</b> | -7VDC      | +10VDC     |

### **Note:**

The module is equipped with the fixed loading resistor of 500Ohm as standard. This resistor can be omitted is required (voltage input).

## 5.11 Connection of position and speed sensors

### 5.11.1 General notes

Depending on module type the KSM100 axis extension module (KSM121, KSM121-2, KSM122, KSM122-2) has (2/4) external encoder interfaces for the connection of industrial incremental and absolute encoders. The encoder interfaces can be configured as incremental, SIN/COS, absolute SSI-encoders or as Proxy.

It is also possible to connect two incremental signal generating sensors (e.g. proximity switches) to the counting inputs of the KSM100 module. The signals must each be read in with normal and complementary track.

### **IMPORTANT**

The voltage supply of the encoder system uses the dedicated terminals on the KSM100 module. This voltage is applied to the encoder plug and monitored by an internal diagnostic process. When the sensor is supplied with an external voltage, this voltage must be supplied through the encoder plug. The corresponding terminal (encoder supply voltage) on the KSM100 module remains unoccupied.

If an external sensor voltage supply is not recirculated through the encoder plug, any failure of this supply must be included in the fault examination of the overall system. This, in particular, requires evidence that this fault is detected or can be excluded when the specified operating voltage of the overall system is fallen short of / exceeded.

EMC - measures such as shielding etc. must be observed.

The two encoders must be non-interacting to each other. This applies for both the electrical as well as the mechanical part.

If both encoders are coupled to the facility to be monitored via common mechanical parts, the connection must be positively designed and should not have any parts that are susceptible to wear (chains, toothed belts, etc.). Should this be the case, additional monitoring features for the mechanical connection of the sensors (e.g. monitoring of a toothed belt) are required).

In case of an active position processing at least one absolute value encoder must be used.

When using two equivalent sensors one must make sure that the sensor with the higher resolution is configured as sensor 1 (process sensor) and the sensor with the lower resolution as sensor 2 (reference sensor).

**Attention:**

The sensor connections must neither be plugged on nor pulled off during operation. This could cause damage to electrical components of the encoder. Always de-energize connected encoders and the KSM100 module **before** plugging on or pulling off encoder connections.

Lines twisted in pairs for signal transmission acc. to RS485 standard must be used for data and clock signals or track A and track B. The wire cross-section must in each individual case be chosen in compliance with the current consumption of the encoder and the cable length required for the installation.

The following applies when using absolute encoders:

In Slave-mode the clock signal is generated by an external process and is read in by the KSM100 module together with the data signal. This type of reading causes a beat which results in a reading fault of the following magnitude:

$$F = (\text{reading time of encoder by external system [ms]} / 8 \text{ [ms]} ) * 100 \%$$

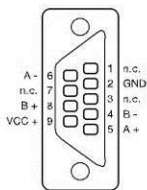
The size of the resulting reading fault F must be taken into account when determining the thresholds in the applied monitoring functions, because this fault cannot be compensated!

## 5.11.2 Assignment of encoder interface

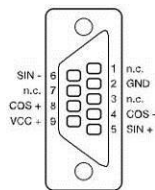
X31/X32<sup>1)</sup>

### Sensor assignment

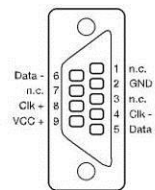
**Incremental - Encoder**



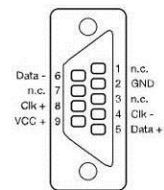
**SIN/COS**



**Absolut - Encoder**



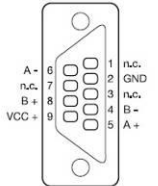
**SSI - Listener**



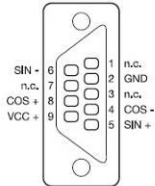
X33/X34<sup>2)</sup>

## Sensor assignment

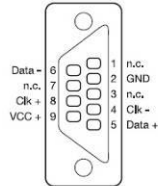
### Incremental - Encoder



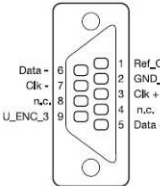
### SIN/COS



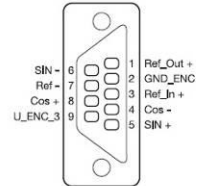
### SSI - Absolot X 31/X 32



### SSI - Absolot X 33/X 34

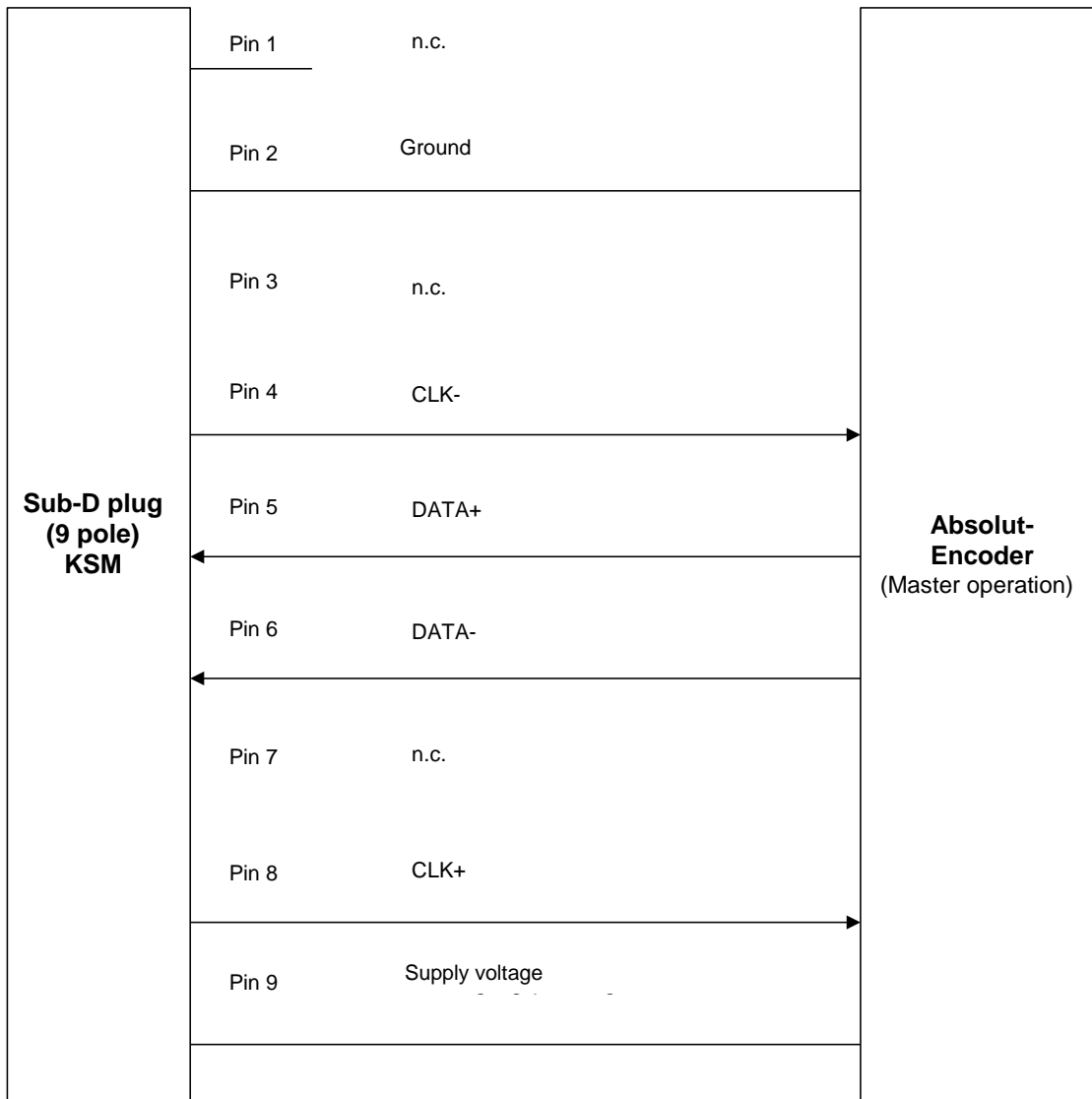


### Resolver



## 5.11.3 Connection variants

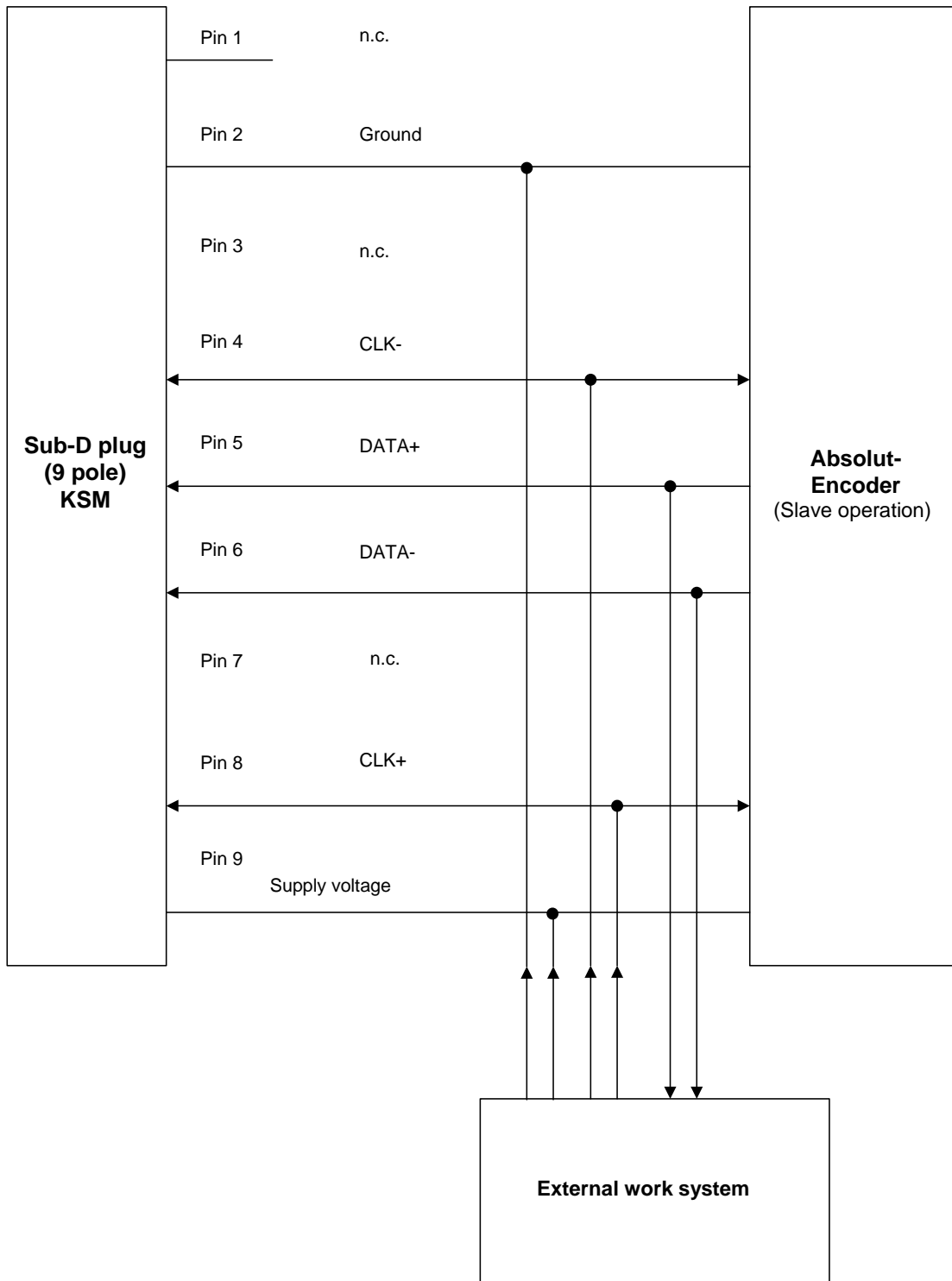
### 5.11.3.1 Connection of an absolute encoder as master





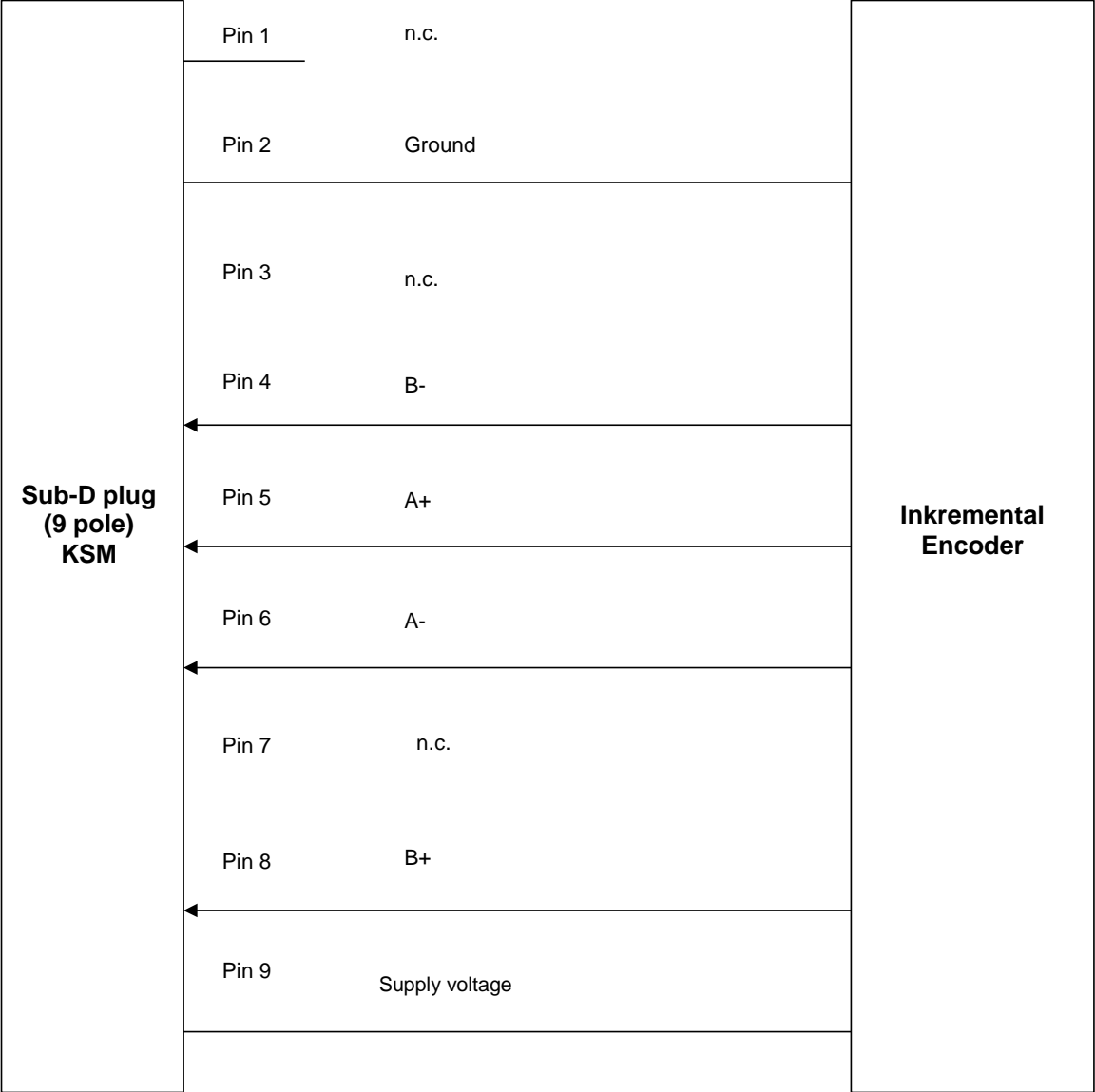
With this type of connection the clock signals are submitted from the KSM100 module to the absolute encoder and the data from the encoder to the KSM100.

### 5.11.3.2 Connection of an absolute encoder as slave



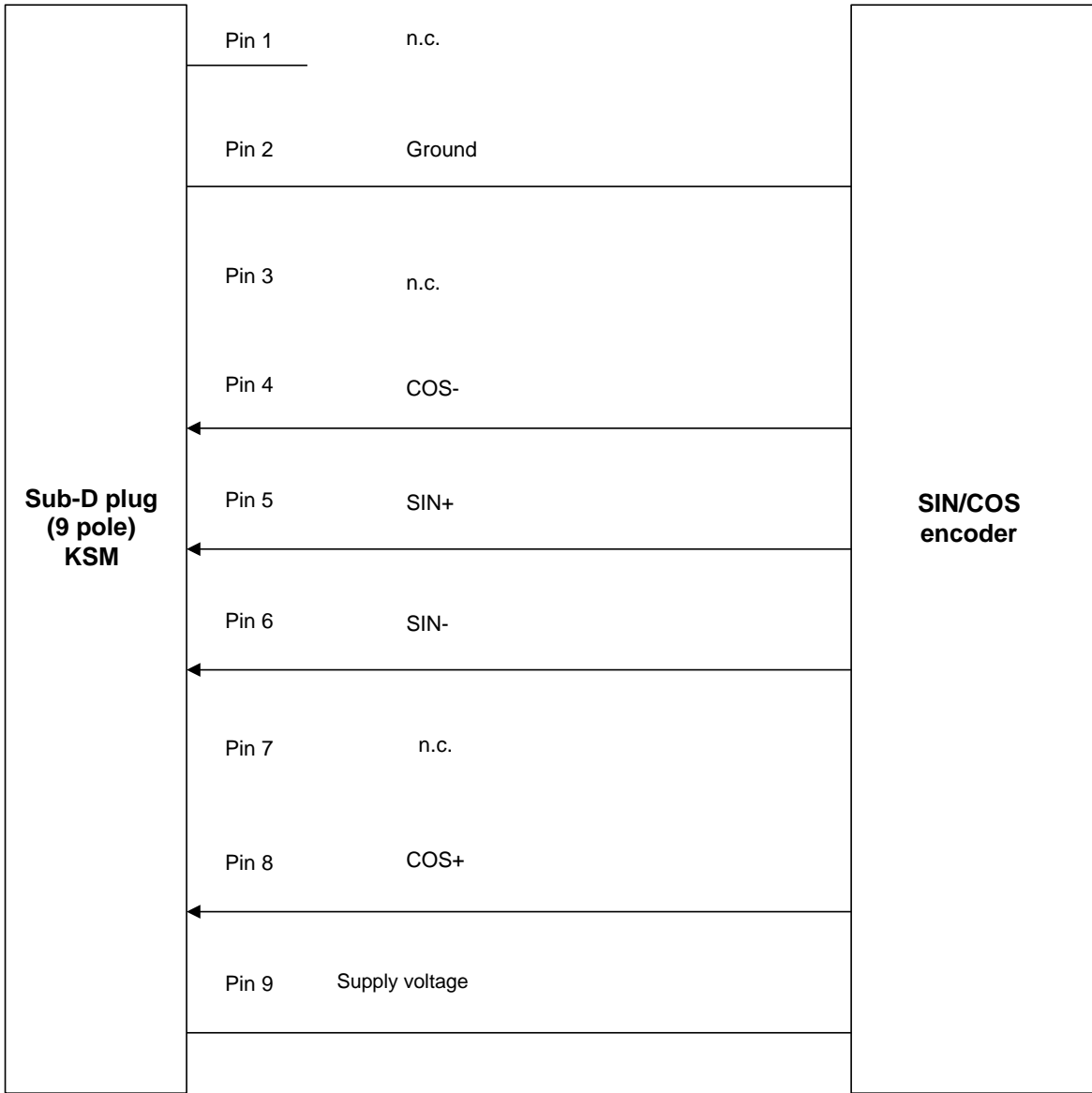
With this type of connection both clock signals and data are read in. In this example the module does not supply the encoder with voltage.

### 5.11.3.3 Connecting an incremental encoder with TTL-signal level



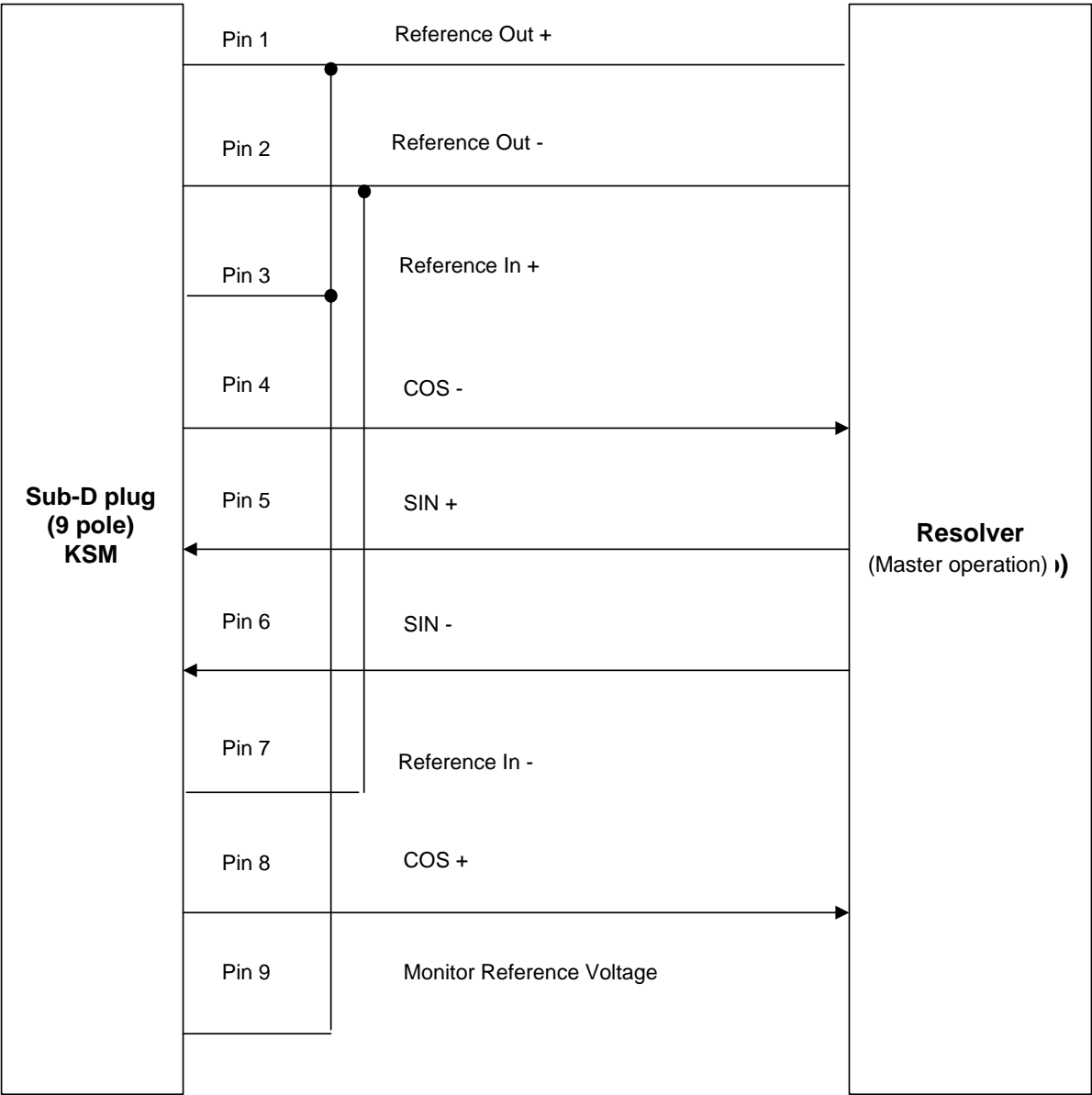
Pins 1, 3 and 7 stay open and are reserved for later expansions.

### 5.11.3.4 Connection of a SIN/COS encoder



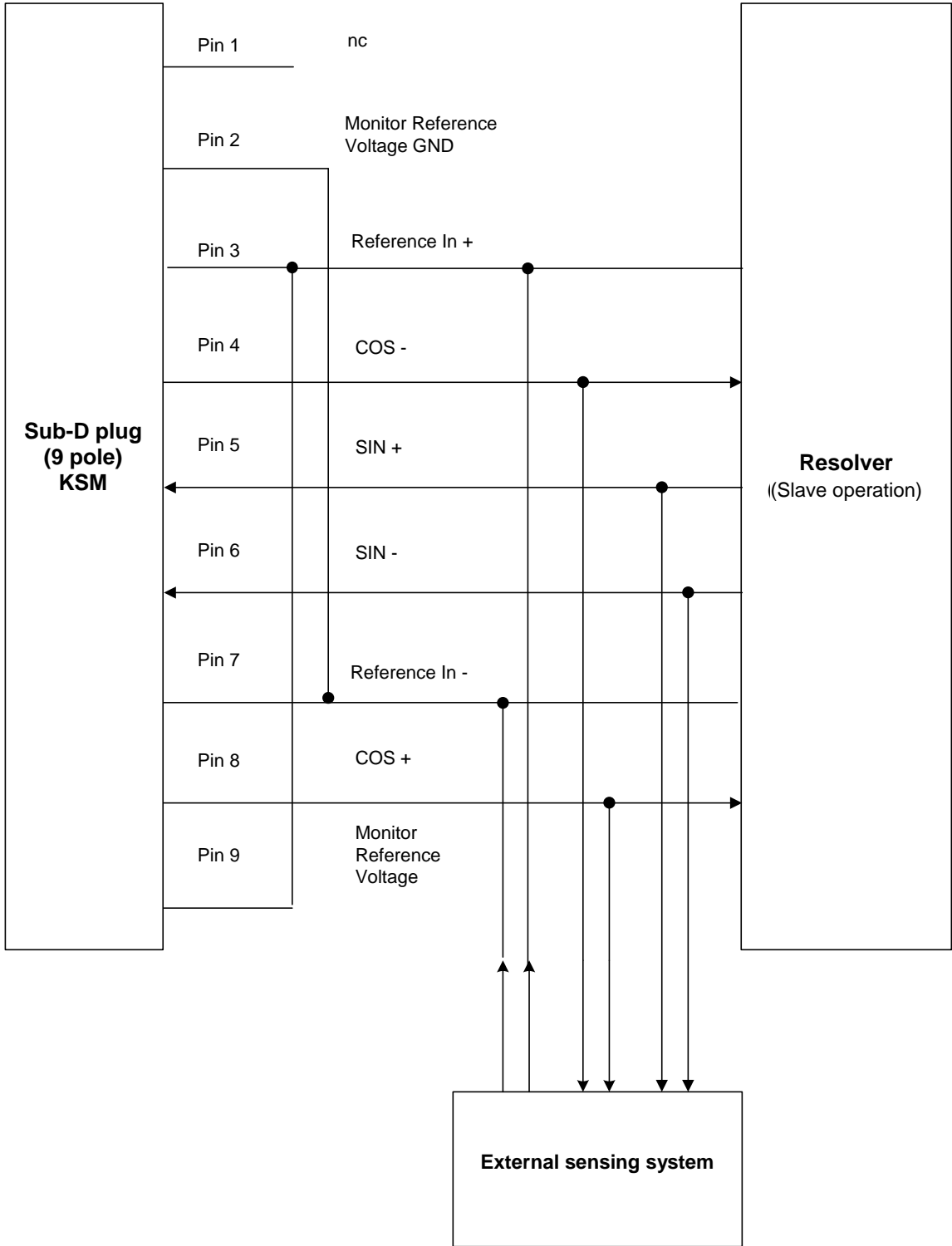
Pins 1, 3 and 7 stay open and are reserved for later expansions.

### 5.11.3.5 Connection of a resolver as master



With this type of connection the clock signals are submitted from the KSM100 module to the absolute encoder and the data from the encoder to the KSM100.

## 5.11.3.6 Connection of a resolver as slave



## 5.12 Configuration of measuring distances

### 5.12.1 General description of encoder configuration

The most important input variables for the monitoring functions of the module are safe position, speed and acceleration. These are obtained by dual-channel generation from the connected sensor system. A category 4 compliant architecture, i.e. continuous dual-channel recording with high degree of diagnostic coverage, is required for PI e acc. to EN 13849-1. For possible single-channel components (e.g. mechanical connection of the sensors/encoders with only one shaft/fastening) fault exclusions acc. to EN ISO 13849-2 may be used, if this should be necessary. For PI d acc. to EN 13849-1 one may work with a reduced degree or diagnostic coverage. Simple design sensor systems (speed monitoring only) may under certain circumstances be sufficient under due consideration of the permissible fault exclusions acc. to EN ISO 13849-2.

See also APPENDIX 1

Further configuration is described in the programming manual:  
37420-820-01-xxF-KSM100 Programierhandbuch.pdf

### 5.12.2 Sensor type

Absolute encoder and incremental measuring systems are possible, as well as counting pulse generating proximity switches

#### 5.12.2.1 Absolute encoder:

Data interface: Serial Synchronous Interface ( SSI ) with variable data length from 12 to 28 bit.  
Data format: Binary or Gray code,  
Physical Layer: RS-422 compatible

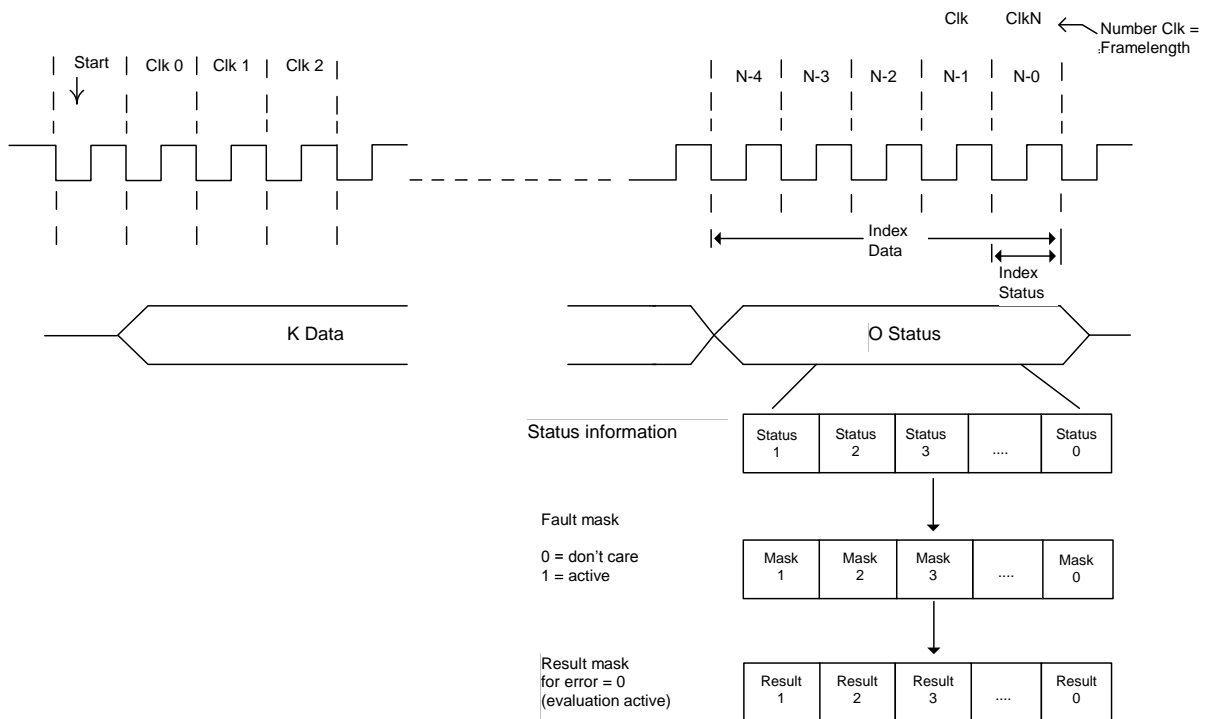
SSI-Master operation:  
Clock rate: 150kHz

SSI-Listener operation (slave mode):  
Max. external clock rate 200 KHz <sup>1)</sup> or 350 kHz <sup>2)</sup>.  
Min. clock pause time 30 µsec  
Max. clock pause time 1 msec

## Diagnoses:

| Diagnose                                  | Parameters  | Fault threshold                        |
|---|---|--|
| Supply voltage monitoring                 | Fixed values<br>5 V, 8 V, 10 V, 12 V,<br>20 V, 24 V | +/- 20 % +/- 2 % (measuring tolerance) |
| Monitoring of differential level on input | Fixed value RS 485-level                            | +/- 20 % +/- 2 % (measuring tolerance) |
| Monitoring of Clk-frequency               | Fixed value   | 100 kHz < f < 350 kHz                  |
| Plausibility of speed versus position     | Fixed value   | $DP < 2 * V * T$ with<br>T = 8 ms      |

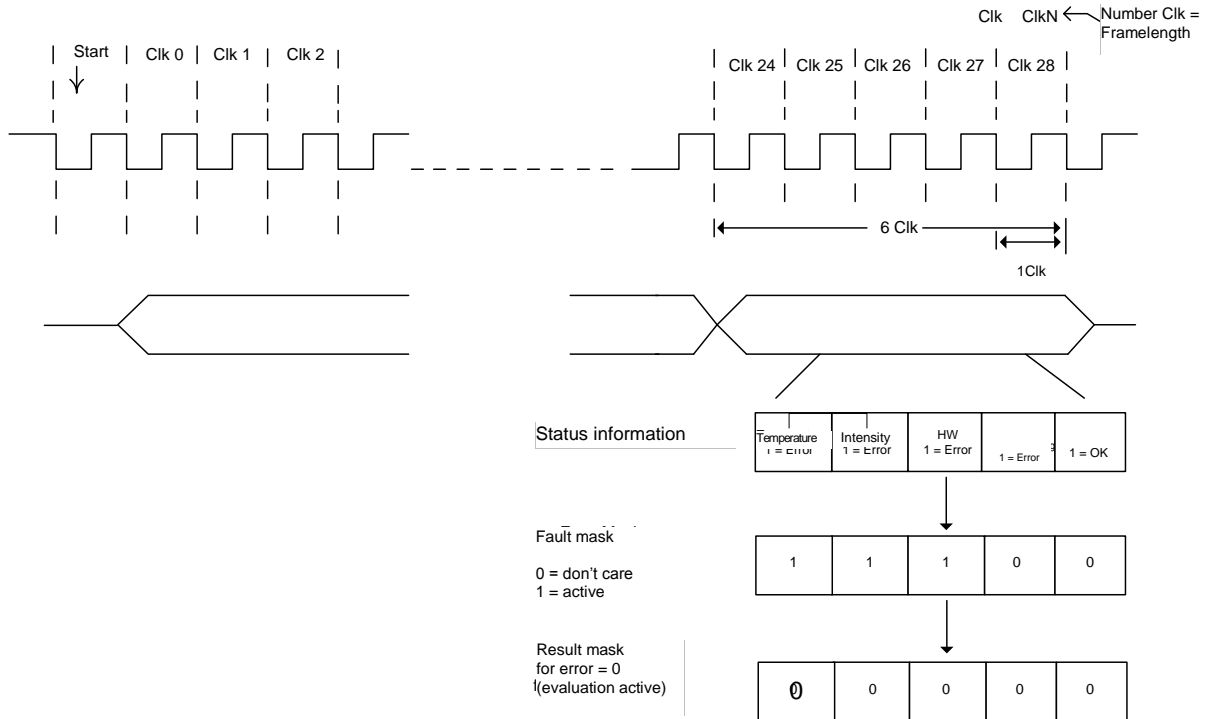
## Parametrization of SSI-format:



# Installation Manual

Example:

SSI-Frame length: 28 cycles  
 Data length: 22 bit  
 Status: 5 bit, 3 bit Fault + 2 bit Warning/ready for operation





# Installation Manual

## 5.12.2.2 Incremental encoder:

Physical Layer: RS-422 compatible  
 Measuring signal A/B. Track with 90 degree phase difference  
 maximum frequency of input cycles 200 KHz <sup>1)</sup> or 500 kHz <sup>2)</sup>

Diagnoses:

| Diagnose   | Parameters  | Fault threshold                      |
|--|---|--------------------------------------|
| Supply voltage monitoring                                      | Fixed values<br>5 V, 8 V, 10 V, 12 V, 20 V,<br>24 V | +/- 20 % +/-2 %(measuring tolerance) |
| Monitoring of differential level on input                      | Fixed value RS 485-level                            | +/- 20 % +/-2 %(measuring tolerance) |
| Monitoring of the counting signal separated for each track A/B | Fixed value   | DP > 4 increments                    |

## 5.12.2.3 SinusCosinus encoder – standard mode

Physical Layer: +/- 0.5 V<sub>ss</sub> (without voltage offset)  
 Measuring signal A/B. Track with 90 degree phase difference  
 Maximum frequency of input clock pulses. 200 KHz <sup>1)</sup> or 500 kHz <sup>2)</sup>

Diagnoses:

| Diagnose   | Parameters  | Fault threshold  |
|--|---|--|
| Supply voltage monitoring                                  | Fixed values<br>5 V, 8 V, 10 V, 12 V, 20 V,<br>24 V | +/- 20 % +/-2 %(measuring tolerance)                     |
| Monitoring of amplitude SIN <sup>2</sup> +COS <sup>2</sup> | Fixed value 1V <sub>SS</sub>                        | 65 % of 1 V <sub>SS</sub> +/- 2.5 %(measuring tolerance) |
| Monitoring of phases A/B                                   | Fixed value 90°                                     | +/- 30° +/-5° (measuring tolerance)                      |

## 5.12.2.4 SinusCosinus encoder – high resolution mode:

Physical Layer: +/- 0.5 V<sub>ss</sub> (without voltage offset)  
 Measuring signal A/B. Track with 90 degree phase difference  
 Maximum frequency of input clock pulses. 15 kHz <sup>2)</sup>

Diagnoses:

| Diagnose   | Parameters                                      | Fault threshold  |
|--|---|--|
| Supply voltage monitoring                                  | Fixed values<br>5 V, 8V, 10 V, 12 V, 20 V, 24 V | +/- 20 % +/-2 %(measuring tolerance)                   |
| Monitoring of amplitude SIN <sup>2</sup> +COS <sup>2</sup> | Fixed value 1V <sub>SS</sub>                    | 65% of 1 V <sub>SS</sub> +/- 2.5%(measuring tolerance) |
| Monitoring of phases A/B                                   | Fixed value 90°                                 | +/- 30° +/-5° (measuring tolerance)                    |
| Monitoring of counting signal / signal phase quadrant      | Fixed value                                     | +/- 45°  |

## 5.12.2.5 Proximity switch

Signal level. 24 V/0 V  
Max. counting frequency. 10 kHz  
Circuit logic de-bounced

Diagnoses:

| <b>Diagnose</b>           | <b>Parameters</b>                               | <b>Fault threshold</b>                |
|---------------------------|---|---------------------------------------|
| Supply voltage monitoring | Fixed values<br>5 V, 8 V, 10 V, 12 V, 20 V, 24V | +/- 20 % +/-2 % (measuring tolerance) |

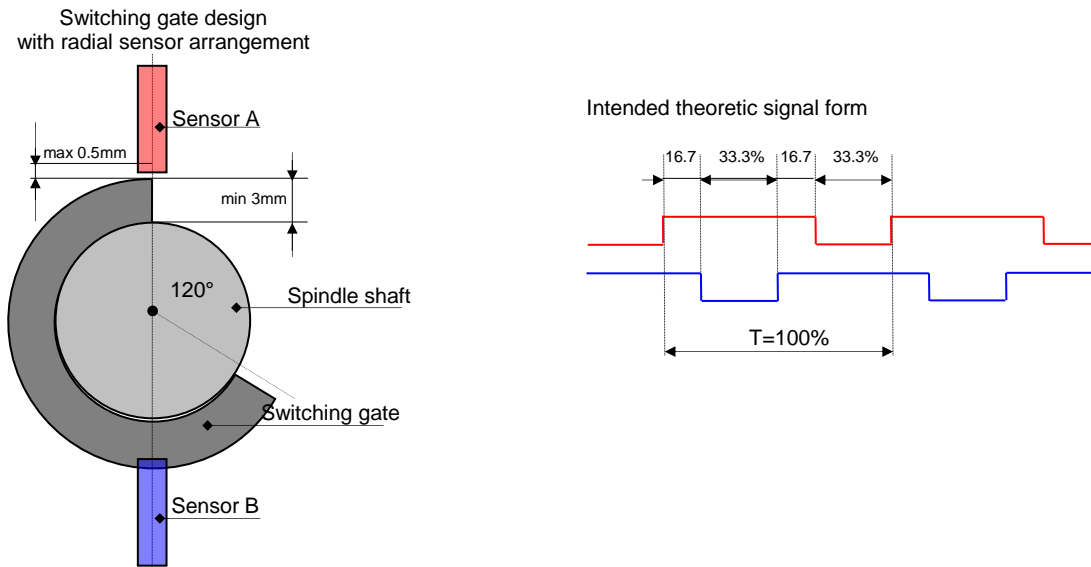
# Installation Manual

## 5.12.2.6 Extended monitoring proximity switch / proximity switch

The extended monitoring uncovers the following faults:

- a) Supply voltage failure
- b) Failure of output signal in driver direction
- c) Malfunction of High signal proximity switch
- d) Interruption of signal path
- e) Mechanical de-adjustment of proximity switch / excessive switching distance of proximity switch

For diagnostic purposes both status conditions of the counting signal are additionally recorded synchronously and compared logically. Attenuation of at least one of the two signals must be ensured by means of a switching gate. The logic will evaluate this instruction.



The diagnose must be designed for at least the following limiting values:

- Max. counting frequency: 4 kHz
- Max. blanking 0-signal: 50 %
- Min. coverage 10 %

Reading in counting signals:

The two counting signals are both separately assigned to the two channels. In each of the channels the status is read in synchronously. In order to ensure synchronization this must be carried out directly after the channel synchronization. Sampling must take place at least 1x per cycle. The max. deviation in synchronization is 20 μs.

The status conditions must be exchanged crosswise through the SPI.

Logic processing:

The following evaluation must be made in both channels:

| Signal A | Signal B | Result |
|----------|----------|--------|
| Low      | Low      | False  |
| High     | Low      | True   |
| Low      | High     | True   |
| High     | High     | True   |

## 5.12.2.7 HTL - Sensor

Signal level: 24V/0V  
 Physical Layer: Push/Pull  
 Measuring signal A/B: Track with 90° phase difference  
 Max. counting pulse frequency: 200 kHz on X27/28 or X29/30  
 (only KSM11-2/12-2)

Diagnoses:

| Diagnose   | Parameters  | Fault threshold                       |
|--|---|---------------------------------------|
| Supply voltage monitoring                                      | Fixed values<br>5 V, 8 V, 10 V, 12 V, 20 V,<br>24 V | +/- 20 % +/-2 % (measuring tolerance) |
| Monitoring of differential level on input                      | Fixed value 24 V                                    | +/- 20 % +/-2 % (measuring tolerance) |
| Monitoring of the counting signal separated for each track A/B | Fixed value   | DP > 4 increments                     |

## 5.12.2.8 Resolver

Measuring signal: SIN/COS – track with 90° phase difference  
 Max. counting pulse frequency: 2 kHz/pole  
 Resolution: 9 bit / pole  
Master-Mode:  
 Frequency reference signal: 8 kHz  
Slave-Mode  
 Frequency reference signal: 6 - 16 kHz  
 Reference signal form: Sinusoidal, triangle

<sup>1)</sup>on X31/32

<sup>2)</sup>on X31/34

Diagnoses:

| Diagnose  | Parameters   | Fault threshold                       |
|---|--|---------------------------------------|
| Monitoring of ratio   | Fixed values<br>2:1, 3:2, 4:1                                    | +/- 20 % +/-2 % (measuring tolerance) |
| Monitoring of signal amplitude SIN <sup>2</sup> +COS <sup>2</sup> | Fixed value  | <2.8 V +/-5 % (measuring tolerance)   |
| Monitoring of phases A/B  | Fixed value 90°  | +/- 7° +/-2° (measuring tolerance)    |
| Monitoring of reference frequency                                 | Fixed values<br>6 .. 12 kHz in steps of 1 kHz,<br>14 kHz, 16 kHz | +/- 20 % +/-5 % (measuring tolerance) |
| Form of reference signal  | Sinusoidal, triangle, no monitoring                              | 40 % form deviation                   |
| Monitoring of counting signal / signal phase quadrant             | Fixed value  | +/- 45°                               |

## 6 Response times of the KSM

The response time is a very important safety related characteristic and must be strictly observed for each application / application related safety function. The following chapter lists the response times for individual functions, probably also in dependence on further parameters. If these data are insufficient for a specific application you should validate the actual time behaviour against the nominal behaviour by means of separate measurements. This applies also for the use of filter functions in particular.

### Safety note:

- The response times must be determined for each application related safety function in nominal behaviour and must then be compared with the actual value by using the following data.
- Special care must be taken when using filter functions. Depending on the filter length / time the response time may be extended, which must be taken into account in the safety related design.
- In case of particularly critical problem formulations the temporal behaviour must be validated by means of measurements.
- During start-up of the device / alarm or fault reset the outputs may (depending on the application program) become active over the response time period. This must be taken into consideration when planning the safety function.

### 6.1 Response times in standard operation

The cycle time of the KSM system serves as basis for calculating the response times. It is optionally available in 3 stages and is during operation **T<sub>cycle</sub> = 16 / 24 / 32 ms**. The specified response times comply with the corresponding maximum running time for the actual application within the KSM100 module. Depending on the application, further, application dependent response times of the sensors and actuators used must be added, in order to obtain the total running time.

Response times when using digital inputs and outputs on the basic group

| <b>Function</b>   | <b>Response time [ms]</b> |           |           | <b>Explanation</b>  |
|---|---------------------------|-----------|-----------|---|
|   | <b>16</b>                 | <b>24</b> | <b>32</b> |   |
| <b>Cycle time</b>   | <b>16</b>                 | <b>24</b> | <b>32</b> |   |
| Activation of a monitoring function by means of ENABLE with subsequent shut-down via digital output   | 16<br>*)                  | 24<br>*)  | 32<br>*)  | Activation of a monitoring function by means of the ENABLE signal.  |
| Activation of a monitoring function by means of ENABLE with subsequent shut-down via safety relay   | 39<br>*)                  | 47<br>*)  | 55<br>*)  | Activation of a monitoring function by means of the ENABLE signal.  |
| Response of an already activated <b>monitoring function</b> including PLC editing in case of position and speed processing via digital output | 36<br>*)                  | 56<br>*)  | 70<br>*)  | With a monitoring function that has already been activated via ENABLE, the module requires <u>one</u> cycle to calculate the current speed value. During the next cycle after calculation of the monitoring function the information is further processed and output by the PLC, i.e. according to the implemented logic this will lead to e.g. switching of an output. |

| Function   | Response time [ms] |          |          | Explanation   |
|--|--------------------|----------|----------|---|
|  | 16                 | 24       | 32       |   |
| <b>Cycle time</b>  |                    |          |          |   |
| Response of an already activated <b>monitoring function</b> including PLC editing in case of position and speed processing via safety relays   | 59<br>*)           | 79<br>*) | 93<br>*) | With a monitoring function that has already been activated via ENABLE, the module requires <u>one</u> cycle to calculate the current speed value. During the next cycle after calculation of the monitoring function the information is further processed and output by the PLC, i.e. according to the implemented logic this will lead to e.g. switching of an output. |
| Activation of digital output via digital input   | 32                 | 48       | 64       | Activation of an input and switching of the output  |
| Activation output relay via digital input  | 42                 | 58       | 74       | Activation of an input and switching of the output  |
| Deactivation of digital output via digital input   | 32                 | 48       | 64       | Deactivation of an input and thus deactivation of the output  |
| Deactivation output relay via digital input  | 55                 | 71       | 87       | Deactivation of an input and thus deactivation of the output  |
| Average filter (setting see encoder dialog SafePLC)  | 0 - 64             | 0 - 64   | 0 - 64   | Group running time of the averager. This running time only effects the monitoring function in connection with position / speed / acceleration, but not the logic processing.  |
| Analog filter  |                    |          |          | The analog filter only affects the safe analog inputs of the KSM-12A module.  |
| <ul style="list-style-type: none"> <li>• 1 (2Hz)</li> <li>• 2 (2Hz)</li> <li>• 3 (2Hz)</li> <li>• 4 (4Hz)</li> <li>• 5 (6Hz)</li> <li>• 6 (8Hz)</li> <li>• 7 (10Hz)</li> <li>• 8 (20Hz)</li> </ul> | 760                | 760      | 760      | Response times of the analog input filters in relation to the input frequency   |
|  | 760                | 760      | 760      |   |
|  | 760                | 760      | 760      |   |
|  | 512                | 512      | 512      |   |
|  | 268                | 268      | 268      |   |
|  | 143                | 143      | 143      |   |
|  | 86                 | 86       | 86       |   |
|  | 56                 | 56       | 56       |   |

**Note:**

\*) : \*) : When using an average filter the response time of this filter must also be added

## 6.2 Response time for FAST\_CHANNEL

FAST\_CHANNEL describes a characteristic of KSM100 to respond quicker to speed requirements than this would be possible with the execution of the safety programs in normal cycle (= 16 / 24 / 32 msec). The FAST\_CHANNEL sampling time is 2 msec + 2 msec for signaling on the bus.

The following response times can be specified:

- 6 msec (Worst Case Condition)

**⚠ Safety note:**

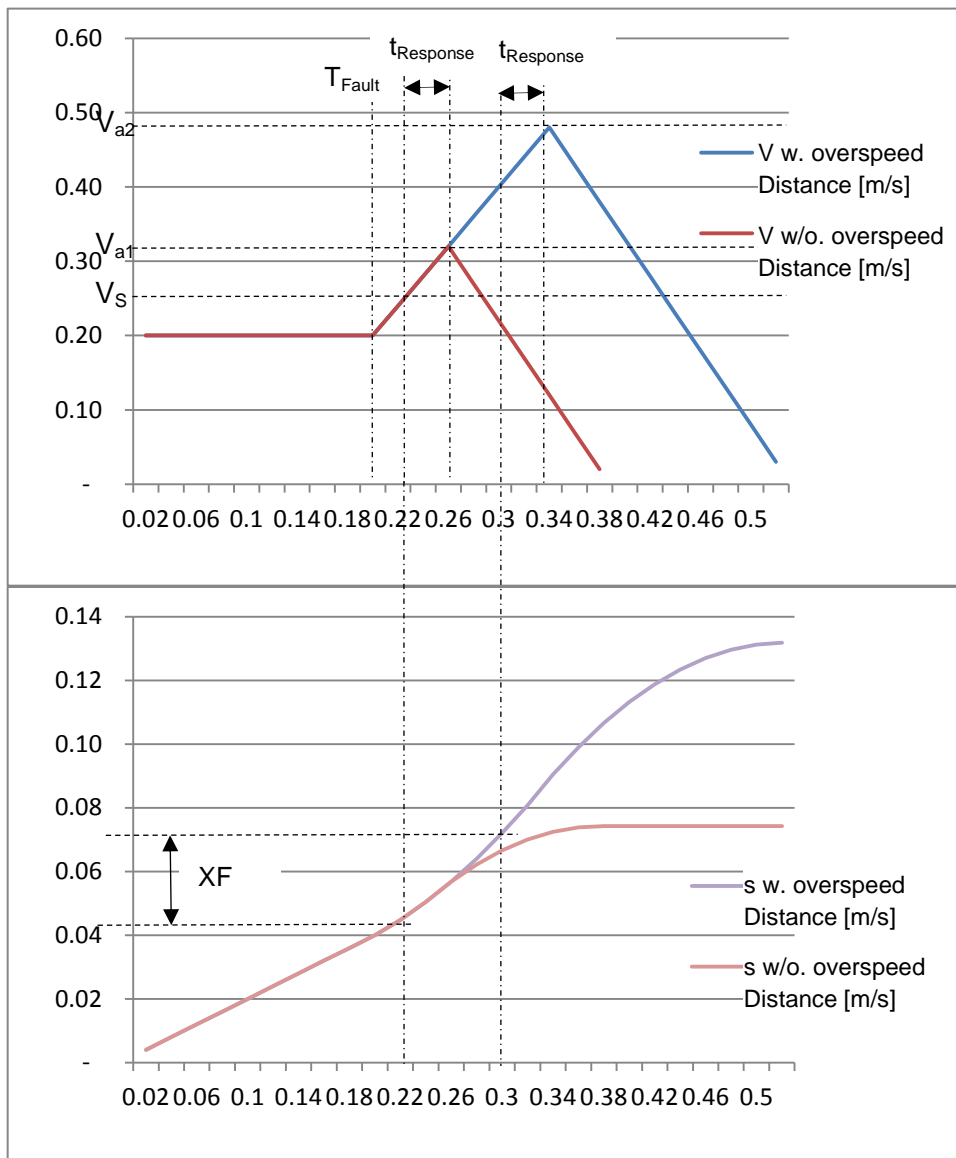
- When using FAST\_CHANNEL you should bear in mind that shutting down within the time specified above for a given speed threshold is only possible, if the sensor information has a sufficient resolution. The smallest resolvable switching threshold of the FAST\_CHANNEL requires at least 2 edge changes on the corresponding sensor system within a period of 2 msec.
- This function can only be used in connection with semi-conductor outputs.

## 6.3 Response times for fault distance monitoring

The following calculation schematic applies for calculating the Worst Case Scenario.

|  |   |
|--|---|
| System speed to the sampling instant                   | $V(t)$                                      |
| System speed in case of KSM response:                  | $V_A(t)$ Monitoring threshold (SLS or SCA): |
|  | $V_S = \text{constant for all } t$          |
| Parameterized filter value:                            | $XF = \text{constant for all } t$           |
| Maximum possible acceleration of the application:      | $a = \text{constant for all } t$            |
| Deceleration after shut-down:                          | $a_v = \text{constant for all } t$          |
| Sampling instant for occurrence of a Worst Case event: | $T_{\text{Fault}}$                          |
| Response time of the KSM-system:                       | $t_{\text{Response}}$                       |

For the Worst Case assessment it is assumed that the drive will initially move exactly to the parameterized threshold  $v_0$  with a speed  $v(k)$  and then will accelerate to the maximum possible value  $a_0$ .



**Diagram:** Behaviour of the drive with / without overspeed distance

Without overspeed distance the following connections result for the course of V and s.

| Parameters     | Calculation methods   | Comment  |
|----------------|---|--|
| $t_{Response}$ | Value from the specified response time KSM<br>+ deceleration time in external shut-down chain | Deceleration time in external shut-off chain derived from relay/contactors and brake data, etc. issued by the manufacturer |
| $a_F, a_V$     | n.a.  | Estimation of the application  |
| $V_{a1}$       | $= V_S + a_F * t_{Response}$  |  |



With overspeed distance the following connections result for the course of V and s.

| Parameters            | Calculation methods   | Comment  |
|-----------------------|---|--|
| $t_{\text{Response}}$ | Value from the specified response time KSM<br>+ deceleration time in external shut-down chain | Deceleration time in external shut-off chain derived from relay/contactors and brake data, etc. issued by the manufacturer |
| $a_F, a_V$            | n.a.  | Estimation of the application  |
| $V_{a2}$              | $= a_F * t_{\text{Response}} + (V_S^2 + 2 * a_F * XF)^{1/2}$                                  |  |

With its effect the filter displaces the set speed threshold  $V_a$  upwards by the amount **delta\_v\_filter**. For the application one must consider the new response time values ( $T_{\text{react}} = T_{\text{KSM}} + T_{\text{filter}}$ ), as well as the speed at shut-down by KSM100 resulting from this.

## 6.4 Response times when using digital inputs and outputs on the extension groups

The cycle time of the KSM system serves as basis for calculating the response times. In operation this is  **$T_{\text{cycle}} = 16 / 24 / 32 \text{ ms}$** . The specified response times comply with the corresponding maximum running time for the actual application within the KSM100 module. Depending on the application, further, application dependent response times of the sensors and actuators used must be added, in order to obtain the total running time.

| Function   | Designation            | Response time [ms]              | Explanation   |
|--|------------------------|---------------------------------|---|
| Worst Case deceleration time inlet in basic module to PAE                            | $T_{\text{IN\_BASE}}$  | $T_{\text{Cycle}}$              | e.g. activation of a monitoring function by an input signal in the basic module                                     |
| Worst Case deceleration time input extension module to PAE in basic module           | $T_{\text{IN\_Ext}}$   | $T_{\text{Cycle}} + 6\text{ms}$ | e.g. activation of a monitoring function by an input signal in the extension module KSM31                           |
| Processing time PAE to PAA in basic module   | $T_{\text{PLC}}$       | $T_{\text{Cycle}}$              | Shut-down by a monitoring function or an input in PAE   |
| Activation / deactivation digital output in basic module from PAA                    | $T_{\text{OUT\_BASE}}$ | -                               | Activation or deactivation of an output in the basic module after changes to the PAA.                               |
| Activation / deactivation digital output in extension module via PAA in basic module | $T_{\text{OUT\_Ext}}$  | $T_{\text{Cycle}} + 8\text{ms}$ | Activation or deactivation of an output in the extension module KSM31 after changes to the PAA in the basic module. |

## Determination of the total response time

$$T_{\text{TOTAL}} = T_{\text{IN}} + T_{\text{PLC}} + T_{\text{OUT}}$$

### Example 1:

Input to extension module, activation of SLS and processing in PLC, output to basic module.

$$T_{\text{TOTAL}} = T_{\text{IN\_Ext}} + T_{\text{PLC}} + T_{\text{OUT\_Base}} = T_{\text{Cycle}} + 6 \text{ ms} + T_{\text{Cycle}} + 0 \text{ ms} = 2 * T_{\text{Cycle}} + 6 \text{ ms};$$

### Example 2:

Input to basic module, activation of SLS and processing in PLC, output to extension module.

$$T_{\text{TOTAL}} = T_{\text{IN\_Base}} + T_{\text{PLC}} + T_{\text{OUT\_Ext}} = T_{\text{Cycle}} + T_{\text{Cycle}} + T_{\text{Cycle}} + 6 \text{ ms} = 3 * T_{\text{Cycle}} + 8 \text{ ms};$$

### Example 3:

Input to extension module, activation of SLS and processing in PLC, output to extension module.

$$T_{\text{TOTAL}} = T_{\text{IN\_Ext}} + T_{\text{PLC}} + T_{\text{OUT\_Ext}} = T_{\text{Cycle}} + 6 \text{ ms} + T_{\text{Cycle}} + T_{\text{Cycle}} + 8 \text{ ms} = 3 * T_{\text{Cycle}} + 14 \text{ ms};$$

## 7 Start-up

### 7.1 Procedure

Start-up must only be performed by qualified personnel!  
Strictly follow the safety regulations when commissioning!

### 7.2 Making sequences

The following phases are passed through and displayed by the front side seven segment display after each new start and fault-free running of the module:

| <i>7 segment display</i> | <i>Mode</i> | <i>Description</i>   |
|--------------------------|-------------|--|
| "1"                      | STARTUP     | Synchronization between both processor systems and checking of configuration/firmware data                                     |
| "2"                      | SENDCONFIG  | Distribution of configuration /firmware data and re-examination of these data. Subsequent area checking of configuration data. |
| "3"                      | STARTUP BUS | If available, initialization of a bus system   |
| "4"                      | RUN         | Normal system operation. All outputs are switched according to the current logic status.                                       |
| "5"                      | STOP        | In stop mode parameter and program data can be loaded externally.  |
| "A"                      | ALARM       | The alarm can be reset via the digital input or the front side reset button.   |
| "E"                      | ECS-Alarm   | The ECS alarm can be reset via the digital inputs or the front side reset button.  |
| "F"                      | Fault       | Fault can only be reset via ON/OFF of the module.  |

## 7.3 LED display

| <i>Colour</i> | <i>Mode</i> | <i>Description</i>                         |
|---------------|-------------|--|
| green         | “flashing”  | System OK, configuration validated         |
| yellow        | “flashing”  | System OK, configuration not yet validated |
| red           | “flashing”  | Alarm                                      |
| red           | “permanent” | Fatal Fault                                |

**Note:**

For all operating states except RUN the outputs are rendered passive by the firmware, i.e. safely switched off. In status RUN the state of the outputs depend on the implemented PLC-program.

## 7.4 Parameterization

Parameterization takes place via the program SafePLC KSM100. The transmission of these data to the module requires a programming adapter, the drivers of which must first be installed by the user.

Parameterization is described in the ***KSM100 programming manual***.

## 7.5 Function test

As a measure to ensure the safety of the module, the reliability of all safety functions must be checked once every year. For this purpose the modules used in the parameterization (inputs, outputs, monitoring functions and logic modules) must be checked with respect to function or shut-down.

See *programming manual*.

## 7.6 Validation

In order to assure the reliability of the implemented safety functions the user must check and document the parameters and links after the start-up and parameterization has taken place. This is supported by a validation assistant in the programming desktop (see chapter "Safety related examination").

## 8 Safety related examination

In order to assure the reliability of the implemented safety functions the user must check and document the parameters and links after the start-up and parameterization has taken place. This is supported by the parameterization software SafePLC KSM100 (see programming manual). On the first page one can enter general system data. The last page of the validation report contains individual evidence concerning the safety related examination.

**Here the following entries are mandatory:**

- Serial number (identical with the serial number on the type plate)
- Identity of the module

Here the responsible tester of the safety module confirms that the CRC's displayed in the programming desktop are identical with the CRC stored in the KSM100 module.

Once all header data have been entered, the validation report can be generated by pressing the control button "Save". The parameterization tool then creates a text file (.TXT) with the file name of the program data set. The text file contains the following information:

- The 3 pages of header data edited above
- The configuration of the encoder
- The parameters of the existing monitoring function
- The PLC program as instruction list

After the transmission of the configuration and program data to the KSM100 module the status LED flashes yellow. This indicates that the configuration data have not yet been validated. Pressing the button "LOCK CONFIGURATION" at the end of the validation dialog highlights the data as "Validated" and the LED flashes in green.

## 9 Maintenance

### 9.1 Modification / handling changes to the device

Maintenance work must solely be carried out by qualified personnel.  
Regular maintenance work is not required.

#### **Repair**

The devices must always be replaced as whole units  
Repair work on the device can only be performed in the factory.

#### **Warranty**

By opening the module without permission the warranty will become null and void.

#### **Note:**

By modifying the module the safety approval will become null and void!

### 9.2 Exchanging a module

The following should be noted when exchanging a module:

Disconnect the electric power converter from the main supply.  
Switch off the electric power supply for the device and disconnect.  
Pull off the encoder plug.  
Disconnect any other pluggable connections.  
Take the module off the top hat rail and pack up EMC-compliant.  
Mount the new module on the top hat rail.  
Reconnect all connections.  
Switch on the electric power converter.  
Switch on the supply voltage.  
Configure the device

#### **Note:**

Pluggable connections of the KSM100 module must generally not be disconnected or connected in live condition. There is a danger of sensor damage, particularly with connected position or speed sensors.

### 9.3 Maintenance intervals

|                    |                        |
|--------------------|------------------------|
| Module replacement | See technical data     |
| Function test      | See chapter "Start-up" |

## 10 Technical data

### 10.1 Environmental conditions

|                            |                        |
|----------------------------|------------------------|
| <b>Class of protection</b> | IP 52                  |
| <b>Ambient temperature</b> | 0°C* ... 50°C          |
| <b>Climatic category</b>   | 3 acc. to DIN 50 178   |
| <b>Lifetime</b>            | 90000h at 50°C ambient |

### 10.2 Safety related characteristic data

|   |  |
|---|--|
| <b>Max. obtainable safety class</b>                               | SIL 3 acc. to EN61508<br>Category 4 acc. to EN945-1<br>Performance-Level e acc. To<br>EN ISO 13849-1 |
| <b>System structure</b>   | 2-channel with diagnose (1002)   |
| <b>Rating of operating mode</b>                                   | “high demand” acc. to EN 61508 (high demand rate)  |
| <b>Probability of an endangering failure per hour (PFH-value)</b> | KSM100 < 1.4 E-8 (14FIT)   |
| <b>Proof-Test-Interval (EN61508)</b>                              | 20 years, after this time the module must be replaced  |





## 11.2 Alarm List KSM100

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3031 / A 3032</b>  |
| Alarm message     | Pulse1 plausibility fault on expansion inlet EAEx.1   |
| Cause             | Configured Pulse1 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3033 / A 3034</b>  |
| Alarm message     | Pulse2 plausibility fault on expansion inlet EAEx.1   |
| Cause             | Configured Pulse2 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3035 / A 3036</b>   |
| Alarm message     | Faulty 24V signal on EAEx.1  |
| Cause             | No permanent 24V voltage applied to this input   |
| Remedy            | Check the voltage on the digital input!<br>Check wiring<br>Check whether Pulse1 or Pulse2 is applied |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3037 / A 3038</b>  |
| Alarm message     | Pulse1 plausibility fault on expansion inlet EAEx.2   |
| Cause             | Configured Pulse1 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3039 / A 3040</b>  |
| Alarm message     | Pulse2 plausibility fault on expansion inlet EAEx.2   |
| Cause             | Configured Pulse2 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3041 / A 3042</b>   |
| Alarm message     | Faulty 24V signal on EAEx.2  |
| Cause             | No permanent 24V voltage applied to this input   |
| Remedy            | Check the voltage on the digital input!<br>Check wiring<br>Check whether Pulse1 or Pulse2 is applied |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3043 / A 3044</b>  |
| Alarm message     | Pulse1 plausibility fault on expansion inlet EAEx.3   |
| Cause             | Configured Pulse1 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3045 / A 3046</b>  |
| Alarm message     | Pulse2 plausibility fault on expansion inlet EAEx.3   |
| Cause             | Configured Pulse2 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3047 / A 3048</b>   |
| Alarm message     | Faulty 24V signal on EAEx.3  |
| Cause             | No permanent 24V voltage applied to this input   |
| Remedy            | Check the voltage on the digital input!<br>Check wiring<br>Check whether Pulse1 or Pulse2 is applied |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3049 / A 3050</b>  |
| Alarm message     | Pulse1 plausibility fault on expansion inlet EAEx.4   |
| Cause             | Configured Pulse1 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3051 / A 3052</b>  |
| Alarm message     | Pulse2 plausibility fault on expansion inlet EAEx.4   |
| Cause             | Configured Pulse2 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3053 / A 3054</b>   |
| Alarm message     | Faulty 24V signal on EAEx.4  |
| Cause             | No permanent 24V voltage applied to this input   |
| Remedy            | Check the voltage on the digital input!<br>Check wiring<br>Check whether Pulse1 or Pulse2 is applied |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3055 / A 3056</b>  |
| Alarm message     | Pulse1 plausibility fault on expansion inlet EAEx.5   |
| Cause             | Configured Pulse1 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3057 / A 3058</b>  |
| Alarm message     | Pulse2 plausibility fault on expansion inlet EAEx.5   |
| Cause             | Configured Pulse2 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3059 / A 3060</b>   |
| Alarm message     | Faulty 24V signal on EAEx.5  |
| Cause             | No permanent 24V voltage applied to this input   |
| Remedy            | Check the voltage on the digital input!<br>Check wiring<br>Check whether Pulse1 or Pulse2 is applied |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3061 / A 3062</b>  |
| Alarm message     | Pulse1 plausibility fault on expansion inlet EAEx.6   |
| Cause             | Configured Pulse1 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3063 / A 3064</b>  |
| Alarm message     | Pulse2 plausibility fault on expansion inlet EAEx.6   |
| Cause             | Configured Pulse2 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3065 / A 3066</b>  |
| Alarm message     | Pulse1 plausibility fault on expansion inlet EAEx.7   |
| Cause             | Configured Pulse1 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3067 / A 3068</b>  |
| Alarm message     | Pulse1 plausibility fault on expansion inlet EAEx.7   |
| Cause             | Configured Pulse1 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3069 / A 3070</b>  |
| Alarm message     | Pulse2 plausibility fault on expansion inlet EAEx.7   |
| Cause             | Configured Pulse2 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3071 / A 3072</b>   |
| Alarm message     | Faulty 24V signal on EAEx.7  |
| Cause             | No permanent 24V voltage applied to this input   |
| Remedy            | Check the voltage on the digital input!<br>Check wiring<br>Check whether Pulse1 or Pulse2 is applied |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3073 / A 3074</b>  |
| Alarm message     | Pulse1 plausibility fault on expansion inlet EAEx.8   |
| Cause             | Configured Pulse2 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3075 / A 3076</b>  |
| Alarm message     | Pulse2 plausibility fault on expansion inlet EAEx.8   |
| Cause             | Configured Pulse2 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3077 / A 3078</b>   |
| message           | Faulty 24V signal on EAEx.8  |
| Cause             | No permanent 24V voltage applied to this input   |
| Remedy            | Check the voltage on the digital input!<br>Check wiring<br>Check whether Pulse1 or Pulse2 is applied |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3079 / A 3080</b>  |
| Alarm message     | Pulse1 plausibility fault on expansion inlet EAEx.9   |
| Cause             | Configured Pulse2 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3081 / A 3082</b>  |
| Alarm message     | Pulse2 plausibility fault on expansion inlet EAEx.9   |
| Cause             | Configured Pulse2 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3083 / A 3084</b>   |
| Alarm message     | Faulty 24V signal on EAEx.9  |
| Cause             | No permanent 24V voltage applied to this input   |
| Remedy            | Check the voltage on the digital input!<br>Check wiring<br>Check whether Pulse1 or Pulse2 is applied |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3085 / A 3086</b>  |
| Alarm message     | Pulse1 plausibility fault on expansion inlet EAEx.10  |
| Cause             | Configured Pulse2 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3087 / A 3088</b>  |
| Alarm message     | Pulse2 plausibility fault on expansion inlet EAEx.10  |
| Cause             | Configured Pulse2 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3089 / A 3090</b>   |
| Alarm message     | Faulty 24V signal on EAEx.10   |
| Cause             | No permanent 24V voltage applied to this input   |
| Remedy            | Check the voltage on the digital input!<br>Check wiring<br>Check whether Pulse1 or Pulse2 is applied |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3101 / A 3102</b>  |
| Alarm message     | Pulse1 plausibility fault on input DI1  |
| Cause             | Configured Pulse1 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3103 / A 3104</b>  |
| Alarm message     | Pulse1 plausibility fault on input DI2  |
| Cause             | Configured Pulse1 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3105 / A 3106</b>  |
| Alarm message     | Pulse1 plausibility fault on input DI3  |
| Cause             | Configured Pulse1 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3107 / A 3108</b>  |
| Alarm message     | Pulse1 plausibility fault on input DI4  |
| Cause             | Configured Pulse1 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3109 / A 3110</b>  |
| Alarm message     | Pulse1 plausibility fault on input DI5  |
| Cause             | Configured Pulse1 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3111 / A 3112</b>  |
| Alarm message     | Pulse1 plausibility fault on input DI6  |
| Cause             | Configured Pulse1 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3113 / A 3114</b>  |
| Alarm message     | Pulse1 plausibility fault on input DI7  |
| Cause             | Configured Pulse1 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3115 / A 3116</b>  |
| Alarm message     | Pulse1 plausibility fault on input DI8  |
| Cause             | Configured Pulse1 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3117 / A 3118</b>  |
| Alarm message     | Pulse2 plausibility fault on input DI1  |
| Cause             | No Pulse2 voltage applied to this input   |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3119 / A 3120</b>  |
| Alarm message     | Pulse2 plausibility fault on input DI2  |
| Cause             | No Pulse2 voltage applied to this input   |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3121 / A 3122</b>  |
| Alarm message     | Pulse2 plausibility fault on input DI3  |
| Cause             | No Pulse2 voltage applied to this input   |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3123 / A 3124</b>  |
| Alarm message     | Pulse2 plausibility fault on input DI4  |
| Cause             | No Pulse2 voltage applied to this input   |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3125 / A 3126</b>  |
| Alarm message     | Pulse2 plausibility fault on input DI5  |
| Cause             | No Pulse2 voltage applied to this input   |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3127 / A 3128</b>  |
| Alarm message     | Pulse2 plausibility fault on input DI6  |
| Cause             | No Pulse2 voltage applied to this input   |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3129 / A 3130</b>  |
| Alarm message     | Pulse2 plausibility fault on input DI7  |
| Cause             | No Pulse2 voltage applied to this input   |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |



|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3131 / A 3132</b>  |
| Alarm message     | Pulse2 plausibility fault on input DI8  |
| Cause             | No Pulse2 voltage applied to this input   |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3133 / A 3134</b>  |
| Alarm message     | Pulse1 plausibility fault on input DI9  |
| Cause             | Configured Pulse1 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3135 / A 3136</b>  |
| Alarm message     | Pulse1 plausibility fault on input DI10   |
| Cause             | Configured Pulse1 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3137 / A 3138</b>  |
| Alarm message     | Pulse1 plausibility fault on input DI11   |
| Cause             | Configured Pulse1 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3139 / A 3140</b>  |
| Alarm message     | Pulse1 plausibility fault on input DI12   |
| Cause             | Configured Pulse1 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3141 / A 3142</b>  |
| Alarm message     | Pulse1 plausibility fault on input DI13   |
| Cause             | Configured Pulse1 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3143 / A 3144</b>  |
| Alarm message     | Pulse1 plausibility fault on input DI14   |
| Cause             | Configured Pulse1 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3147 / A 3148</b>  |
| Alarm message     | Pulse2 plausibility fault on input DI9  |
| Cause             | Configured Pulse2 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input DI9 acc. to planning and circuit diagram<br>Check wiring |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3149 / A 3150</b>   |
| Alarm message     | Pulse2 plausibility fault on input DI10  |
| Cause             | Configured Pulse2 voltage not applied to this input.   |
| Remedy            | Check the configuration of the digital input DI10 acc. to planning and circuit diagram<br>Check wiring |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3151 / A 3152</b>   |
| Alarm message     | Pulse2 plausibility fault on input DI11  |
| Cause             | Configured Pulse2 voltage not applied to this input.   |
| Remedy            | Check the configuration of the digital input DI11 acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3153 / A 3154</b>  |
| Alarm message     | Pulse2 plausibility fault on input DI12   |
| Cause             | Configured Pulse2 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3155 / A 3156</b>  |
| Alarm message     | Pulse2 plausibility fault on input DI13   |
| Cause             | Configured Pulse2 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3157 / A 3158</b>  |
| Alarm message     | Pulse2 plausibility fault on input DI14   |
| Cause             | Configured Pulse2 voltage not applied to this input.  |
| Remedy            | Check the configuration of the digital input acc. to planning and circuit diagram<br>Check wiring |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3159 / A 3160</b>   |
| Alarm message     | Faulty 24V signal on DI1   |
| Cause             | No permanent 24V voltage applied to this input   |
| Remedy            | Check the voltage on the digital input!<br>Check wiring<br>Check whether Pulse1 or Pulse2 is applied |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3161 / A 3162</b>   |
| Alarm message     | Faulty 24V signal on DI2   |
| Cause             | No permanent 24V voltage applied to this input   |
| Remedy            | Check the voltage on the digital input!<br>Check wiring<br>Check whether Pulse1 or Pulse2 is applied |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3163 / A 3164</b>   |
| Alarm message     | Faulty 24V signal on DI3   |
| Cause             | No permanent 24V voltage applied to this input   |
| Remedy            | Check the voltage on the digital input!<br>Check wiring<br>Check whether Pulse1 or Pulse2 is applied |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3165 / A 3166</b>   |
| Alarm message     | Faulty 24V signal on DI4   |
| Cause             | No permanent 24V voltage applied to this input   |
| Remedy            | Check the voltage on the digital input!<br>Check wiring<br>Check whether Pulse1 or Pulse2 is applied |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3167 / A 3168</b>   |
| Alarm message     | Faulty 24V signal on DI5   |
| Cause             | No permanent 24V voltage applied to this input   |
| Remedy            | Check the voltage on the digital input!<br>Check wiring<br>Check whether Pulse1 or Pulse2 is applied |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3169 / A 3170</b>   |
| Alarm message     | Faulty 24V signal on DI6   |
| Cause             | No permanent 24V voltage applied to this input   |
| Remedy            | Check the voltage on the digital input!<br>Check wiring<br>Check whether Pulse1 or Pulse2 is applied |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3171 / A 3172</b>   |
| Alarm message     | Faulty 24V signal on DI7   |
| Cause             | No permanent 24V voltage applied to this input   |
| Remedy            | Check the voltage on the digital input!<br>Check wiring<br>Check whether Pulse1 or Pulse2 is applied |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3173 / A 3174</b>   |
| Alarm message     | Faulty 24V signal on DI8   |
| Cause             | No permanent 24V voltage applied to this input   |
| Remedy            | Check the voltage on the digital input!<br>Check wiring<br>Check whether Pulse1 or Pulse2 is applied |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3175 / A 3176</b>   |
| Alarm message     | Faulty 24V signal on DI9   |
| Cause             | No permanent 24V voltage applied to this input   |
| Remedy            | Check the voltage on the digital input!<br>Check wiring<br>Check whether Pulse1 or Pulse2 is applied |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3177 / A 3178</b>   |
| Alarm message     | Faulty 24V signal on DI10  |
| Cause             | No permanent 24V voltage applied to this input   |
| Remedy            | Check the voltage on the digital input!<br>Check wiring<br>Check whether Pulse1 or Pulse2 is applied |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3179 / A 3180</b>   |
| Alarm message     | Faulty 24V signal on DI11  |
| Cause             | No permanent 24V voltage applied to this input   |
| Remedy            | Check the voltage on the digital input!<br>Check wiring<br>Check whether Pulse1 or Pulse2 is applied |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3181 / A 3182</b>   |
| Alarm message     | Faulty 24V signal on DI12  |
| Cause             | No permanent 24V voltage applied to this input   |
| Remedy            | Check the voltage on the digital input!<br>Check wiring<br>Check whether Pulse1 or Pulse2 is applied |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3183 / A 3184</b>   |
| Alarm message     | Faulty 24V signal on DI13  |
| Cause             | No permanent 24V voltage applied to this input   |
| Remedy            | Check the voltage on the digital input!<br>Check wiring<br>Check whether Pulse1 or Pulse2 is applied |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3185 / A 3186</b>   |
| Alarm message     | Faulty 24V signal on DI14  |
| Cause             | No permanent 24V voltage applied to this input   |
| Remedy            | Check the voltage on the digital input!<br>Check wiring<br>Check whether Pulse1 or Pulse2 is applied |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3191 / A 3192</b>                                     |
| Alarm message     | Short-circuit fault digital inputs                         |
| Cause             | Short circuit between the digital inputs within the module |
| Remedy            | Consult the manufacturer                                   |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3197 / A 3198</b>                         |
| Alarm message     | Faulty OSSD input test                         |
| Cause             | OSSD test faulty                               |
| Remedy            | 24V check the input voltage on all OSSD inputs |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3209 / A 3210</b>  |
| Fault message     | Encoder supply voltage X31 faulty.  |
| Cause             | Encoder supply voltage does not comply with configured threshold<br>Component fault in module |
| Remedy            | Check configuration!<br>Check encoder supply voltage<br>Switch device off/on.                 |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3213 / A 3214</b>  |
| Fault message     | Encoder supply voltage X32 faulty.  |
| Cause             | Encoder supply voltage does not comply with configured threshold<br>Component fault in module |
| Remedy            | Check configuration!<br>Check encoder supply voltage<br>Switch device off/on.                 |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3225 / A 3226</b>  |
| Fault message     | Deviation Ain1 to Ain2 too big  |
| Cause             | Different voltages on both inputs<br>configured threshold too low                                 |
| Remedy            | Check voltages on Ain1!<br>Check configuration of threshold/input filter<br>Switch device off/on. |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3227 / A 3228</b>  |
| Fault message     | Deviation Ain3 to Ain4 too big  |
| Cause             | Different voltages on both inputs<br>configured threshold too low                                 |
| Remedy            | Check voltages on Ain1!<br>Check configuration of threshold/input filter<br>Switch device off/on. |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3229 / A 3230</b>   |
| Fault message     | Plausibility test for encoder voltage faulty                           |
| Cause             | Encoder voltage value  |
| Remedy            | Check encoder voltage supply<br>Check wiring of encoder voltage supply |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3231 / A 3232</b>   |
| Fault message     | Plausibility test for analog inputs faulty                             |
| Cause             | Fault in analog input signal   |
| Remedy            | Check connection of analog inputs<br>Analog input voltage out of range |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3233 / A 3234</b>  |
| Fault message     | Open-circuit monitoring AIN1 has triggered                          |
| Cause             | Open-circuit monitoring activated (< 1000mV)                        |
| Remedy            | Check configuration of activation/sensor<br>Check sensor connection |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3235 / A 3236</b>  |
| Fault message     | Open-circuit monitoring AIN2 has triggered                          |
| Cause             | Open-circuit monitoring activated (< 1000mV)                        |
| Remedy            | Check configuration of activation/sensor<br>Check sensor connection |

|                   |                        |
|-------------------|------------------------|
| <b>Alarm code</b> | <b>A 3237 / A 3238</b> |
| Fault message     | Analog adder overflow  |
| Cause             |                        |
| Remedy            |                        |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3301 / A 3302</b>   |
| Alarm message     | Plausibility fault speed sensing axis 1  |
| Cause             | The difference between the two speed sensors is higher than the configured speed shut-down threshold   |
| Remedy            | Check the theory of the distance once again using the data set in the encoder configuration<br>Check the speed sensor<br>Use the SCOPE function to adjust superimposable speed signals |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3303 / A 3304</b>   |
| Alarm message     | Plausibility fault position sensing axis 1   |
| Cause             | The difference between the two position sensors is higher than the configured incremental shut-down threshold  |
| Remedy            | Check the theory of the distance using the configured data or the sensor setting<br>Check the position signal<br>Are all signals correctly connected to the 9-pole encoder plug?<br>Check the encoder plug for correct wiring.<br>If proximity switches are used, these are correctly connected.<br>Use the SCOPE function to adjust superimposable position signals |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3307 / A 3308</b>  |
| Alarm message     | Plausibility fault position range axis 1  |
| Cause             | The current position is outside the configured measuring length   |
| Remedy            | Check the theory of the distance using the configured data or the sensor setting<br>Check the position signal, if necessary correct the offset<br>Use the SCOPE function to read out the position and to set into relation to configured values |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3309 / A 3310</b>   |
| Alarm message     | Plausibility fault because of faulty speed axis 1  |
| Cause             | The current speed is outside the configured maximum speed  |
| Remedy            | The drive moves outside the permissible and configured speed range<br>Check configuration<br>Use the SCOPE function to analyse the course of speed |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3311 / A 3312</b>  |
| Alarm message     | Configuration fault: Acceleration axis 1  |
| Cause             | The current acceleration is outside the configured acceleration range   |
| Remedy            | The drive has exceeded the permissible acceleration range<br>Check the configuration of maximum speed<br>Use the SCOPE function to analyse the course of speed/acceleration |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3313 / A 3314</b>                               |
| Fault message     | SSI sensor fault                                     |
| Cause             | Encoder step change SSI-value within a cycle too big |
| Remedy            | Check encoder wiring<br>Check encoder configuration  |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3318</b>                                       |
| Fault message     | Incremental encoder axis 1 faulty                   |
| Cause             | Track A does not match track B                      |
| Remedy            | Check encoder wiring<br>Check encoder configuration |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3321 / A 3322</b>   |
| Alarm message     | Plausibility fault speed sensing axis 2  |
| Cause             | The difference between the two speed sensors is higher than the configured speed shut-down threshold   |
| Remedy            | Check the theory of the distance once again using the data set in the encoder configuration<br>Check the speed sensor<br>Use the SCOPE function to adjust superimposable speed signals |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3323 / A 3324</b>   |
| Alarm message     | Plausibility fault position sensing axis 2   |
| Cause             | The difference between the two position sensors is higher than the configured incremental shut-down threshold  |
| Remedy            | Check the theory of the distance using the configured data or the sensor setting<br>Check the position signal<br>Are all signals correctly connected to the 9-pole encoder plug?<br>Check the encoder plug for correct wiring.<br>If proximity switches are used, these are correctly connected.<br>Use the SCOPE function to adjust superimposable position signals |



|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3327 / A 3328</b>  |
| Alarm message     | Plausibility fault position range axis 2  |
| Cause             | The current position is outside the configured measuring length   |
| Remedy            | Check the theory of the distance using the configured data or the sensor setting<br>Check the position signal, if necessary correct the offset<br>Use the SCOPE function to read out the position and to set into relation to configured values |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3329 / A 3330</b>   |
| Alarm message     | Plausibility fault because of faulty speed axis 2  |
| Cause             | The current speed is outside the configured maximum speed  |
| Remedy            | The drive moves outside the permissible and configured speed range<br>Check configuration<br>Use the SCOPE function to analyse the course of speed |

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|-------------------|---|
| <b>Alarm code</b> | <b>A 3331 / A 3332</b>  |
| Alarm message     | Configuration fault: Acceleration axis 2  |
| Cause             | The current acceleration is outside the configured acceleration range   |
| Remedy            | The drive has exceeded the permissible acceleration range<br>Check the configuration of maximum speed<br>Use the SCOPE function to analyse the course of speed/acceleration |

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|-------------------|---|
| <b>Alarm code</b> | <b>A 3333 / A 3334</b>                          |
| Alarm message     | Plausibility fault of SinCos encoder            |
| Cause             | Wrong encoder type connected                    |
| Remedy            | Check configuration<br>Check encoder assignment |

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|-------------------|---|
| <b>Alarm code</b> | <b>A 3337 / A3338</b>                               |
| Fault message     | Incremental encoder axis 2 faulty                   |
| Cause             | Track A does not match track B                      |
| Remedy            | Check encoder wiring<br>Check encoder configuration |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3407 / A 3408</b>                                       |
| Alarm message     | Difference level RS485Treiber1 fault INC_B or SSI_CLK faulty |
| Cause             | No encoder connection<br>Wrong encoder type connected        |
| Remedy            | Check encoder connection<br>Check encoder wiring             |

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|-------------------|---|
| <b>Alarm code</b> | <b>A 3409 / A 3410</b>  |
| Alarm message     | Difference level RS485Treiber2 fault INC_A or SSI_DATA faulty |
| Cause             | No encoder connection<br>Wrong encoder type connected         |
| Remedy            | Check encoder connection<br>Check encoder wiring              |

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|-------------------|---|
| <b>Alarm code</b> | <b>A 3411 / A 3412</b>  |
| Fault message     | Fault Sine/Cosine plausibility X31                            |
| Cause             | Plausibility monitoring of individual tracks faulty           |
| Remedy            | Check encoder wiring<br>Sine- to Cosine- track must be linear |

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|-------------------|---|
| <b>Alarm code</b> | <b>A 3413 / A 3414</b>  |
| Fault message     | Fault Sine/Cosine plausibility X32                            |
| Cause             | Plausibility monitoring of individual tracks faulty           |
| Remedy            | Check encoder wiring<br>Sine- to Cosine- track must be linear |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3451 / A 3452</b>   |
| Alarm message     | Faulty resolver frequency  |
| Cause             | Resolver frequency outside the permissible range. Exciter frequency fault in resolver. |
| Remedy            | Check the resolver frequency if it is within the permissible range.                    |

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|-------------------|---|
| <b>Alarm code</b> | <b>A 3453 / A3454</b>   |
| Fault message     | Mean value of the resolver reference signal is outside the permissible range. |
| Cause             | Mean value of the resolver reference signal is outside the permissible range. |
| Remedy            | Check the connected resolver.   |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3457 / A3458</b>                              |
| Fault message     | Reference voltage of the extension board is faulty |
| Cause             | HW fault in the extension board                    |
| Remedy            | Check the extension board                          |

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|-------------------|---|
| <b>Alarm code</b> | <b>A 3459 / A3460</b>   |
| Fault message     | The amplitude/pointer length formed from the two signals sine and cosine (see also unit circle) is outside the permissible range. |
| Cause             | Incorrect encoder configuration<br>Incorrect resolver connection  |
| Remedy            | Check the encoder configuration<br>Check the resolver connections   |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3461 / A3462</b>  |
| Fault message     | The PIC reports a general status fault, e.g. when setting up a connection or because a timeout occurred during processing. |
| Cause             | Internal fault   |
| Remedy            | Power cycle of the device<br>Check the extension board   |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3463 / A3464</b>  |
| Fault message     | Plausibility test between the analog sine signal and the TTL-level at the Schmitt-trigger output do not match. |
| Cause             | Faulty encoder signals from the encoder  |
| Remedy            | Check the encoder connection<br>Check the encoder signal   |

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|-------------------|---|
| <b>Alarm code</b> | <b>A 3465 / A3466</b>   |
| Fault message     | The quotient of arithmetic mean value / square mean value is outside the permissible range. |
| Cause             | Faulty encoder signals from the encoder   |
| Remedy            | Check the encoder connection<br>Check the encoder signal                                    |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3467 / A3468</b>                        |
| Fault message     | Connection setup between CPU and PIC failed. |
| Cause             | Faulty HW of the extension board             |
| Remedy            | Check the extension board                    |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3469 / A3470</b>                                    |
| Fault message     | Resolver_Quadrant  |
| Cause             | Faulty encoder signals from the encoder                  |
| Remedy            | Check the encoder connection<br>Check the encoder signal |

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|-------------------|---|
| <b>Alarm code</b> | <b>A 3471 / A3472</b>   |
| Fault message     | Resolver_UENC   |
| Cause             | No voltage applied to the extension board   |
| Remedy            | Check whether voltage is correctly applied to the terminals of the extension board. |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3473 / A3474</b>                                    |
| Fault message     | TTL/HTL signal faulty                                    |
| Cause             | Faulty encoder signals from the encoder                  |
| Remedy            | Check the encoder connection<br>Check the encoder signal |

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|-------------------|---|
| <b>Alarm code</b> | <b>A 3475 / A3476</b>   |
| Fault message     | Resolver_TRACE Fault  |
| Cause             | Counting signals of the encoder are incorrect   |
| Remedy            | Check the encoder connection<br>Check the encoder signal<br>Check the extension board |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3505 / A 3506</b>                       |
| Fault message     | Read head fault WCS encoder system axis 1    |
| Cause             | WCS read head has detected a fault           |
| Remedy            | Read out fault types from WCS encoder system |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3507 / A 3508</b>                       |
| Fault message     | Read head fault WCS encoder system axis 1    |
| Cause             | WCS read head has detected a fault           |
| Remedy            | Read out fault types from WCS encoder system |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3551 / A3552</b>   |
| Fault message     | SSI_ECE STATUS 1. axis SSI Ext Encoder  |
| Cause             | Evaluation of the 1st status bit is faulty  |
| Remedy            | Check the encoder connection<br>Check the encoder signal<br>Replace the SSI-encoder |

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|-------------------|---|
| <b>Alarm code</b> | <b>A 3553 / A3554</b>   |
| Fault message     | SSI_ECE STATUS 1. axis SSI Ext Encoder  |
| Cause             | Evaluation of the 2nd status bit is faulty  |
| Remedy            | Check the encoder connection<br>Check the encoder signal<br>Replace the SSI-encoder |

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|-------------------|---|
| <b>Alarm code</b> | <b>A 3555 / A3556</b>   |
| Fault message     | SSI_ECE STATUS 1. axis SSI Ext Encoder  |
| Cause             | Evaluation of the 3rd status bit is faulty  |
| Remedy            | Check the encoder connection<br>Check the encoder signal<br>Replace the SSI-encoder |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3557 / A3558</b>   |
| Fault message     | SSI_ECE STATUS 1. axis SSI Ext Encoder  |
| Cause             | Evaluation of the 4th status bit is faulty  |
| Remedy            | Check the encoder connection<br>Check the encoder signal<br>Replace the SSI-encoder |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3559 / A3560</b>   |
| Fault message     | SSI_ECE STATUS 1. axis SSI Ext Encoder  |
| Cause             | Evaluation of the 5th status bit is faulty  |
| Remedy            | Check the encoder connection<br>Check the encoder signal<br>Replace the SSI-encoder |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3561 / A3562</b>   |
| Fault message     | SSI_ECE STATUS 2. axis SSI Ext Encoder  |
| Cause             | Evaluation of the 1st status bit is faulty  |
| Remedy            | Check the encoder connection<br>Check the encoder signal<br>Replace the SSI-encoder |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3563 / A3564</b>   |
| Fault message     | SSI_ECE STATUS 2. axis SSI Ext Encoder  |
| Cause             | Evaluation of the 2nd status bit is faulty  |
| Remedy            | Check the encoder connection<br>Check the encoder signal<br>Replace the SSI-encoder |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3565 / A3566</b>   |
| Fault message     | SSI_ECE STATUS 2. axis SSI Ext Encoder  |
| Cause             | Evaluation of the 3rd status bit is faulty  |
| Remedy            | Check the encoder connection<br>Check the encoder signal<br>Replace the SSI-encoder |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3567 / A3568</b>   |
| Fault message     | SSI_ECE STATUS 2. axis SSI Ext Encoder  |
| Cause             | Evaluation of the 4th status bit is faulty  |
| Remedy            | Check the encoder connection<br>Check the encoder signal<br>Replace the SSI-encoder |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3569 / A3570</b>   |
| Fault message     | SSI_ECE STATUS 2. axis SSI Ext Encoder  |
| Cause             | Evaluation of the 5th status bit is faulty  |
| Remedy            | Check the encoder connection<br>Check the encoder signal<br>Replace the SSI-encoder |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3571 / A3572</b>   |
| Fault message     | SSI STATUS 1. axis SSI Encoder  |
| Cause             | Evaluation of the 1st status bit is faulty  |
| Remedy            | Check the encoder connection<br>Check the encoder signal<br>Replace the SSI-encoder |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3573 / A3574</b>   |
| Fault message     | SSI STATUS 1. axis SSI Encoder  |
| Cause             | Evaluation of the 2nd status bit is faulty  |
| Remedy            | Check the encoder connection<br>Check the encoder signal<br>Replace the SSI-encoder |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3575 / A3576</b>   |
| Fault message     | SSI STATUS 1. axis SSI Encoder  |
| Cause             | Evaluation of the 3rd status bit is faulty  |
| Remedy            | Check the encoder connection<br>Check the encoder signal<br>Replace the SSI-encoder |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3577 / A3578</b>   |
| Fault message     | SSI STATUS 1. axis SSI Encoder  |
| Cause             | Evaluation of the 4th status bit is faulty  |
| Remedy            | Check the encoder connection<br>Check the encoder signal<br>Replace the SSI-encoder |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 3579 / A3580</b>   |
| Fault message     | SSI STATUS 1. axis SSI Encoder  |
| Cause             | Evaluation of the 5th status bit is faulty  |
| Remedy            | Check the encoder connection<br>Check the encoder signal<br>Replace the SSI-encoder |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3801 / A3802</b>                      |
| Fault message     | Faulty switching of output EAAx.1          |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3803 / A3804</b>                      |
| Fault message     | Faulty switching of output EAAx.2          |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3805 / A3806</b>                      |
| Fault message     | Faulty switching of output EAAx.3          |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3807 / A3808</b>                      |
| Fault message     | Faulty switching of output EAAx.4          |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3809 / A3810</b>                      |
| Fault message     | Faulty switching of output EAAx.5          |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3811 / A3812</b>                      |
| Fault message     | Faulty switching of output EAAx.6          |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3813 / A3814</b>                      |
| Fault message     | Faulty switching of output EAAx.7          |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3815 / A3816</b>                      |
| Fault message     | Faulty switching of output EAAx.8          |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3817 / A3818</b>                      |
| Fault message     | Faulty switching of output EAAx.9          |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3819 / A3820</b>                      |
| Fault message     | Faulty switching of output EAAx.10         |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3901 / A3902</b>                      |
| Fault message     | Faulty switching of output EAA0.11         |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3903 / A3904</b>                      |
| Fault message     | Faulty switching of output EAA0.12         |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3905 / A3906</b>                      |
| Fault message     | Faulty switching of output EAA0.13         |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3907 / A3908</b>                      |
| Fault message     | Faulty switching of output EAA0.14         |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3909 / A3910</b>                      |
| Fault message     | Faulty switching of output EAA0.15         |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3911 / A3912</b>                      |
| Fault message     | Faulty switching of output EAA0.16         |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3913 / A3914</b>                      |
| Fault message     | Faulty switching of output EAA0.17         |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3915 / A3916</b>                      |
| Fault message     | Faulty switching of output EAA0.18         |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3917 / A3918</b>                      |
| Fault message     | Faulty switching of output EAA0.19         |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3919 / A3920</b>                      |
| Fault message     | Faulty switching of output EAAx.20         |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3921 / A3922</b>                      |
| Fault message     | Faulty switching of output EAAx.21         |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |



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|-------------------|--|
| <b>Alarm code</b> | <b>A 3923 / A3924</b>                      |
| Fault message     | Faulty switching of output EAAx.22         |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3925 / A3926</b>                      |
| Fault message     | Faulty switching of output EAAx.23         |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3927 / A3928</b>                      |
| Fault message     | Faulty switching of output EAAx.24         |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3929 / A3930</b>                      |
| Fault message     | Faulty switching of output EAAx.25         |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3931 / A3932</b>                      |
| Fault message     | Faulty switching of output EAAx.26         |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3933 / A3934</b>                      |
| Fault message     | Faulty switching of output EAAx.27         |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3935 / A3936</b>                      |
| Fault message     | Faulty switching of output EAAx.28         |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|-------------------|--|
| <b>Alarm code</b> | <b>A 3937 / A3938</b>                      |
| Fault message     | Faulty switching of output EAAx.29         |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

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|----------------------|--|
| <b>Alarm code</b>    | <b>A 3939 / A3940</b>                      |
| <i>Fault message</i> | Faulty switching of output EAAx.30         |
| <i>Cause</i>         | Short-circuit of output with "24V" or "0V" |
| <i>Remedy</i>        | Faulty wiring output (short-circuit)       |

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|----------------------|--|
| <b>Alarm code</b>    | <b>A 3941 / A3942</b>                      |
| <i>Fault message</i> | Faulty switching of output EAA0.31         |
| <i>Cause</i>         | Short-circuit of output with "24V" or "0V" |
| <i>Remedy</i>        | Faulty wiring output (short-circuit)       |

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| <b>Alarm code</b>    | <b>A 3943 / A3944</b>                      |
| <i>Fault message</i> | Faulty switching of output EAA0.32         |
| <i>Cause</i>         | Short-circuit of output with "24V" or "0V" |
| <i>Remedy</i>        | Faulty wiring output (short-circuit)       |

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| <b>Alarm code</b>    | <b>A 3945 / A3946</b>                      |
| <i>Fault message</i> | Faulty switching of output EAA0.33         |
| <i>Cause</i>         | Short-circuit of output with "24V" or "0V" |
| <i>Remedy</i>        | Faulty wiring output (short-circuit)       |

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| <b>Alarm code</b>    | <b>A 3947 / A3948</b>                      |
| <i>Fault message</i> | Faulty switching of output EAA0.34         |
| <i>Cause</i>         | Short-circuit of output with "24V" or "0V" |
| <i>Remedy</i>        | Faulty wiring output (short-circuit)       |

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|----------------------|--|
| <b>Alarm code</b>    | <b>A 3949 / A3950</b>                      |
| <i>Fault message</i> | Faulty switching of output EAA0.35         |
| <i>Cause</i>         | Short-circuit of output with "24V" or "0V" |
| <i>Remedy</i>        | Faulty wiring output (short-circuit)       |

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|----------------------|--|
| <b>Alarm code</b>    | <b>A 3951 / A3952</b>                      |
| <i>Fault message</i> | Faulty switching of output EAA0.36         |
| <i>Cause</i>         | Short-circuit of output with "24V" or "0V" |
| <i>Remedy</i>        | Faulty wiring output (short-circuit)       |

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|----------------------|--|
| <b>Alarm code</b>    | <b>A 3953 / A3954</b>                      |
| <i>Fault message</i> | Faulty switching of output EAA0.37         |
| <i>Cause</i>         | Short-circuit of output with "24V" or "0V" |
| <i>Remedy</i>        | Faulty wiring output (short-circuit)       |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3955 / A3956</b>                      |
| Fault message     | Faulty switching of output EAA0.38         |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3957 / A3958</b>                      |
| Fault message     | Faulty switching of output EAA0.39         |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 3959 / A3960</b>                      |
| Fault message     | Faulty switching of output EAAx.40         |
| Cause             | Short-circuit of output with "24V" or "0V" |
| Remedy            | Faulty wiring output (short-circuit)       |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 4001 / A 4002</b>   |
| Alarm message     | CCW and CW rotation monitoring SDI1 activated at the same time         |
| Cause             | Multiple activation  |
| Remedy            | In programming make sure that only one "Enable" is activated at a time |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 4003 / A 4004</b>   |
| Alarm message     | CCW and CW rotation monitoring SDI2 activated at the same time         |
| Cause             | Multiple activation  |
| Remedy            | In programming make sure that only one "Enable" is activated at a time |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 4401 / A 4402</b>  |
| Alarm message     | Faulty EMU (ID1) monitoring   |
| Cause             | Faulty examination of external switching contact axis module  |
| Remedy            | Check feedback EMU (normally closed contact)<br>Check control<br>Check configuration of deceleration time |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 4403 / A 4404</b>  |
| Alarm message     | Faulty EMU (ID2) monitoring   |
| Cause             | Faulty examination of external switching contact axis module  |
| Remedy            | Check feedback EMU (normally closed contact)<br>Check control<br>Check configuration of deceleration time |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 4411 / A 4412</b>  |
| Alarm message     | Faulty EMU (ID1) monitoring   |
| Cause             | Faulty examination of external switching contact EA module  |
| Remedy            | Check feedback EMU (normally closed contact)<br>Check control<br>Check configuration of deceleration time |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 4413 / A 4414</b>  |
| Alarm message     | Faulty EMU (ID2) monitoring   |
| Cause             | Faulty examination of external switching contact EA module  |
| Remedy            | Check feedback EMU (normally closed contact)<br>Check control<br>Check configuration of deceleration time |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 4415 / A 4416</b>  |
| Alarm message     | Faulty EMU (ID3) monitoring   |
| Cause             | Faulty examination of external switching contact EA module  |
| Remedy            | Check feedback EMU (normally closed contact)<br>Check control<br>Check configuration of deceleration time |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 4417 / A 4418</b>  |
| Alarm message     | Faulty EMU (ID4) monitoring   |
| Cause             | Faulty examination of external switching contact EA module  |
| Remedy            | Check feedback EMU (normally closed contact)<br>Check control<br>Check configuration of deceleration time |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 4419 / A 4420</b>  |
| Alarm message     | Faulty EMU (ID5) monitoring   |
| Cause             | Faulty examination of external switching contact EA module  |
| Remedy            | Check feedback EMU (normally closed contact)<br>Check control<br>Check configuration of deceleration time |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 4421 / A 4422</b>  |
| Alarm message     | Faulty EMU (ID6) monitoring   |
| Cause             | Faulty examination of external switching contact EA module  |
| Remedy            | Check feedback EMU (normally closed contact)<br>Check control<br>Check configuration of deceleration time |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 4423 / A 4424</b>  |
| Alarm message     | Faulty EMU (ID7) monitoring   |
| Cause             | Faulty examination of external switching contact EA module  |
| Remedy            | Check feedback EMU (normally closed contact)<br>Check control<br>Check configuration of deceleration time |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 4425 / A 4426</b>  |
| Alarm message     | Faulty EMU (ID8) monitoring   |
| Cause             | Faulty examination of external switching contact EA module  |
| Remedy            | Check feedback EMU (normally closed contact)<br>Check control<br>Check configuration of deceleration time |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 4427 / A 4428</b>  |
| Alarm message     | Faulty EMU (ID9) monitoring   |
| Cause             | Faulty examination of external switching contact EA module  |
| Remedy            | Check feedback EMU (normally closed contact)<br>Check control<br>Check configuration of deceleration time |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 4429 / A 4430</b>  |
| Alarm message     | Faulty EMU (ID10) monitoring  |
| Cause             | Faulty examination of external switching contact EA module  |
| Remedy            | Check feedback EMU (normally closed contact)<br>Check control<br>Check configuration of deceleration time |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 4601 / A 4602</b>   |
| Alarm message     | Monitoring range left and right of SLP1 activated at the same time     |
| Cause             | Multiple activation  |
| Remedy            | In programming make sure that only one "Enable" is activated at a time |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 4603 / A 4604</b>   |
| Alarm message     | Monitoring range left and right of SLP2 activated at the same time     |
| Cause             | Multiple activation  |
| Remedy            | In programming make sure that only one "Enable" is activated at a time |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 4605 / A 4606</b>                                |
| Alarm message     | SLP1 Teach-In Status Faults                           |
| Cause             | SET and QUIT input have a faulty switching sequence   |
| Remedy            | Check input configuration<br>Check switching sequence |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 4607 / A 4608</b>                              |
| Alarm message     | SLP 2 Teach In status fault                         |
| Cause             | SET and QUIT input have a faulty switching sequence |
| Remedy            | Check configuration<br>Check switching sequence     |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 4609 / A 4610</b>                        |
| Alarm message     | SLP1 Teach In position fault                  |
| Cause             | Teach In position outside the measuring range |
| Remedy            | Check transfer position                       |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 4611 / A 4612</b>                        |
| Alarm message     | SLP2 Teach In position fault                  |
| Cause             | Teach In position outside the measuring range |
| Remedy            | Check transfer position                       |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 4613 / A 4614</b>  |
| Alarm message     | SLP1 Teach In SOS activation fault  |
| Cause             | The drive moved during Teach In (SOS fault)   |
| Remedy            | The drive must be stopped when using the Teach In function<br>Check whether SOS has already triggered |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 4615 / A 4616</b>  |
| Alarm message     | SLP 2 Teach In SOS activation fault   |
| Cause             | The drive moved during Teach In (SOS fault)   |
| Remedy            | The drive must be stopped when using the Teach In function<br>Check whether SOS has already triggered |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 4901 / A 4902</b>   |
| Alarm message     | CCW and CW rotation monitoring SLI1 activated at the same time         |
| Cause             | Multiple activation  |
| Remedy            | In programming make sure that only one "Enable" is activated at a time |

|                   |  |
|-------------------|--|
| <b>Alarm code</b> | <b>A 4903 / A 4904</b>   |
| Alarm message     | CCW and CW rotation monitoring SLI2 activated at the same time         |
| Cause             | Multiple activation  |
| Remedy            | In programming make sure that only one "Enable" is activated at a time |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 5001 / A 5002</b>                            |
| Alarm message     | Test deactivation of digital inputs 1...14 faulty |
| Cause             | Inputs are still active after deactivation        |
| Remedy            | Check wiring of digital inputs                    |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5101 / A 5102</b>           |
| Alarm message     | Pulse fault EAE0.1               |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5103 / A 5104</b>           |
| Alarm message     | Pulse fault EAE0.2               |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5105 / A 5106</b>           |
| Alarm message     | Pulse fault EAE0.3               |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5107 / A 5108</b>           |
| Alarm message     | Pulse fault EAE0.4               |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5109 / A 5110</b>           |
| Alarm message     | Pulse fault EAE0.5               |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5111 / A 5112</b>           |
| Alarm message     | Pulse fault EAE0.6               |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5113 / A 5114</b>           |
| Alarm message     | Pulse fault EAE0.7               |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5115 / A 5116</b>           |
| Alarm message     | Pulse fault EAE0.8               |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5117 / A 5118</b>           |
| Alarm message     | Pulse fault EAE0.9               |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5119 / A 5120</b>           |
| Alarm message     | Pulse fault EAE0.10              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5121 / A 5122</b>           |
| Alarm message     | Pulse fault EAE0.11              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5123 / A 5124</b>           |
| Alarm message     | Pulse fault EAE0.12              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5125 / A 5126</b>           |
| Alarm message     | Pulse fault EAE0.13              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5127 / A 5128</b>           |
| Alarm message     | Pulse fault EAE0.14              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |



|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5129 / A 5130</b>           |
| Alarm message     | Pulse fault EAE0.15              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5131 / A 5132</b>           |
| Alarm message     | Pulse fault EAE0.16              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5133 / A 5134</b>           |
| Alarm message     | Pulse fault EAE0.17              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5135 / A 5136</b>           |
| Alarm message     | Pulse fault EAE0.18              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5137 / A 5138</b>           |
| Alarm message     | Pulse fault EAE0.19              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5139 / A 5140</b>           |
| Alarm message     | Pulse fault EAE0.20              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5141 / A 5142</b>           |
| Alarm message     | Pulse fault EAE0.21              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5143 / A 5144</b>           |
| Alarm message     | Pulse fault EAE0.22              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5145 / A 5146</b>           |
| Alarm message     | Pulse fault EAE0.23              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5147 / A 5148</b>           |
| Alarm message     | Pulse fault EAE0.24              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5149 / A 5150</b>           |
| Alarm message     | Pulse fault EAE0.25              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5151 / A 5152</b>           |
| Alarm message     | Pulse fault EAE0.26              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5153 / A 5154</b>           |
| Alarm message     | Pulse fault EAE0.27              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5155 / A 5156</b>           |
| Alarm message     | Pulse fault EAE0.28              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5157 / A 5158</b>           |
| Alarm message     | Pulse fault EAE0.29              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5159 / A 5160</b>           |
| Alarm message     | Pulse fault EAE0.30              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5161 / A 5162</b>           |
| Alarm message     | Pulse fault EAE0.31              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5163 / A 5164</b>           |
| Alarm message     | Pulse fault EAE0.32              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5165 / A 5166</b>           |
| Alarm message     | Pulse fault EAE0.33              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5167 / A 5168</b>           |
| Alarm message     | Pulse fault EAE0.34              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5169 / A 5170</b>           |
| Alarm message     | Pulse fault EAE0.35              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5171 / A 5172</b>           |
| Alarm message     | Pulse fault EAE0.36              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5173 / A 5174</b>           |
| Alarm message     | Pulse fault EAE0.37              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5175 / A 5176</b>           |
| Alarm message     | Pulse fault EAE0.38              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5177 / A 5178</b>           |
| Alarm message     | Pulse fault EAE0.39              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |                                  |
|-------------------|----------------------------------|
| <b>Alarm code</b> | <b>A 5179 / A 5180</b>           |
| Alarm message     | Pulse fault EAE0.40              |
| Cause             | Unexpected status of pulse input |
| Remedy            | Check wiring of digital inputs   |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 6701 / A 6702</b>                                |
| Alarm message     | Timeout fault MET                                     |
| Cause             | Input element with time monitoring is faulty          |
| Remedy            | Check wiring of input element<br>Input element faulty |

|                   |   |
|-------------------|---|
| <b>Alarm code</b> | <b>A 6703 / A 6704</b>                                  |
| Alarm message     | Timeout fault MEZ                                       |
| Cause             | Two-hand control element with time monitoring is faulty |
| Remedy            | Check wiring of input element<br>Input element faulty   |

## Fatal Fault list KSM100

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 1001</b>   |
| Fault message           | Configuration data were incorrectly loaded into the monitoring device     |
| Cause                   | Disturbed connection when loading the program into the monitoring device. |
| Remedy                  | Reload the configuration data, then switch module off/on.                 |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 1003</b>   |
| Fault message           | Configuration data invalid for software version of module!  |
| Cause                   | Module configured with incorrect software version of the programming desktop.                               |
| Remedy                  | Parameterize the module with the approved version of the programming desktop, the switch the module off/on. |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 1007</b>   |
| Fault message           | Device not programmed with the correct programming desktop  |
| Cause                   | Program or configuration data transferred to the device using the wrong programming desktop                 |
| Remedy                  | Check the module design and parameterize again with a valid programming desktop. Then switch device off/on. |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 1307</b>  |
| Fault message           | Fault when deleting configuration data from the Flash Memory |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 1311 / F1312</b>                             |
| Fault message           | Internal fault – please contact the manufacturer! |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 1314</b>                                     |
| Fault message           | Internal fault – please contact the manufacturer! |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 1330</b>                                     |
| Fault message           | Internal fault – please contact the manufacturer! |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 1401 / F 1402</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 1403 / F 1404</b>                            |
| Fault message           | CRC of configuration data invalid!                |
| Cause                   | Configuration data were incorrectly transferred   |
| Remedy                  | Transfer the configuration data again             |
| <b>Fatal Error Code</b> | <b>F 1406</b>                                     |
| Fault message           | Internal fault – please contact the manufacturer! |
| <b>Fatal Error Code</b> | <b>F 1407 / F 1408</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |
| <b>Fatal Error Code</b> | <b>F 1501 / F 1502</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |
| <b>Fatal Error Code</b> | <b>F 1503 / F 1504</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |
| <b>Fatal Error Code</b> | <b>F 1505 / F 1506</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |
| <b>Fatal Error Code</b> | <b>F 1601 / F 1602</b>                            |
| Fault message           | Range test of device description is faulty.       |
| <b>Fatal Error Code</b> | <b>F 1603 / F 1604</b>                            |
| Fault message           | Range test of Access Data faulty                  |
| <b>Fatal Error Code</b> | <b>F 1605 / F 1606</b>                            |
| Fault message           | Range test of EMU faulty                          |
| <b>Fatal Error Code</b> | <b>F 1607 / F 1608</b>                            |
| Fault message           | Range test SCA faulty                             |
| <b>Fatal Error Code</b> | <b>F 1609 / F 1610</b>                            |
| Fault message           | Range test SSX faulty                             |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 1611 / F 1612</b>                 |
| Fault message           | Range test SEL faulty                  |
| <b>Fatal Error Code</b> | <b>F 1613 / F 1614</b>                 |
| Fault message           | Range test SLP faulty                  |
| <b>Fatal Error Code</b> | <b>F 1615 / F 1616</b>                 |
| Fault message           | Range test SOS faulty                  |
| <b>Fatal Error Code</b> | <b>F 1617 / F 1618</b>                 |
| Fault message           | Range test SLS faulty                  |
| <b>Fatal Error Code</b> | <b>F 1619 / F 1620</b>                 |
| Fault message           | Range test SDI faulty                  |
| <b>Fatal Error Code</b> | <b>F 1621 / F 1622</b>                 |
| Fault message           | Range test SLI faulty                  |
| <b>Fatal Error Code</b> | <b>F 1623 / F 1624</b>                 |
| Fault message           | Range test of PLC faulty               |
| <b>Fatal Error Code</b> | <b>F 1625 / F 1626</b>                 |
| Fault message           | Range test of shut-down channel faulty |
| <b>Fatal Error Code</b> | <b>F 1627 / F 1628</b>                 |
| Fault message           | Range test of outputs faulty           |
| <b>Fatal Error Code</b> | <b>F 1629 / F 1630</b>                 |
| Fault message           | Range test of digital inputs faulty.   |
| <b>Fatal Error Code</b> | <b>F 1631 / F 1632</b>                 |
| Fault message           | Range test of analog input             |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 1633 / F 1634</b>                  |
| Fault message           | Range test of encoder type faulty       |
| <b>Fatal Error Code</b> | <b>F 1635 / F 1636</b>                  |
| Fault message           | Range test of encoder processing faulty |
| <b>Fatal Error Code</b> | <b>F 1637 / F 1638</b>                  |
| Fault message           | Range test of encoder position faulty   |
| <b>Fatal Error Code</b> | <b>F 1639 / F 1640</b>                  |
| Fault message           | Range test of PDM faulty.               |
| <b>Fatal Error Code</b> | <b>F 1641 / F 1642</b>                  |
| Fault message           | Range test of adder circuitry faulty    |
| <b>Fatal Error Code</b> | <b>F 1645 / F 1646</b>                  |
| Fault message           | Range test of axis management faulty    |
| <b>Fatal Error Code</b> | <b>F 1647 / F 1648</b>                  |
| Fault message           | Range test of expansion modules faulty  |
| <b>Fatal Error Code</b> | <b>F 1649 / F 1650</b>                  |
| Fault message           | Range test of PLC timer faulty          |
| <b>Fatal Error Code</b> | <b>F 1651 / F 1652</b>                  |
| Fault message           | Range test of system faulty             |
| <b>Fatal Error Code</b> | <b>F 1653 / F 1654</b>                  |
| Fault message           | Range test connection table faulty      |
| <b>Fatal Error Code</b> | <b>F 1655 / F 1656</b>                  |
| Fault message           | Range test SAC faulty                   |



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|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 1657 / F 1658</b>  |
| Fault message           | Range test of diagnose faulty                                       |
| <b>Fatal Error Code</b> | <b>F 2001 / F 2002</b>  |
| Fault message           | Internal fault – please contact the manufacturer!                   |
| <b>Fatal Error Code</b> | <b>F 2003 / F 2004</b>  |
| Fault message           | Timeout when transmitting configuration and firmware data           |
| <b>Fatal Error Code</b> | <b>F 2005</b>   |
| Fault message           | Internal fault – please contact the manufacturer!                   |
| <b>Fatal Error Code</b> | <b>F 2007</b>   |
| Fault message           | Internal fault – please contact the manufacturer!                   |
| <b>Fatal Error Code</b> | <b>F 2009</b>   |
| Fault message           | Internal fault – please contact the manufacturer!                   |
| <b>Fatal Error Code</b> | <b>F 2011</b>   |
| Fault message           | Internal fault – please contact the manufacturer!                   |
| <b>Fatal Error Code</b> | <b>F 2013 / F 2014</b>  |
| Fault message           | Internal fault – please contact the manufacturer!                   |
| <b>Fatal Error Code</b> | <b>F 3001 / F 3002</b>  |
| Fault message           | Internal fault – please contact the manufacturer!                   |
| <b>Fatal Error Code</b> | <b>F 3201 / F 3202</b>  |
| Fault message           | Processor voltage 2.5V outside defined range                        |
| Cause                   | Supply voltage for module not correct!<br>Component fault in module |
| Remedy                  | Check device supply voltage!<br>Switch device off/on.               |
| <b>Fatal Error Code</b> | <b>F 3203</b>   |
| Fault message           | Supply voltage 24V module faulty.                                   |

|        |   |
|--------|---|
| Cause  | Supply voltage for module not correct!<br>Component fault in module |
| Remedy | Check device supply voltage!<br>Switch device off/on.               |

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| <b>Fatal Error Code</b> | <b>F 3204</b>   |
| Fault message           | Internal supply voltage 5.7V faulty                                 |
| Cause                   | Supply voltage for module not correct!<br>Component fault in module |
| Remedy                  | Check device supply voltage!<br>Switch device off/on.               |

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| <b>Fatal Error Code</b> | <b>F 3217 / F 3218</b>  |
| Fault message           | Internal supply voltage 5V faulty                                   |
| Cause                   | Supply voltage for module not correct!<br>Component fault in module |
| Remedy                  | Check device supply voltage!<br>Switch device off/on.               |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3306</b>  |
| Fault message           | Plausibility fault position switching axis 1   |
| Cause                   | During position switching SOS, SLI or SDI is permanently activated.  |
| Remedy                  | Check activation of SOS<br>Check activation of SLI<br>Activation of SDI (only for monitoring via position) |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3316</b>  |
| Fault message           | Fault in encoder alignment axis 1                    |
| Cause                   | Incorrect position triggering by system A            |
| Remedy                  | Check encoder configuration<br>Switch device off/on. |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3326</b>  |
| Fault message           | Plausibility fault position switching axis 2   |
| Cause                   | During position switching SOS, SLI or SDI is permanently activated.  |
| Remedy                  | Check activation of SOS<br>Check activation of SLI<br>Activation of SDI (only for monitoring via position) |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3336</b>  |
| Fault message           | Fault in encoder alignment axis 2                    |
| Cause                   | Incorrect position triggering by system A            |
| Remedy                  | Check encoder configuration<br>Switch device off/on. |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3407 / F 3408</b>                               |
| Fault message           | Fault encoder axis 1                                 |
| Cause                   |  |
| Remedy                  | Check encoder configuration<br>Switch device off/on. |

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|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3409 / F 3410</b>                               |
| Fault message           | Fault encoder axis 2                                 |
| Cause                   |  |
| Remedy                  | Check encoder configuration<br>Switch device off/on. |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 3411 / F 3412</b>  |
| Fault message           | SinCos encoder plausibility fault axis 1  |
| Cause                   | Faulty SinCos encoder signal  |
| Remedy                  | Check encoder configuration<br>Check / replace encoder<br>Check wiring<br>Switch device off/on. |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 3413 / F 3414</b>  |
| Fault message           | SinCos encoder plausibility fault axis 2  |
| Cause                   | Faulty SinCos encoder signal  |
| Remedy                  | Check encoder configuration<br>Check / replace encoder<br>Check wiring<br>Switch device off/on. |

|                         |                                       |
|-------------------------|---------------------------------------|
| <b>Fatal Error Code</b> | <b>F 3505 / F 3506</b>                |
| Fault message           | WCS encoder plausibility fault axis 1 |
| Cause                   |                                       |
| Remedy                  |                                       |

|                         |                                       |
|-------------------------|---------------------------------------|
| <b>Fatal Error Code</b> | <b>F 3507 / F 3508</b>                |
| Fault message           | WCS encoder plausibility fault axis 2 |
| Cause                   |                                       |
| Remedy                  |                                       |

|                         |                                     |
|-------------------------|-------------------------------------|
| <b>Fatal Error Code</b> | <b>F 3603 / F 3604</b>              |
| Fault message           | Faulty switching of relay K1        |
| Cause                   | Internal triggering of relay faulty |
| Remedy                  | Switch device off/on                |

|                         |                                     |
|-------------------------|-------------------------------------|
| <b>Fatal Error Code</b> | <b>F 3605 / F 3606</b>              |
| Fault message           | Faulty switching of relay K2        |
| Cause                   | Internal triggering of relay faulty |
| Remedy                  | Switch device off/on                |

|                         |                                       |
|-------------------------|---------------------------------------|
| <b>Fatal Error Code</b> | <b>F 3609</b>                         |
| Fault message           | Faulty switching of "0V" driver DO1_L |
| Cause                   | Switching state of output faulty      |
| Remedy                  | Switch device off/on                  |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3610</b>                          |
| Fault message           | Faulty switching of "24V" driver DO1_H |
| Cause                   | Switching state of output faulty       |
| Remedy                  | Switch device off/on                   |

|                         |                                       |
|-------------------------|---------------------------------------|
| <b>Fatal Error Code</b> | <b>F 3611</b>                         |
| Fault message           | Faulty switching of "0V" driver DO2_L |
| Cause                   | Switching state of output faulty      |
| Remedy                  | Switch device off/on                  |

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|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3612</b>                          |
| Fault message           | Faulty switching of "24V" driver DO2_H |
| Cause                   | Switching state of output faulty       |
| Remedy                  | Switch device off/on                   |

|                         |                                       |
|-------------------------|---------------------------------------|
| <b>Fatal Error Code</b> | <b>F 3613</b>                         |
| Fault message           | Faulty switching of "0V" driver DO1_L |
| Cause                   | Short-circuit of output with "0V"     |
| Remedy                  | Switch device off/on                  |

|                         |                                      |
|-------------------------|--------------------------------------|
| <b>Fatal Error Code</b> | <b>F 3614</b>                        |
| Fault message           | Faulty testing of "24V" driver DO1_H |
| Cause                   | Short-circuit of output with "24V"   |
| Remedy                  | Switch device off/on                 |

|                         |                                     |
|-------------------------|-------------------------------------|
| <b>Fatal Error Code</b> | <b>F 3615</b>                       |
| Fault message           | Faulty testing of "0V" driver DO2_L |
| Cause                   | Short-circuit of output with "0V"   |
| Remedy                  | Switch device off/on                |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 3616</b>                                     |
| Fault message           | Faulty testing of "24V" driver DO2_H              |
| Cause                   | Short-circuit of output with "24V"                |
| Remedy                  | Switch device off/on                              |
| <b>Fatal Error Code</b> | <b>F 3617</b>                                     |
| Fault message           | Internal fault – please contact the manufacturer! |
| <b>Fatal Error Code</b> | <b>F 3618</b>                                     |
| Fault message           | Internal fault – please contact the manufacturer! |
| <b>Fatal Error Code</b> | <b>F 3619</b>                                     |
| Fault message           | Internal fault – please contact the manufacturer! |
| <b>Fatal Error Code</b> | <b>F 3620</b>                                     |
| Fault message           | Internal fault – please contact the manufacturer! |
| <b>Fatal Error Code</b> | <b>F 3621</b>                                     |
| Fault message           | Internal fault – please contact the manufacturer! |
| <b>Fatal Error Code</b> | <b>F 3622</b>                                     |
| Fault message           | Internal fault – please contact the manufacturer! |
| <b>Fatal Error Code</b> | <b>F 3701 / F 3702</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |
| <b>Fatal Error Code</b> | <b>F 3703 / F 3704</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |
| <b>Fatal Error Code</b> | <b>F 3842</b>                                     |
| Fault message           | Faulty dynamic test of output EAAx.1              |
| Cause                   | Short-circuit of output with "24V"                |
| Remedy                  | Check the wiring<br>Switch device off/on          |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3844</b>                            |
| Fault message           | Faulty dynamic test of output EAAx.2     |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3846</b>                            |
| Fault message           | Faulty dynamic test of output EAAx.3     |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3848</b>                            |
| Fault message           | Faulty dynamic test of output EAAx.4     |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3850</b>                            |
| Fault message           | Faulty dynamic test of output EAAx.5     |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

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|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3852</b>                            |
| Fault message           | Faulty dynamic test of output EAAx.6     |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3854</b>                            |
| Fault message           | Faulty dynamic test of output EAAx.7     |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3856</b>                            |
| Fault message           | Faulty dynamic test of output EAAx.8     |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3858</b>                              |
| Fault message           | Faulty dynamic test of output EAAx.9       |
| Cause                   | Short-circuit of output with "24V"         |
| Remedy                  | Check the wiring<br>Switch device off/on   |
| <b>Fatal Error Code</b> | <b>F 3860</b>                              |
| Fault message           | Faulty dynamic test of output EAAx.10      |
| Cause                   | Short-circuit of output with "24V"         |
| Remedy                  | Check the wiring<br>Switch device off/on   |
| <b>Fatal Error Code</b> | <b>F 3871</b>                              |
| Fault message           | MainTrans EAAx.1 ... EAAx.6 dynamic test   |
| Cause                   | Short-circuit of outputs with "24V"        |
| Remedy                  | Check the wiring<br>Switch device off/on   |
| <b>Fatal Error Code</b> | <b>F 3873</b>                              |
| Fault message           | MainTrans EAAx.7... EAAx.10 dynamic test   |
| Cause                   | Short-circuit of outputs with "24V"        |
| Remedy                  | Check the wiring<br>Switch device off/on   |
| <b>Fatal Error Code</b> | <b>F 3891</b>                              |
| Fault message           | MainTrans EAAx.01 ... EAAx.06 static test  |
| Cause                   | Short-circuit of output with "24V" or "0V" |
| Remedy                  | Check the wiring<br>Switch device off/on   |
| <b>Fatal Error Code</b> | <b>F 3893</b>                              |
| Fault message           | MainTrans EAAx.07 ... EAAx.10 static test  |
| Cause                   | Short-circuit of output with "24V" or "0V" |
| Remedy                  | Check the wiring<br>Switch device off/on   |
| <b>Fatal Error Code</b> | <b>F 3971</b>                              |
| Fault message           | MainTrans EAA11 ... EAA16 static test      |
| Cause                   | Short-circuit of output with "24V" or "0V" |
| Remedy                  | Check the wiring<br>Switch device off/on   |
| <b>Fatal Error Code</b> | <b>F 3973</b>                              |

|               |  |
|---------------|--|
| Fault message | MainTrans EAA16 ... EAA20 static test      |
| Cause         | Short-circuit of output with "24V" or "0V" |
| Remedy        | Check the wiring<br>Switch device off/on   |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3975</b>                            |
| Fault message           | MainTrans EAA11 ... EAA16 static test    |
| Cause                   | Short-circuit of outputs with "24V"      |
| Remedy                  | Check the wiring<br>Switch device off/on |

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|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3977</b>                            |
| Fault message           | MainTrans EAA17 ... EAA20 static test    |
| Cause                   | Short-circuit of outputs with "24V"      |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3981</b>                              |
| Fault message           | MainTrans EAA21 ... EAA26 static test      |
| Cause                   | Short-circuit of output with "24V" or "0V" |
| Remedy                  | Check the wiring<br>Switch device off/on   |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3983</b>                              |
| Fault message           | MainTrans EAA26 ... EAA30 static test      |
| Cause                   | Short-circuit of output with "24V" or "0V" |
| Remedy                  | Check the wiring<br>Switch device off/on   |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3985</b>                            |
| Fault message           | MainTrans EAA21 ... EAA26 dynamic test   |
| Cause                   | Short-circuit of outputs with "24V"      |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3987</b>                            |
| Fault message           | MainTrans EAA27 ... EAA30 dynamic test   |
| Cause                   | Short-circuit of outputs with "24V"      |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3991</b>                              |
| Fault message           | MainTrans EAA31 ... EAA36 static test      |
| Cause                   | Short-circuit of output with "24V" or "0V" |



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| Remedy | Check the wiring<br>Switch device off/on |
|--------|--|

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|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3993</b>                              |
| Fault message           | MainTrans EAA36 ... EAA40 static test      |
| Cause                   | Short-circuit of output with "24V" or "0V" |
| Remedy                  | Check the wiring<br>Switch device off/on   |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3995</b>                            |
| Fault message           | MainTrans EAA31 ... EAA36 dynamic test   |
| Cause                   | Short-circuit of outputs with "24V"      |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 3997</b>                            |
| Fault message           | MainTrans EAA37 ... EAA40 dynamic test   |
| Cause                   | Short-circuit of outputs with "24V"      |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 4501 / F 4502</b>                              |
| Alarm message           | Faulty calculation of SSX brake ramp                |
| Cause                   | Faulty configuration                                |
| Remedy                  | Check SSX configuration<br>Consult the manufacturer |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 4503 / F 4504</b>                          |
| Alarm message           | Faulty calculation of SSX limit curve           |
| Cause                   | Faulty calculation of SSX limit curve           |
| Remedy                  | Check configuration<br>Consult the manufacturer |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 4600</b>                                   |
| Alarm message           | OLC Both Enabled                                |
| Cause                   |   |
| Remedy                  | Check configuration<br>Consult the manufacturer |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 4624</b>                                   |
| Alarm message           | OLC TeachIn State Error                         |
| Cause                   |   |
| Remedy                  | Check configuration<br>Consult the manufacturer |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 4648</b>                                   |
| Alarm message           | OLC TeachIn position fault                      |
| Cause                   |   |
| Remedy                  | Check configuration<br>Consult the manufacturer |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 4672</b>                                   |
| Alarm message           | OLC ZSC Error                                   |
| Cause                   |   |
| Remedy                  | Check configuration<br>Consult the manufacturer |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 4900</b>                                   |
| Alarm message           | JSS Both Enabled                                |
| Cause                   |   |
| Remedy                  | Check configuration<br>Consult the manufacturer |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5201 / F5202</b>                    |
| Fault message           | Fault EAA0.11 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5203 / F5204</b>                    |
| Fault message           | Fault EAA0.12 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5205 / F5206</b>                    |
| Fault message           | Fault EAA0.13 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5207 / F5208</b>                    |
| Fault message           | Fault EAA0.14 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5209 / F5210</b>                    |
| Fault message           | Fault EAA0.15 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5211 / F5212</b>                    |
| Fault message           | Fault EAA0.16 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5213 / F5214</b>                    |
| Fault message           | Fault EAA0.17 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5215 / F5216</b>                    |
| Fault message           | Fault EAA0.18 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5217 / F5218</b>                    |
| Fault message           | Fault EAA0.19 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5219 / F5220</b>                    |
| Fault message           | Fault EAA0.20 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5221 / F5222</b>                    |
| Fault message           | Fault EAA0.21 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5223 / F5224</b>                    |
| Fault message           | Fault EAA0.22 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5225 / F5226</b>                    |
| Fault message           | Fault EAA0.23 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5227 / F5228</b>                    |
| Fault message           | Fault EAA0.24 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5229 / F5230</b>                    |
| Fault message           | Fault EAA0.25 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5231 / F5232</b>                    |
| Fault message           | Fault EAA0.26 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5233 / F5234</b>                    |
| Fault message           | Fault EAA0.27 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5235 / F5236</b>                    |
| Fault message           | Fault EAA0.28 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5237 / F5238</b>                    |
| Fault message           | Fault EAA0.29 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |                                    |
|-------------------------|------------------------------------|
| <b>Fatal Error Code</b> | <b>F 5239 / F5240</b>              |
| Fault message           | Fault EAA0.30 dynamic test         |
| Cause                   | Short-circuit of output with "24V" |

|        |  |
|--------|--|
| Remedy | Check the wiring<br>Switch device off/on |
|--------|--|

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5241 / F5242</b>                    |
| Fault message           | Fault EAA0.31 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5243 / F5244</b>                    |
| Fault message           | Fault EAA0.32 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5245 / F5246</b>                    |
| Fault message           | Fault EAA0.33 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5247 / F5248</b>                    |
| Fault message           | Fault EAA0.34 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5249 / F5250</b>                    |
| Fault message           | Fault EAA0.35 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5251 / F5252</b>                    |
| Fault message           | Fault EAA0.36 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5253 / F5254</b>                    |
| Fault message           | Fault EAA0.37 dynamic test               |
| Cause                   | Short-circuit of output with "24V"       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |                            |
|-------------------------|----------------------------|
| <b>Fatal Error Code</b> | <b>F 5255 / F5256</b>      |
| Fault message           | Fault EAA0.38 dynamic test |

|        |  |
|--------|--|
| Cause  | Short-circuit of output with “24V”       |
| Remedy | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5257 / F5258</b>                    |
| Fault message           | Fault EAA0.39 dynamic test               |
| Cause                   | Short-circuit of output with “24V”       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |  |
|-------------------------|--|
| <b>Fatal Error Code</b> | <b>F 5259 / F5260</b>                    |
| Fault message           | Fault EAA0.40 dynamic test               |
| Cause                   | Short-circuit of output with “24V”       |
| Remedy                  | Check the wiring<br>Switch device off/on |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 6801 / F 6802</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |
|                         |   |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 6803 / F 6804</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 6805 / F 6806</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 6807 / F 6808</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 6809 / F 6810</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 6811 / F 6812</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 6813 / F 6814</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 8205 / F 8206</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 8207 / F 8208</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |
| <b>Fatal Error Code</b> | <b>F 8213 / F 8214</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |
| <b>Fatal Error Code</b> | <b>F 8220</b>                                     |
| Fault message           | Internal fault – please contact the manufacturer! |
| <b>Fatal Error Code</b> | <b>F 8221 / F 8222</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |
| <b>Fatal Error Code</b> | <b>F 8223 / F 8224</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |
| <b>Fatal Error Code</b> | <b>F 8225</b>                                     |
| Fault message           | Internal fault – please contact the manufacturer! |
| <b>Fatal Error Code</b> | <b>F 8227</b>                                     |
| Fault message           | Internal fault – please contact the manufacturer! |
| <b>Fatal Error Code</b> | <b>F 8228</b>                                     |
| Fault message           | Internal fault – please contact the manufacturer! |
| <b>Fatal Error Code</b> | <b>F 9001 / F 9002</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |
| <b>Fatal Error Code</b> | <b>F 9007 / F 9008</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |
| <b>Fatal Error Code</b> | <b>F 9009 / F 9010</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |
| <b>Fatal Error Code</b> | <b>F 9011 / F 9012</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |
| <b>Fatal Error Code</b> | <b>F 9013 / F 9014</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 9015 / F 9016</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 9017 / F 9018</b>                            |
| Fault message           | Internal fault – please contact the manufacturer! |

|                         |   |
|-------------------------|---|
| <b>Fatal Error Code</b> | <b>F 9051</b>                                     |
| Fault message           | Internal fault – please contact the manufacturer! |

|                         |                                       |
|-------------------------|---------------------------------------|
| <b>Fatal Error Code</b> | <b>F 9101 / F 9102</b>                |
| Fault message           | SDDC signature fault                  |
| Cause                   | Configuration fault bus communication |
| Remedy                  | Switch device off/on                  |



## 12 Encoder types

| No. | Type<br>Encoder to interface<br>X31/32 | Type<br>Encoder to interface<br>X33/34 | Type<br>Encoder to X<br>23 | Secure<br>speed | Secure<br>direction | Secure<br>position | Fault exclusion  | DC                             |   |   |
|-----|--|--|----------------------------|-----------------|---------------------|--------------------|--|--------------------------------|---|---|
|     |  |  |                            |                 |                     |                    |  | 1-channel<br>partial<br>system | 2-channel<br>partial<br>system<br>dynamic | 2-channel<br>partial<br>system<br>non-<br>dynamic<br>(standstill<br>monitoring) |
| 69  | NC                                     | NC                                     | 1 x Bero + 1<br>x Bero     | X               |                     |                    | Fault exclusion mech. shaft breakage, positive encoder shaft connection required, if common elements are in use. | n.a.                           | 99%                                       | 80-90%  |
| 1   | Incremental                            | NC                                     | NC                         | X               |                     |                    | Fault exclusion mech. shaft breakage, positive encoder shaft connection required                                 | 60%                            | 99%                                       | 80-90%  |
| 51  | Incremental                            | Incremental                            | NC                         | X               | X                   |                    |  | n.a.                           | 99%                                       | 95%   |
| 3   | Incremental                            | NC                                     | 1 x Bero                   | X               |                     |                    |  | n.a.                           | 99%                                       | 90-95%  |
| 68  | Incremental                            | NC                                     | 2 x Bero 90°               | X               | X                   |                    |  | n.a.                           | 99%                                       | 90-95%  |
| 62  | Incremental                            | SIN/COS                                | NC                         | X               | X                   |                    |  | n.a.                           | 99%                                       | 99%   |
| 54  | Incremental                            | HTL                                    | NC                         | X               | X                   |                    |  | n.a.                           | 99%                                       | 90-95%  |
| 58  | Incremental                            | Resolver                               | NC                         | X               | X                   |                    |  | n.a.                           | 99%                                       | 99%   |
| 65  | Incremental                            | SSI                                    | NC                         | X               | X                   | X                  |  | n.a.                           | 99%                                       | 90-95%  |

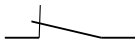
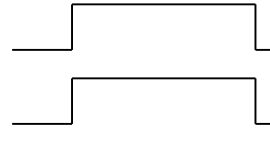

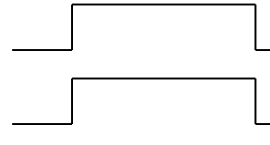
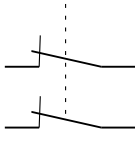
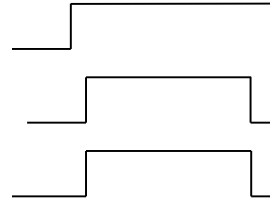
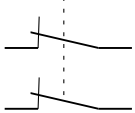
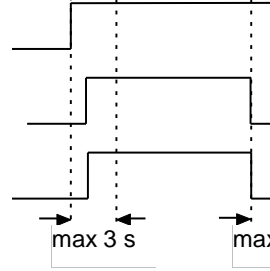
| No. | Type<br>Encoder to<br>interface<br>X31/32 | Type<br>Encoder to<br>interface<br>X33/34 | Type<br>Encoder to<br>X 23 | Secure<br>speed | Secure<br>direction | Secure<br>position | Fault exclusion  | DC                             |   |   |
|-----|---|---|----------------------------|-----------------|---------------------|--------------------|--|--------------------------------|---|---|
|     |   |   |                            |                 |                     |                    |  | 1-channel<br>partial<br>system | 2-channel<br>partial<br>system<br>dynamic | 2-channel<br>partial<br>system<br>non-<br>dynamic<br>(standstill<br>monitoring) |
| 2   | SIN/COS                                   | NC  | NC                         | X               | X                   |                    | Fault exclusion mech. shaft breakage, positive encoder shaft connection required | 90%                            | 99%                                       | 90-95%  |
| 52  | SIN/COS                                   | Incremental                               | NC                         | X               | X                   |                    |  | n.a.                           | 99%                                       | 95-99%  |
| 4   | SIN/COS                                   | NC  | 1 x Bero                   | X               | X                   |                    |  | n.a.                           | 99%                                       | 90-95%  |
| 50  | SIN/COS                                   | NC  | 2 x Bero 90°               | X               | X                   |                    |  | n.a.                           | 99%                                       | 95-99%  |
| 55  | SIN/COS                                   | HTL                                       | NC                         | X               | X                   |                    |  | n.a.                           | 99%                                       | 95-99%  |
| 59  | SIN/COS                                   | Resolver                                  | NC                         | X               | X                   |                    |  | n.a.                           | 99%                                       | 99%   |
| 66  | SIN/COS                                   | SSI                                       | NC                         | X               | X                   | X                  |  | n.a.                           | 99%                                       | 95-99%  |

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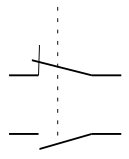
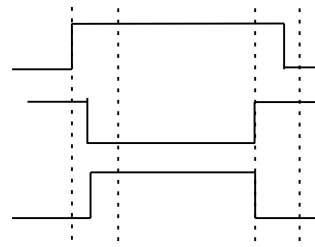
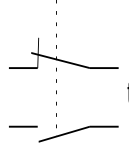
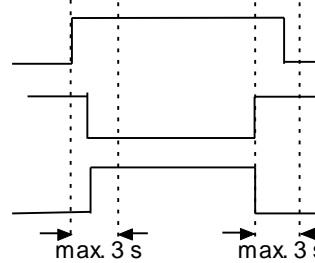
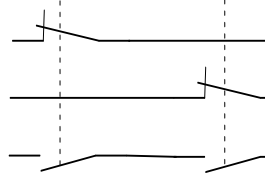
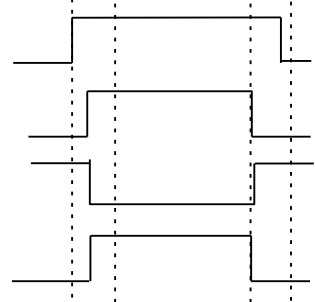
| No. | Type<br>Encoder to<br>interface<br>X31/32 | Type<br>Encoder to<br>interface<br>X33/34 | Type<br>Encoder to<br>X 23 | Secure<br>speed | Secure<br>direction | Secure<br>position | Fault exclusion  | DC                             |   |   |
|-----|---|---|----------------------------|-----------------|---------------------|--------------------|--|--------------------------------|---|---|
|     |   |   |                            |                 |                     |                    |  | 1-channel<br>partial<br>system | 2-channel<br>partial<br>system<br>dynamic | 2-channel<br>partial<br>system<br>non-<br>dynamic<br>(standstill<br>monitoring) |
| 8   | SSI                                       | NC  | 2 x Bero 90°               | X               | X                   | X                  |  | n.a.                           | 99%                                       | 90-95%  |
| 63  | SSI                                       | SIN/COS                                   | NC                         | X               | X                   | X                  |  | n.a.                           | 99%                                       | 95-99%  |
| 60  | SSI                                       | Resolver                                  | NC                         | X               | X                   | X                  |  | n.a.                           | 99%                                       | 95-99%  |
| 67  | SSI                                       | SSI                                       | NC                         | X               | X                   | X                  |  | n.a.                           | 99%                                       | 90-95%  |
| 61  | NC  | SIN/COS                                   | NC                         | X               | X                   |                    | Fault exclusion mech. shaft breakage, positive encoder shaft connection required | 90%                            | 99%                                       | 90-95%  |
| 57  | NC  | Resolver                                  | NC                         | X               | X                   |                    | Fault exclusion mech. shaft breakage, positive encoder shaft connection required | 90%                            | 99%                                       | 90-95%  |
| 53  | NC  | HTL                                       | NC                         | X               |                     |                    | Fault exclusion mech. shaft breakage, positive encoder shaft connection required | 60%                            | 99%                                       | 80-90%  |
| 64  | NC  | SSI                                       | 2 x Bero 90°               | X               | X                   | X                  |  | n.a.                           | 99%                                       | 90-95%  |

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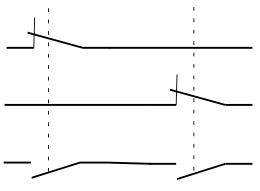
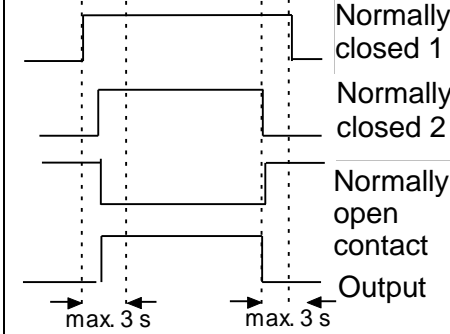
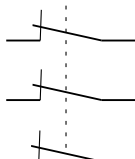
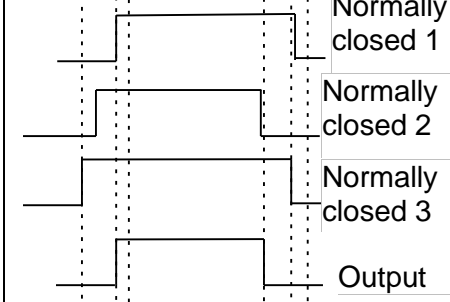
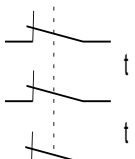
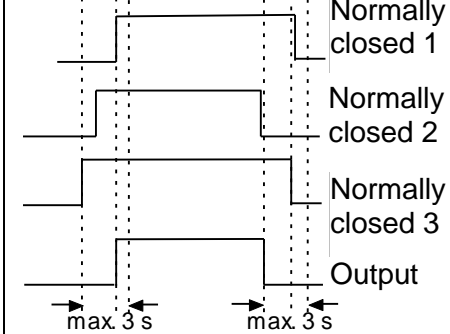
## 13 Switch types

| Type | Graphic symbols  | Truth table   | Logic function | Function block | Function |   |   |   |                   |   |   |   |   |   |   |   |   |  |                               |  |  |
|------|--|---|----------------|----------------|----------|---|---|---|-------------------|---|---|---|---|---|---|---|---|--|-------------------------------|--|--|
| 1    | <br>eSwitch_1o    | <table border="1"> <tr> <td>NC</td> <td>O</td> </tr> <tr> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>1</td> </tr> </table>   | NC             | O              | 0        | 0 | 1 | 1 | LD E.1<br>ST IE.X |   | Normally open, only shown normally closed |  Normally closed contact<br>Output |   |   |   |   |   |  |                               |  |  |
| NC   | O  |   |                |                |          |   |   |   |                   |   |   |   |   |   |   |   |   |  |                               |  |  |
| 0    | 0  |   |                |                |          |   |   |   |                   |   |   |   |   |   |   |   |   |  |                               |  |  |
| 1    | 1  |   |                |                |          |   |   |   |                   |   |   |   |   |   |   |   |   |  |                               |  |  |
| 2    | <br>sSwitch_1s    | <table border="1"> <tr> <td>NO</td> <td>O</td> </tr> <tr> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>1</td> </tr> </table>   | NO             | O              | 0        | 0 | 1 | 1 | LD E.1<br>ST IE.X |   | Normally open, as type 1                  |  Normally closed contact<br>Output |   |   |   |   |   |  |                               |  |  |
| NO   | O  |   |                |                |          |   |   |   |                   |   |   |   |   |   |   |   |   |  |                               |  |  |
| 0    | 0  |   |                |                |          |   |   |   |                   |   |   |   |   |   |   |   |   |  |                               |  |  |
| 1    | 1  |   |                |                |          |   |   |   |                   |   |   |   |   |   |   |   |   |  |                               |  |  |
| 3    | <br>eSwitch_2o    | <table border="1"> <tr> <td>NC1</td> <td>NC2</td> <td>O</td> </tr> <tr> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> </tr> </table> | NC1            | NC2            | O        | 0 | 0 | 0 | 1                 | 0 | 0   | 0   | 1 | 0 | 1 | 1 | 1 | LD E.1<br>AND E.2<br>ST IE.X   |                               | AND operation of both inputs   |  Normally closed 1<br>Normally closed 2<br>Output                         |
| NC1  | NC2  | O   |                |                |          |   |   |   |                   |   |   |   |   |   |   |   |   |  |                               |  |  |
| 0    | 0  | 0   |                |                |          |   |   |   |                   |   |   |   |   |   |   |   |   |  |                               |  |  |
| 1    | 0  | 0   |                |                |          |   |   |   |                   |   |   |   |   |   |   |   |   |  |                               |  |  |
| 0    | 1  | 0   |                |                |          |   |   |   |                   |   |   |   |   |   |   |   |   |  |                               |  |  |
| 1    | 1  | 1   |                |                |          |   |   |   |                   |   |   |   |   |   |   |   |   |  |                               |  |  |
| 4    | <br>eSwitch_2oT | <table border="1"> <tr> <td>NC1</td> <td>NC2</td> <td>O</td> </tr> <tr> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> </tr> </table> | NC1            | NC2            | O        | 0 | 0 | 0 | 1                 | 0 | 0   | 0   | 1 | 0 | 1 | 1 | 1 | LD E.1<br>OR E.2<br>ST META_EN.1<br><br>LD E.1<br>AND E.2<br>ST METB_EN.1<br><br>LD MET.1<br>ST IE.X | Time monitoring<br>MET1..MET4 | Like 3, but with time monitoring of state changes. In case of signal changes at NO or NC a complementary signal must follow within a period of t=3 s. If not, detect fault and O=0 |  Normally closed 1<br>Normally closed 2<br>Output<br>max 3 s<br>max 3 s |
| NC1  | NC2  | O   |                |                |          |   |   |   |                   |   |   |   |   |   |   |   |   |  |                               |  |  |
| 0    | 0  | 0   |                |                |          |   |   |   |                   |   |   |   |   |   |   |   |   |  |                               |  |  |
| 1    | 0  | 0   |                |                |          |   |   |   |                   |   |   |   |   |   |   |   |   |  |                               |  |  |
| 0    | 1  | 0   |                |                |          |   |   |   |                   |   |   |   |   |   |   |   |   |  |                               |  |  |
| 1    | 1  | 1   |                |                |          |   |   |   |                   |   |   |   |   |   |   |   |   |  |                               |  |  |

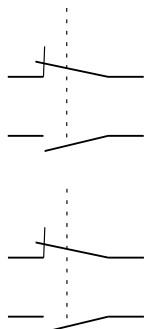
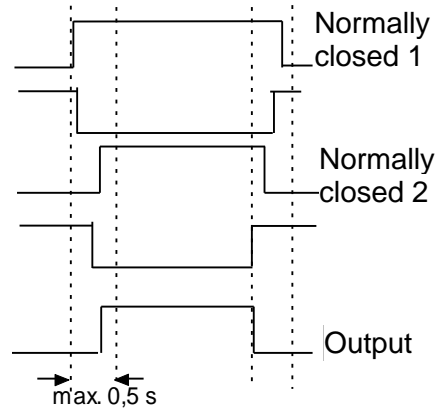
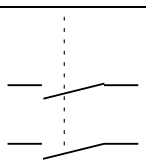
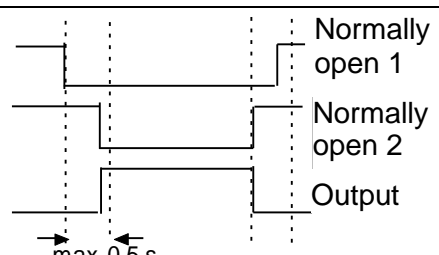
# Installation Manual

| Type | Graphic symbols  | Truth table  |    |    | Function |    |   |   |   |   |   |   |   |   |   |   |   |  |                                   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |   |  |
|------|--|--|----|----|----------|----|---|---|---|---|---|---|---|---|---|---|---|--|-----------------------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|--|---|--|
| 5    |  <p>eSwitch_1s1o</p>  | <table border="1"> <thead> <tr> <th>NO</th> <th>NC</th> <th>O</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>1</td> </tr> <tr> <td>1</td> <td>1</td> <td>0</td> </tr> </tbody> </table>  | NO | NC | O        | 0  | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | <p>LD E.1<br/>AND NOT E.2<br/>ST IE.X</p>  |                                   | <p>Monitoring for NO=inactive and NC=active</p>   |  <p>Normally closed contact<br/>Normally open contact<br/>Output</p>                               |   |   |   |   |   |   |   |   |   |   |   |   |  |   |  |
| NO   | NC   | O  |    |    |          |    |   |   |   |   |   |   |   |   |   |   |   |  |                                   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |   |  |
| 0    | 0  | 0  |    |    |          |    |   |   |   |   |   |   |   |   |   |   |   |  |                                   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |   |  |
| 1    | 0  | 0  |    |    |          |    |   |   |   |   |   |   |   |   |   |   |   |  |                                   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |   |  |
| 0    | 1  | 1  |    |    |          |    |   |   |   |   |   |   |   |   |   |   |   |  |                                   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |   |  |
| 1    | 1  | 0  |    |    |          |    |   |   |   |   |   |   |   |   |   |   |   |  |                                   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |   |  |
| 6    |  <p>eSwitch_1s1oT</p> | <table border="1"> <thead> <tr> <th>NO</th> <th>NC</th> <th>O</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>1</td> </tr> <tr> <td>1</td> <td>1</td> <td>0</td> </tr> </tbody> </table>  | NO | NC | O        | 0  | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | <p>LD E.1<br/>OR NOT E.2<br/>ST META_EN.1</p> <p>LD E1<br/>AND NOT E2<br/>ST METB_EN.1</p> <p>LD MET.1<br/>ST IE.X</p> | <p>Time monitoring MET1..MET4</p> | <p>Like 5, but with time monitoring of state changes. In case of signal changes at NO or NC a complementary signal must follow within a period of t=3 s. If not, detect fault and O=0</p> |  <p>Normally closed contact<br/>Normally open contact<br/>Output</p> <p>max. 3 s      max. 3 s</p> |   |   |   |   |   |   |   |   |   |   |   |   |  |   |  |
| NO   | NC   | O  |    |    |          |    |   |   |   |   |   |   |   |   |   |   |   |  |                                   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |   |  |
| 0    | 0  | 0  |    |    |          |    |   |   |   |   |   |   |   |   |   |   |   |  |                                   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |   |  |
| 1    | 0  | 0  |    |    |          |    |   |   |   |   |   |   |   |   |   |   |   |  |                                   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |   |  |
| 0    | 1  | 1  |    |    |          |    |   |   |   |   |   |   |   |   |   |   |   |  |                                   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |   |  |
| 1    | 1  | 0  |    |    |          |    |   |   |   |   |   |   |   |   |   |   |   |  |                                   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |   |  |
| 7    |  <p>eSwitch_2s2o</p> | <table border="1"> <thead> <tr> <th>NO</th> <th>NC</th> <th>NO</th> <th>NC</th> <th>O</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>1</td> <td>2</td> <td>2</td> <td></td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> <td>1</td> <td>1</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> <td>1</td> <td>0</td> </tr> </tbody> </table> | NO | NC | NO       | NC | O | 1 | 1 | 2 | 2 |   | 1 | 0 | 1 | 0 | 0 | 0  | 1                                 | 1   | 0   | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | <p>LD E.1<br/>AND E.2<br/>AND NOT E.3<br/>ST IE.X</p> |  | <p>Monitoring for NO1*NO2=inactive and NC1*NC2=active</p> |  <p>Normally closed 1<br/>Normally closed 2<br/>Normally open contact<br/>Output</p> |
| NO   | NC   | NO   | NC | O  |          |    |   |   |   |   |   |   |   |   |   |   |   |  |                                   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |   |  |
| 1    | 1  | 2  | 2  |    |          |    |   |   |   |   |   |   |   |   |   |   |   |  |                                   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |   |  |
| 1    | 0  | 1  | 0  | 0  |          |    |   |   |   |   |   |   |   |   |   |   |   |  |                                   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |   |  |
| 0    | 1  | 1  | 0  | 0  |          |    |   |   |   |   |   |   |   |   |   |   |   |  |                                   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |   |  |
| 0    | 1  | 0  | 1  | 1  |          |    |   |   |   |   |   |   |   |   |   |   |   |  |                                   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |   |  |
| 1    | 0  | 0  | 1  | 0  |          |    |   |   |   |   |   |   |   |   |   |   |   |  |                                   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |   |  |

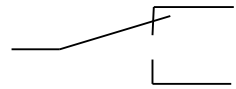
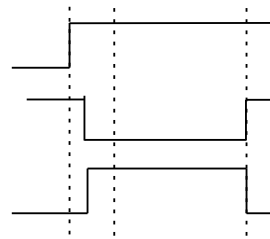
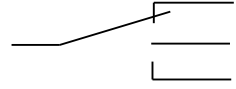
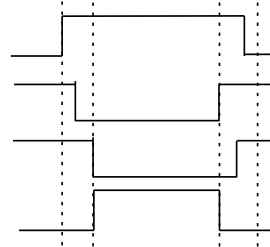
# Installation Manual

| Type | Graphic symbols  | Truth table   |     |     | Function |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                                       |  |   |   |   |   |                                       |   |   |
|------|--|---|-----|-----|----------|----|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|--|---------------------------------------|--|---|---|---|---|---------------------------------------|---|---|
| 8    |  <p>eSwitch_2s2oT</p> | <table border="1"> <thead> <tr> <th>NO</th> <th>NC</th> <th>NO</th> <th>NC</th> <th>O</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>1</td> <td>2</td> <td>2</td> <td>0</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> <td>1</td> <td>1</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> <td>1</td> <td>0</td> </tr> </tbody> </table> | NO  | NC  | NO       | NC | O | 1 | 1 | 2 | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1  | 1                                     | 0  | 0   | 1 | 0 | <p>LD E.1<br/>OR E.2<br/>OR NOT E.3<br/>ST META_EN.1</p> <p>LD E.1<br/>AND E.2<br/>AND NOT E.3<br/>ST METB_EN.1</p> <p>LD MET.1<br/>ST IE.X</p> | <p>Time monitoring<br/>MET1..MET4</p> | <p>Like 6, but with time monitoring of state changes. In case of signal changes at NO (Attention: Bus line) or NC a complementary signal must follow within a period of t=3 s. If not, detect fault and O=0</p> |  <p>Normally closed 1<br/>Normally closed 2<br/>Normally open contact<br/>Output</p> <p>max. 3 s    max. 3 s</p> |
| NO   | NC   | NO  | NC  | O   |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                                       |  |   |   |   |   |                                       |   |   |
| 1    | 1  | 2   | 2   | 0   |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                                       |  |   |   |   |   |                                       |   |   |
| 1    | 0  | 1   | 0   | 0   |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                                       |  |   |   |   |   |                                       |   |   |
| 0    | 1  | 1   | 0   | 0   |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                                       |  |   |   |   |   |                                       |   |   |
| 0    | 1  | 0   | 1   | 1   |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                                       |  |   |   |   |   |                                       |   |   |
| 1    | 0  | 0   | 1   | 0   |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                                       |  |   |   |   |   |                                       |   |   |
| 9    |  <p>eSwitch_3o</p>    | <table border="1"> <thead> <tr> <th>NC1</th> <th>NC2</th> <th>NC3</th> <th>O</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> <td>1</td> </tr> </tbody> </table>   | NC1 | NC2 | NC3      | O  | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | <p>LD E.1<br/>AND E.2<br/>AND E.3<br/>ST IE.X</p>  |                                       | <p>AND operation of both inputs</p>  |  <p>Normally closed 1<br/>Normally closed 2<br/>Normally closed 3<br/>Output</p>                              |   |   |   |                                       |   |   |
| NC1  | NC2  | NC3   | O   |     |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                                       |  |   |   |   |   |                                       |   |   |
| 0    | 0  | 0   | 0   |     |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                                       |  |   |   |   |   |                                       |   |   |
| 1    | 0  | 0   | 0   |     |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                                       |  |   |   |   |   |                                       |   |   |
| 0    | 1  | 0   | 0   |     |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                                       |  |   |   |   |   |                                       |   |   |
| 1    | 1  | 0   | 0   |     |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                                       |  |   |   |   |   |                                       |   |   |
| 1    | 1  | 1   | 1   |     |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                                       |  |   |   |   |   |                                       |   |   |
| 10   |  <p>eSwitch_3oT</p> | <table border="1"> <thead> <tr> <th>NC1</th> <th>NC2</th> <th>NC3</th> <th>O</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> <td>1</td> </tr> </tbody> </table>   | NC1 | NC2 | NC3      | O  | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | <p>LD E.1<br/>OR E.2<br/>OR E.3<br/>ST META_EN.1</p> <p>LD E.1<br/>AND E.2<br/>AND E.3<br/>ST METB_EN.1<br/>LD MET.1<br/>ST IE.X</p> | <p>Time monitoring<br/>MET1..MET4</p> | <p>Like 8, but with time monitoring of state changes. In case of signal change on one of the NC-inputs the other inputs must follow within a period of t=3 s. If not, detect fault and O=0</p> |  <p>Normally closed 1<br/>Normally closed 2<br/>Normally closed 3<br/>Output</p> <p>max. 3 s    max. 3 s</p> |   |   |   |                                       |   |   |
| NC1  | NC2  | NC3   | O   |     |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                                       |  |   |   |   |   |                                       |   |   |
| 0    | 0  | 0   | 0   |     |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                                       |  |   |   |   |   |                                       |   |   |
| 1    | 0  | 0   | 0   |     |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                                       |  |   |   |   |   |                                       |   |   |
| 0    | 1  | 0   | 0   |     |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                                       |  |   |   |   |   |                                       |   |   |
| 1    | 1  | 0   | 0   |     |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                                       |  |   |   |   |   |                                       |   |   |
| 1    | 1  | 1   | 1   |     |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                                       |  |   |   |   |   |                                       |   |   |

# Installation Manual

| Type | Graphic symbols   | Truth table  |    |    | Function |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                           |  |  |   |   |   |   |   |   |   |   |   |                           |  |   |
|------|---|--|----|----|----------|----|---|---|---|---|---|---|---|---|---|---|---|---|---|---|--|---------------------------|--|--|---|---|---|---|---|---|---|---|---|---------------------------|--|---|
| 11   | <br><br>eTwoHand_2o  | <table border="1"> <tr> <td>NC</td> <td>NO</td> <td>NC</td> <td>NO</td> <td>O</td> </tr> <tr> <td>1</td> <td>1</td> <td>2</td> <td>2</td> <td></td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> <td>1</td> <td>0</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> <td>1</td> <td>0</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> <td>1</td> <td>1</td> </tr> </table> | NC | NO | NC       | NO | O | 1 | 1 | 2 | 2 |   | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1  | 0                         | 1  | 0  | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | LD NOT E.1<br>OR E.2<br>OR NOT E.3<br>OR E.4<br>ST MEZ_EN.1<br><br>LD E.1<br>AND NOT E2<br>AND E3<br>AND NOT E4<br>ST MEZ_EN.2<br><br>LD NOT E1<br>AND E.2<br>AND NOT E3<br>AND E.4<br>ST MEZ_EN.3<br><br>LD MEZ.1<br>ST IE.X | Two-hand operation<br>MEZ | Monitoring for<br>$NO1*NO2=inactive$ and<br>$NC1*NC2=active$ + temporal<br>monitoring of this status. This<br>means that in case of a signal<br>change of an NO from 1->0 or<br>NC from 0->1, the other signals<br>(i.e. further $NO=0$ or $NC=1$ ) must<br>follow within a period of 0.5 s. If<br>not, the output = 0.<br>No interference evaluation! No<br>temporal monitoring when<br>changing to inactive state. |  |
| NC   | NO  | NC   | NO | O  |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                           |  |  |   |   |   |   |   |   |   |   |   |                           |  |   |
| 1    | 1   | 2  | 2  |    |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                           |  |  |   |   |   |   |   |   |   |   |   |                           |  |   |
| 0    | 1   | 0  | 1  | 0  |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                           |  |  |   |   |   |   |   |   |   |   |   |                           |  |   |
| 1    | 0   | 0  | 1  | 0  |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                           |  |  |   |   |   |   |   |   |   |   |   |                           |  |   |
| 1    | 0   | 1  | 0  | 0  |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                           |  |  |   |   |   |   |   |   |   |   |   |                           |  |   |
| 0    | 1   | 0  | 1  | 1  |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                           |  |  |   |   |   |   |   |   |   |   |   |                           |  |   |
| 12   | <br><br>eTwoHand_2s | <table border="1"> <tr> <td>NO</td> <td>NO</td> <td>O</td> </tr> <tr> <td>1</td> <td>2</td> <td></td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> </tr> <tr> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> </tr> </table>   | NO | NO | O        | 1  | 2 |   | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | LD E.1<br>OR E.2<br>ST MEZ_EN.1<br><br>LD NOT E.1<br>AND NOT E.2<br>ST MEZ_EN.2<br><br>LD E.1<br>AND E.2<br>ST MEZ_EN.3<br><br>LD MEZ.1<br>ST IE.X | Two-hand operation<br>MEZ | Monitoring for<br>$NO1*NO2=inactive$ + temporal<br>monitoring of this status. This<br>means that in case of a signal<br>change of one NO from 1->0 the<br>other signal (i.e. another $NO=0$ )<br>must follow within a period of 0.5<br>s. If not, the output = 0.<br>No interference evaluation! No<br>temporal monitoring when<br>changing to inactive state. |  |   |   |   |   |   |   |   |   |   |                           |  |   |
| NO   | NO  | O  |    |    |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                           |  |  |   |   |   |   |   |   |   |   |   |                           |  |   |
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| 0    | 0   | 0  |    |    |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                           |  |  |   |   |   |   |   |   |   |   |   |                           |  |   |
| 1    | 1   | 1  |    |    |          |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                           |  |  |   |   |   |   |   |   |   |   |   |                           |  |   |

# Installation Manual

| Type | Graphic symbols  | Truth table  |    |    | Function |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |
|------|--|--|----|----|----------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|--|-----------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|--|-----------------|---|---|
| 13   |  <p>eMode_1s1o</p>    | <table border="1"> <tr> <td>N</td> <td>N</td> <td>O</td> <td>O</td> </tr> <tr> <td>O</td> <td>O</td> <td>1</td> <td>2</td> </tr> <tr> <td>1</td> <td>2</td> <td></td> <td></td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>0</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>1</td> <td>0</td> <td>0</td> </tr> </table>   | N  | N  | O        | O | O | O | 1 | 2 | 1 | 2 |   |   | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | <p>LD E.1<br/>AND NOT E.2<br/>ST IE.X</p> <p>LD NOT E.1<br/>AND E.2<br/>ST IE.X2</p> | Selector switch | Clear linkage of permissible switch positions |  <p>Normally closed contact</p> <p>Normally open contact</p> <p>Output</p> |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |
| N    | N  | O  | O  |    |          |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |
| O    | O  | 1  | 2  |    |          |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |
| 1    | 2  |  |    |    |          |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |
| 1    | 0  | 1  | 0  |    |          |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |
| 0    | 1  | 0  | 1  |    |          |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |
| 0    | 0  | 0  | 0  |    |          |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |
| 1    | 1  | 0  | 0  |    |          |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |
| 14   |  <p>eMode_3switch</p> | <table border="1"> <tr> <td>NO</td> <td>NO</td> <td>NO</td> <td>O</td> <td>O</td> <td>O</td> </tr> <tr> <td>1</td> <td>2</td> <td>3</td> <td>1</td> <td>2</td> <td>3</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> <td>0</td> <td>1</td> <td>0</td> </tr> <tr> <td>0</td> <td>0</td> <td>1</td> <td>0</td> <td>0</td> <td>1</td> </tr> <tr> <td>1</td> <td>1</td> <td>0</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>1</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>0</td> <td>0</td> <td>0</td> <td>0</td> <td>0</td> </tr> </table> | NO | NO | NO       | O | O | O | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0  | 1               | 1   | 1   | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | <p>LD E.1<br/>AND NOT E.2<br/>AND NOT E.3<br/>ST IE.X</p> <p>LDN E.1<br/>AND E2<br/>AND NOT E.3<br/>ST IE.X2</p> <p>LDN E.1<br/>AND NOT E.2<br/>AND E.3<br/>ST IE.X3</p> | Selector switch | Clear linkage of permissible switch positions |  <p>Switch 1</p> <p>Switch 2</p> <p>Switch 3</p> <p>Output 1</p> |
| NO   | NO   | NO   | O  | O  | O        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |
| 1    | 2  | 3  | 1  | 2  | 3        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |
| 1    | 0  | 0  | 1  | 0  | 0        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |
| 0    | 1  | 0  | 0  | 1  | 0        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |
| 0    | 0  | 1  | 0  | 0  | 1        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |
| 1    | 1  | 0  | 0  | 0  | 0        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |
| 1    | 0  | 1  | 0  | 0  | 0        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |
| 0    | 1  | 1  | 0  | 0  | 0        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |
| 1    | 1  | 1  | 0  | 0  | 0        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |
| 0    | 0  | 0  | 0  | 0  | 0        |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |                 |   |   |



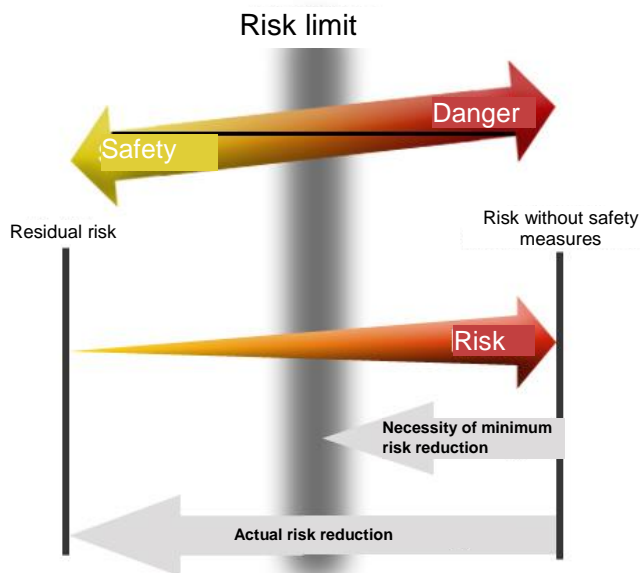
## 14 Notes on designing, programming, validating and testing safety related applications

The following notes describe the procedure for designing, programming, validating and testing safety related applications

The information should help the user to classify, to easily understand and to use all steps from risk assessment all the way to the system test. For better understanding the respective subjects, the individual steps are explained by means of examples.

### 14.1 Risk assessment

The manufacturer of a machine must generally guarantee the safety of any machine designed or delivered by him. The assessment of safety must be based on the applicable and appropriate regulations and standards. Objective of the safety assessment and the measures derived from this must be the reduction of risks for persons down to an acceptable minimum.

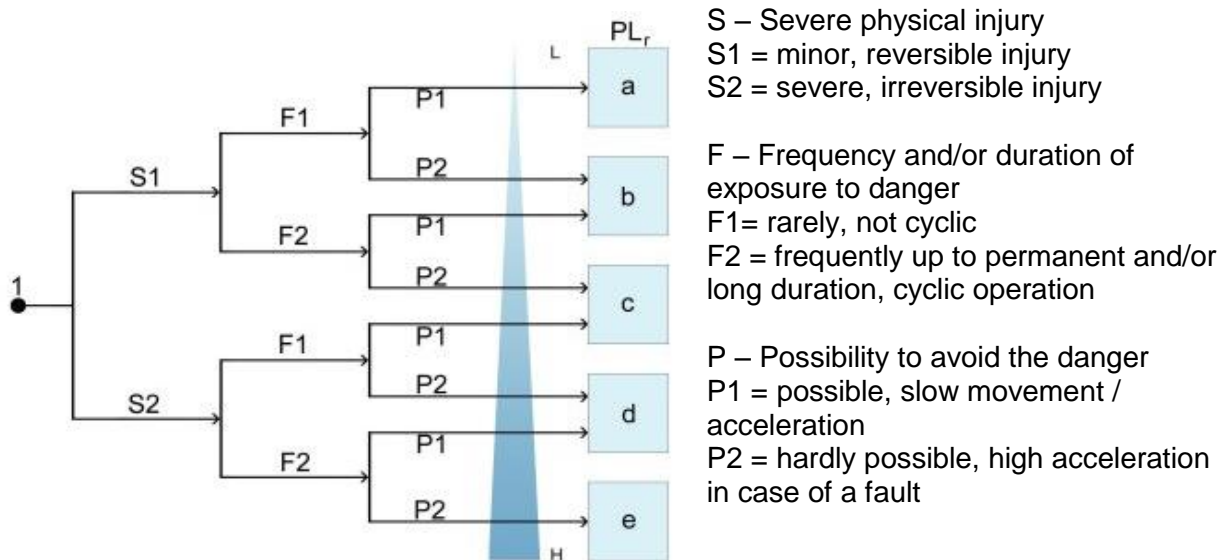


The risk analysis must account for all operating conditions of the machine, such as operation, setup work and maintenance or installation and decommissioning as well as predictable erroneous operation.

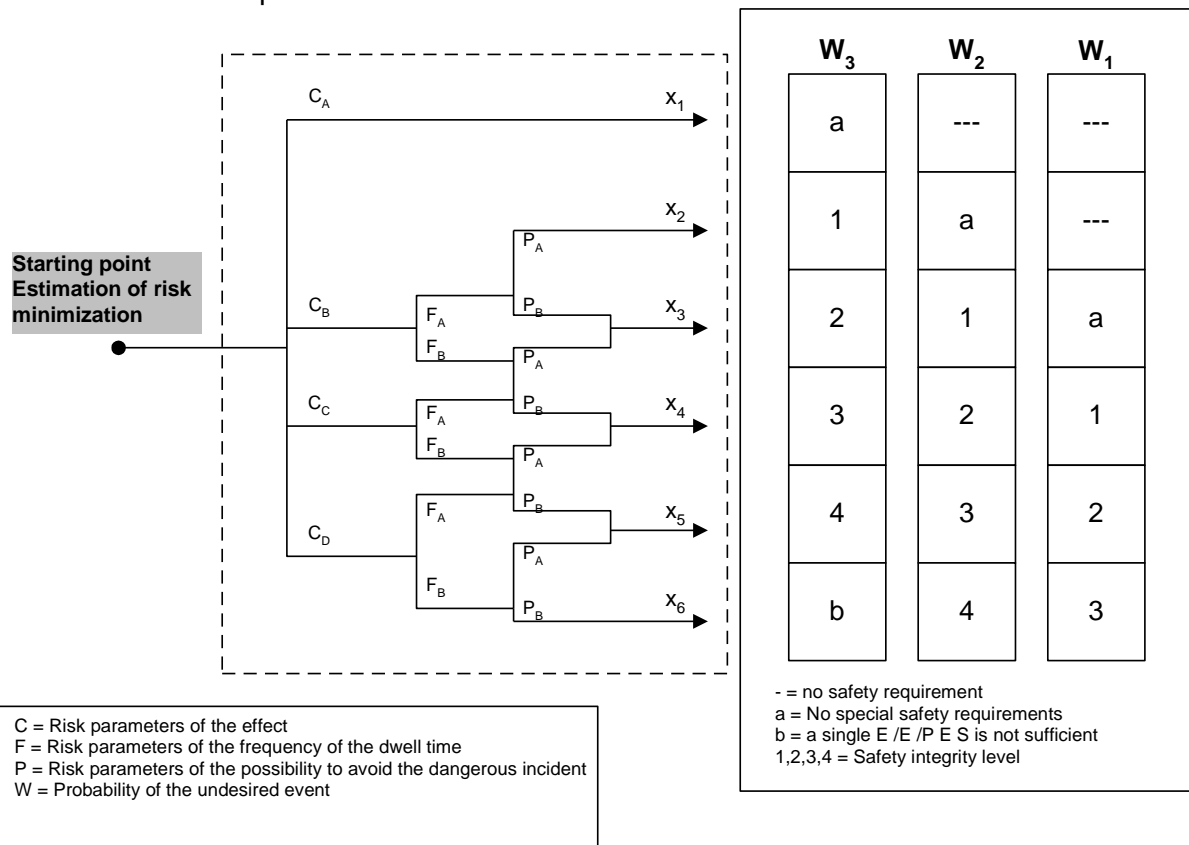
The procedure required for the risk analysis and the measures for reducing such risks can be found in the applicable standards

EN ISO 13849-1 Safety of machines

EN ISO 61508 Functional safety of safety related e/e/p e systems



Risk assessment as per EN ISO 61508



The risks to be examined can also be found in applicable regulations and standards, or must be considered separately by the manufacturer based on his specific knowledge of the machine.

For machines sold within the EU the minimum risks to be examined are specified in the EU machine directive 2006/42/EU or in the latest version of this directive.

Further information concerning the risk assessment and the safe design of machines can be found in the standards

EN 14121 Safety of machines - risk assessment

EN 12100 Safety of machines - basic terms, general design guidelines

Measures to be applied in order to reduce identified risks must at least be of the same level as the danger itself. The regulations and standards specified above contain examples of such measures and the associated requirements.

## 14.2 Required technical documents

The manufacturer is obliged to supply various technical documents. The minimum extent is also contained in the applicable regulations and standards.

The EU machine directive, for example, requires the delivery of the following documents:

1. The technical file shall comprise the following:

a) a construction file including:

- a general description of the machinery,
- the overall drawing of the machinery and drawings of the control circuits, as well as the pertinent descriptions and explanations necessary for understanding the operation of the machinery,
- full detailed drawings, accompanied by any calculation notes, test results, certificates, etc., required to check the conformity of the machinery with the essential health and safety requirements,
- the documentation on risk assessment demonstrating the procedure followed, including:
  - i) a list of the essential health and safety requirements which apply to the machinery,
  - ii) the description of the protective measures implemented to eliminate identified hazards or to reduce risks and, when appropriate, the indication of the residual risks associated with the machinery,
- the standards and other technical specifications used, indicating the essential health and safety requirements covered by these standards,
- any technical report giving the results of the tests carried out either by the manufacturer or by a body chosen by the manufacturer or his authorised representative,
- a copy of the instructions for the machinery,
- where appropriate, the declaration of incorporation for included partly completed machinery and the relevant assembly instructions for such machinery,
- where appropriate, copies of the EC declaration of conformity of machinery or other products incorporated into the machinery,
- a copy of the EC declaration of conformity;

b) for series manufacture, the internal measures that will be implemented to ensure that the machinery remains in conformity with the provisions of this Directive.

Source BGIA Report 2/2008

The documents must be easy to understand and should be written in the language of the corresponding country.

# Installation Manual

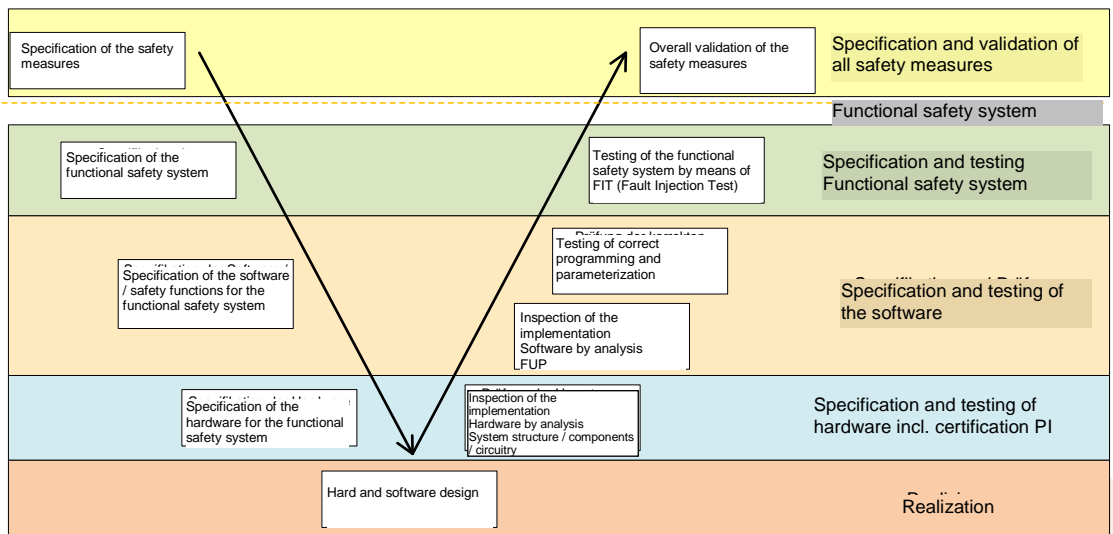
## 14.3 Necessary steps for draft, realization and testing

The realization of plant sections with safety related function requires special attention in planning, realization and testing. Also for this the standards (see ISO 13849-2 or EN ISO 61508) contain specific guidelines. The effort thereby is orientated on the complexity of the task for system components with safety related function.

For the realization of such functions the KSM-series offers safety relevant control and monitoring functions to support the system architecture (architecture Cat. 4 acc. to EN ISO 13849-1) and, above all, also the programming language and tested safety functions. Programming uses the form FUP (function plan oriented programming) recommended by the safety standards. It fully meets the requirements on the programming language with limited scope of languages (LVM) for the essential simplifications in documentation and testing. The individual steps in any case require careful planning and analysis of the methods and systems used. Furthermore, the individual steps must be documented in an understandable way.

### V-model (simplified)

The implementation of safety related functions requires a structured approach, like the V-model that is exemplary described in applicable standards. The following shows an exemplary approach for applications with modules of the KSM100 series.



## Phases of the V-model:

| Designation   | Description  | Validation phase   |
|---|--|--|
| Specification and validation of all safety measures | Design phase<br>Specification of all applicable passive or active safety measures to be applied, such as covers, barriers, max. machine parameters, safety related functions, etc.   | Testing of all passive and active safety measures for correct implementation and effectiveness.  |
| Specification of the functional safety systems      | Specification of the active safety systems and their assignment to the risks to be reduced, such as e.g. reduced speed in setup operation, stop-mode, monitoring of access areas, etc.<br>Specification of the PIR or the demanded SIL for each individual safety function | Testing of all active safety systems regarding effectiveness and compliance with specific parameters, such as e.g. erroneous increased speed, faulty stop, responding of monitoring facilities, etc. by means of practical tests                                 |
| Specification of software / safety functions        | Specification of the functionality of individual safety functions incl. the definition of the shut-down circuit, etc.<br>Definition of parameters for individual safety functions, such as e.g. max. speed, stop ramps and - categories, etc.                              | Examination of the correct implementation of functional specifications by analysing the FUP-programming Validation of the application program and the parameters by comparing the validation report with FUP or the specifications for parameters                |
| Specification of the hardware                       | Specification of the system structure and the functions of the individual sensors, command units, control components and actuators regarding their safety functions  | Testing of the correct implementation of specifications. Determination of the failure probability or PI by means of analysis of the overall architecture and the characteristic data of all components involved, each related to the individual safety functions |
| Hard and software design                            | Actual planning and implementation of system structure / wiring.<br><br>Actual implementation of safety functions by programming in FUP  | Nil  |



## 14.3.1 Specification of safety requirements (structural schematic)

The safety requirements must be individually analysed on the basis of applicable standards, e.g. product standard.

- 1 General product and project information**
  - 1.1 Product identification
  - 1.2 Author, version, date, document name, file name
  - 1.3 Contents
  - 1.4 Terminology, definitions, glossary
  - 1.5 Version history and changes
  - 1.6 Directives, standards and technical rules relevant to development
- 2 Functional information on the machine, where relevant to safety**
  - 2.1 Intended use and reasonably foreseeable misuse
  - 2.2 Process description (operating functions)
  - 2.3 Operating modes (e.g. setup mode, automatic mode, operation of localized relevance or of parts of the machine)
  - 2.4 Characteristic data, e.g. cycle times, response times, overrun distances
  - 2.5 Other characteristics of the machine
  - 2.6 Safe state of the machine
  - 2.7 Interaction between processes (see also 2.2) and manual actions (repair, setup, cleaning, troubleshooting, etc.)
  - 2.8 Emergency operations
- 3 Required Performance Level(s) (PL<sub>r</sub>)**
  - 3.1 Reference to existing documentation concerning the hazard analysis and risk assessment for the machine
  - 3.2 Results of the risk assessment for each identified hazard or hazardous situation and specification of the safety function(s) required in each case for risk reduction

## 4 Safety functions (information applies to each safety function)

- Description of the function (“input – logic – output”) including all functional characteristics (refer also to Tables 5.1 and 5.2)
- Activation/deactivation conditions or events (e.g. operating modes of the machine)
- Behaviour of the machine when the safety function is triggered
- Conditions to be observed for re-starting
- Performance criteria/performance data
- Process (timing behaviour) of the safety function, including response time
- Frequency of actuation (i.e. demand rate), recovery time following demand
- Other data
- Adjustable parameters (where provided)
- Classification and assignment of priorities in the event of simultaneous demand for and processing of multiple safety functions
- Functional concept for separation or independence/freedom of reciprocal action from non-safety functions and further safety functions

## 5 Required information for the SRP/CS design

- 5.1 Allocation of the SRP/CS and the form of technology by which the safety function is to be implemented; intended equipment
- 5.2 Selection of the Category, designated architecture (structure) in the form of a safety-related block diagram and description
- 5.3 Description of the interfaces (process interfaces, internal interfaces, user interfaces, control and display elements, etc.)
- 5.4 Behaviour at switch-on, implementation of the required starting and restarting behaviour
- 5.5 Performance data: cycle times, response times, etc.
- 5.6 Behaviour of the SRP/CS in the event of component failures and faults (achieve and maintain the safe state), including timing behaviour
- 5.7 Failure modes of components, modules or blocks which are to be considered; where applicable, reasoning for fault exclusions
- 5.8 Concept for implementation of the detection and control of random and systematic failures (self-tests, test circuits, monitoring arrangements, comparisons, plausibility tests, fault detection by the process, etc.)
- 5.9 Quantitative aspects
  - 5.9.1 Target values for  $MTTF_d$  and  $DC_{avg}$



- 5.9.2 Switching frequency of components subject to wear
- 5.9.3 Frequency of measures for fault detection
- 5.9.4 Mission time, where different from the assumption upon which the intended architecture is based (20 years)
- 5.10 Operating and limit data (operating and storage temperature range, humidity class, IP degree of protection, resistance values for shock/vibration/EMC, supply data with tolerances, etc.)
- 5.11 Generic standards to be applied for design (for the equipment, for protection against electric shock/hazardous shock currents, for resistance to environmental conditions, etc.)
- 5.12 Technical and organizational measures for protected access to safety-related parameters and to SRP/CS characteristics (protection against tampering, access protection, program/data protection) and for protection against unauthorized operation (key switch, code, etc.), for example in non-standard operating modes
- 5.13 General technical requirements and organizational framework for commissioning, testing and acceptance, and for maintenance and repair

Source General specification, excerpt from BGIA Report 2/2008 concerning EN ISO 13849-1



## **Example for an automatic handling machine:**

### Description of function:

The automatic handling machine serves the purpose of automatically picking up truck cabins of different heights. After being picked up, the height of the cabin is correctly detected, so that within the working area the cabin cannot be lowered below a certain height. Within the working area the automatic machine must not exceed a maximum speed. Once the cabin has been completely finished, it is put down at the end of the processing line and the automatic handling machine moves along a return track back to the beginning of the track to pick up the next cabin.

### Limits of the machine:

**Spatial limits:** The working area must provide sufficient space for the workers, so that they are able to carry out all necessary work on the cabin..... In the return pass there must be sufficient space for the empty suspension gear of the automatic handler...

**Temporal limits:** Description of lifetime, description of ageing processes, which could cause changes of machine parameters, (e.g. brakes). Monitoring mechanisms must be implemented for such cases.

**Limits of use:** The automatic machine automatically fetches new cabins and moves these through a processing area. Workers work in the processing area .... etc.

The following operating modes are intended: Setup operation, automatic operation and service operation ... etc.

### Identification of dangers:

The following dangers are of relevance with the automatic handling machine:

Danger 1: Crushing by cabin / lifting beam falling down

Danger 2: Impact by moving cabin / lifting beam

Danger 3: Crushing by too fast lowering of the cabin in case of a fault

Danger 4:.....

### Risk analysis:

G1: The weight of cabin and lifting beam is so high, that it will cause irreversible crushing or even fatalities.

G2: The moving cabin/lifting beam may cause impacts that can lead to irreversible injuries.

G3: ....

### Risk assessment

A risk reduction is required under due consideration of all operating conditions.

Inherently (risk from the project) safe design

Movement of the cabin in direction x and y within the working area cannot be avoided. In the processing area the cabin must be moved up/down ...

The following measures can be applied:

Avoid dangers caused by too fast movements

Avoid dangers caused by too small distances

Example for a risk analysis:

| Risk assessment as per EN ISO 12100:2010   |  |  |   | Date  | Aug. 03, 2011 |
|--|--|--|---|---|---------------|
| Project number   | 20   | Conversion - transfer press  |   |   |               |
| Customer   | KOLLMORGEN   |  |   |   |               |
| 01 Mechanical dangers  |  |  |   |   |               |
| Description  |  | Standard   | Solution  | Risk  |               |
| <b>01.07 Gravity</b>   |  |  |   | <b>R5</b>   |               |
| Life phase   | II<br>III  | Category   | all operating modes   |   |               |
| <b>Pinching; pressing</b>  |  | EN 60204-1   |   | S4/A1/E1/M2   |               |
| In case of an energy failure (electric power failure) the force generator will drop. Should the worker be inside the press in this particular moment, the force generator may drop on the worker.  |  |  | In events of energy losses the safety valve will change to secure state and press movements are no longer possible.   | <input checked="" type="checkbox"/> Electrical                |               |
| 01.13 moving parts   |  |  |   |   | <b>R19</b>    |
| Life phase   | II<br>III  | Category   | Feed operation  |   |               |
| <b>Pinching; pressing</b>  |  | EN 692<br>EN 61800-5-2<br>EN ISO 13849-1<br>EN ISO 13849-2<br>EN 574<br>EN ISO 11161 |   | S4/A1/E1/M2<br><input checked="" type="checkbox"/> Electrical |               |
| When feeding the work piece the press cushion needs to be moved. The hand is then inside the press. The press itself is active and may perform movements. There is a risk that the brake may close while hand and arm are inside the tool. |  |  | The press can only be moved with a securely reduced speed. (SLS) A safety relevant joystick is used for this purpose. When the joystick head is released, the standstill of the press is monitored. (SOS) The tool can only be closed after the hand has been withdrawn from the tool and two-hand operation has been triggered. If the secure reduced speed of > 10m/s or the standstill status is violated, the safety chain will trigger the safety valves and the press with change to secure status. In SIL3 the KSM fail-safe control system from KOLLMORGEN makes sure that safety related standstill and secure reduced speed are possible. |   |               |
| 03 Thermal dangers   |  |  |   |   |               |
| Description  |  | Standard   | Solution  | Risk  |               |
| www.Csafe.biz  | Live phase I=Transport II=Assembly III=Operation IV=Waste          |  |   | 1 / 2   |               |
| Risk assessment as per EN ISO 12100:2010   |  |  |   | Date  | Aug. 03, 2011 |
| Project number   | 20   | Conversion - transfer press  |   |   |               |
| Customer   | KOLLMORGEN   |  |   |   |               |
| 03.03 Objects or materials with high or low temperature  |  |  |   |   | <b>R6</b>     |
| Life phase   | III  | Category   | Feed operation<br>Changeover<br>Cleaning and cleanliness<br>Troubleshooting and fault rectification   |   |               |
| <b>Combustion:</b>   |  | EN 60204-1<br>EN ISO 13849-1<br>EN ISO 13849-2                                       |   | S3/A2/E3/M1<br><input checked="" type="checkbox"/> Electrical |               |
| The pre-heating tool for the foaming system is heated up to a temperature of 120°C Danger of touching or overtemperature in case of a fault.   |  |  | The temperature of the pre-heating system is monitored, so that dangerous temperatures cannot be reached. A warning sign additionally warns against touching. In normal operation the temperature does not rise this far that a significant danger would arise. The temperature is monitored by secure analog inputs and a heat sensor, so that in case of a fault the pre-heating unit will be switched off and secured against switching on again.  |   |               |
| www.Csafe.biz  | Live phase I=Transport II=Assembly III=Operation IV=Waste disposal |  |   | 2 / 2   |               |



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## 14.3.2 Specification of the functional safety system

Derived from the general danger and risk analysis for the machine, the active safety functions must be identified and specified.

Active safety functions are, e.g. securely reduced speed under certain system conditions, monitored stop and standstill functions, area monitoring facilities, processing of monitoring facilities like light grid, switching mats, etc.

The safety functions must each be delimited and the specific requirements in function and safety level must be defined.

### 14.3.2.1 Definition of safety functions

The definition of the safety function must:

- specify the risk to be covered,
- describe the exact function,
- list all sensors, command equipment involved,
- specify all control units and
- designate the shut-down circuit mentioned.

The definition should serve as basis for the specification of the hardware and software design. For each of the safety functions defined this way one may need to determine parameters to be used, like e.g. max. system speed in setup operation, etc.

Examples for safety functions:

SF1: STO (securely switched off torque) to protect against secure starting

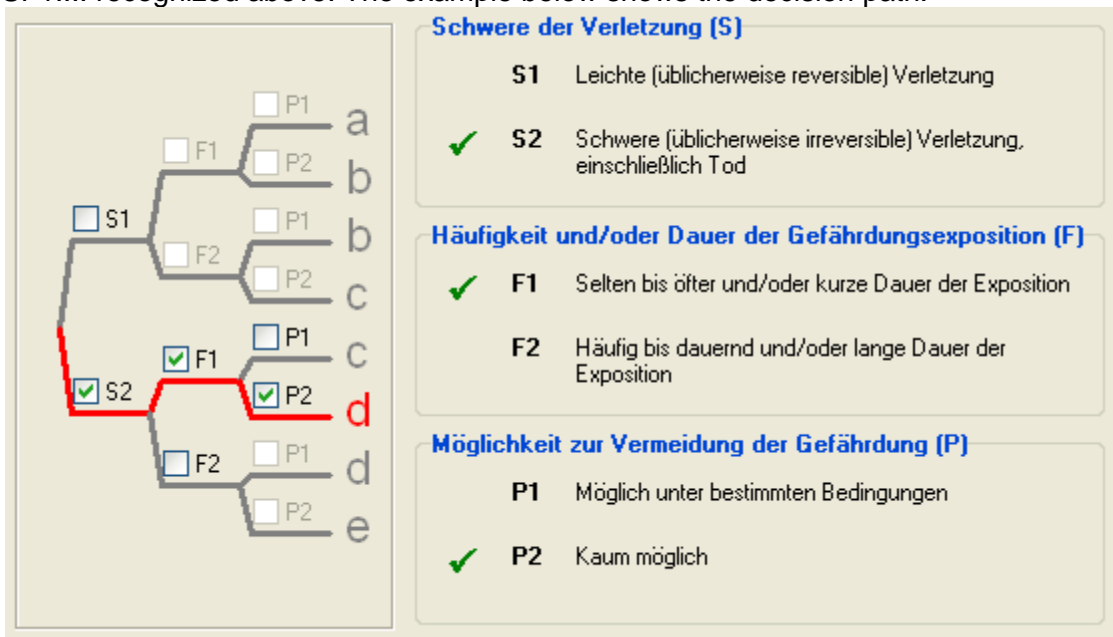
SF2: Secure speeds

SF3: Secure positions

SF4:.....

### 14.3.2.2 Required performance level (PLr) (additional emergency stop)

The required performance level must now be determined on basis of the safety functions SF1.... recognized above. The example below shows the decision path.



Example for SF1: Result PLr = d (source Sistema)

14.3.2.3 Example – Specification of safety functions in form of a table

| Cons.-No. | Safety function   | Ref from GFA | PI <sub>r</sub> | Measuring value /sensor  | Implementation of software  | Nominal Parameters                         | Input/ Activation  | Response/ Output               |
|-----------|---|--------------|-----------------|--|---|--|--|--------------------------------|
| 1.1       | Limitation of max. travel speed of travel gear up<br>Monitoring of the max. speed   | 2.3          | e               | 1 x WCS absolute encoder<br>1 x Incremental encoder on motor / drive wheel | Monitoring by means of tested safety function SLS for fixed limits  | 550mm/s<br>Fault distance monitoring 200mm | Permanently<br><br>Reset:<br>Acknowledgement button  | Operation stop<br><br>SF 1.7.1 |
| 1.2       | Limitation of max. travel speed in working area of workers<br>Monitoring of the maximum speed to < 0.33 m/s   | 2.4          | e               | 1 x WCS absolute encoder<br>1 x Incremental encoder on motor / drive wheel | Monitoring by means of tested safety function SLS for fixed limits  | 60 mm/s<br>Fault distance monitoring 200mm | Identification of worker's work area via position of carriage AND NOT Setup<br><br>Reset:<br>Acknowledgement button                      | SF 1.7.1                       |
| 1.3       | Limitation of max. travel speed in setup operation<br>Monitoring of the maximum speed to < 0.07 m/s   | 3.1          | d               | 1 x WCS absolute encoder<br>1 x Incremental encoder on motor / drive wheel | Monitoring by means of tested safety function SLS for fixed limits  | 70mm/s<br>Fault distance monitoring 200mm  | Operating mode Setup AND button "Bridge safety"<br><br>Reset:<br>Acknowledgement button  | SF 1.7.1                       |
| 1.4       | Collision protection of carriage<br><br>Monitoring of the distances between carriages for minimum distance by means of redundant laser distance measurement | 2.5          | d               | 2 x Laser distance measuring facilities                                    | Monitoring of distances by means of tested SAC function.<br><br>The analog distance measurements are reciprocally compared for max. tolerance (diagnose of analog sensor) monitored for minimum value (SAC function) Min distance value 25 % of the max. value of the measuring device. |  | Carriage inside worker's working range<br><br>Reset:<br>Acknowledgement button   | SF 1.7.1                       |
| 1.6.1     | Monitoring of carriage sensor system<br>Muting management of the two carriage sensors   | 5.1          | e               | 1 x WCS absolute encoder<br>1 x Incremental encoder on motor / drive wheel | Muting of diagnoses for both carriage sensors by means of tested SCA function<br>Muting is started before each gap, a faulty encoder value will be temporarily suppressed. Within the gap an encoder value outside 2 to 160000mm will cause muting.                                     |  | Pos 1 (7626 - 7850)<br>Pos 2 (11030-1263)<br>Pos 3 (75134-5338)<br>Pos 4 (145562-145622)<br>Pos 5 (143935-143995)<br>Pos 6 (80000-80060) | SF 1.6.2                       |

## 14.3.3 Software specification

The software specification refers to the previous specification of the safety functions. It can also be replaced by a correspondingly worked out specification of the safety functions, as far as this contains all specifications (see example under 14.3.2.3).

However, it is recommended to prepare an extracted list. This list should contain the following data:

- Designation of safety function
- Description of function
- Parameters, as far as available
- Triggering event / operating status
- Response / output

The specification in detail should be suitable for later validation of the programming.

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Example of software specification

| Cons.-No. | Safety function  | PIr | Measuring value /sensor  | Solution new   | Input/activation   | Response/output                |
|-----------|--|-----|--|--|--|--------------------------------|
| 1.4       | Monitoring V_Rope to V_Nominal<br>Monitoring of differences between speed of main drive and rope drive for maximum value | d   | Digital incremental encoder,<br><br>tachometer generator rope sheave | Monitoring by means of tested function SLS + SAC with comparison of speed ranges /analog value ranges = comparison for diagnose of the speed detection<br><br>Shut-down dual-channel new (see below) | Permanently<br><br>Reset:<br>Acknowledgement button                                    | Operation stop<br><br>SF 1.3.1 |
| 1.6       | Backstop<br>Monitoring for reversing   | d   | Mechanical limit switch 22S2<br><br>Digital incremental encoder      | Monitoring by means of tested function direction monitoring SDI  | EMERGENCY (auxiliary contact 28K4 – reversing)<br><br>Reset:<br>Acknowledgement button | Operation stop<br><br>SF 1.3.1 |
| 1.15      | Step-by-step shut-down / activation of the safety brake  | e   | -  | Processing of SF in Safe PLC   | SF 1.2<br>SF 1.3.2<br>SF 1.7<br>SF 1.8   | Setting the safety brake       |
| 1.8       | Standstill functional  | d   | Digital incremental encoder  | Standstill monitoring by means of tested function SOS  | Regulator lock<br>OR<br>Set service brake  | SF 1.15/<br>Set safety brake   |
| 1.9       | direction monitoring   | e   | Digital incremental encoder,   | Monitoring by means of tested function direction monitoring SDI  | 28K1 = FORW.<br>28K2 = BACK<br>= secure <signals from control "Frey"™"                 | Operation stop<br><br>SF 1.3.1 |

## 14.3.4 Hardware specification

The hardware specification should describe the entire system design and, in particular, the components used with their specific characteristic data. The hardware specification serves as basis for the determination of the achieved safety level based on the architecture and the characteristic data of all devices involved in a safety function.

Furthermore, the hardware specification should also specify the design measures applied for protecting against systematic and common cause faults.

### 14.3.4.1 Selection of SRP/CS and operating means

The selection of SRP/CS (Safety related parts of control system) is most suitable to achieve the intended safety level and should be made for any safety function. The components with safety relevant function must be designated in a total overview of the system structure and are to be assigned to the individual safety functions. The safety related code numbers must be determined for these components.

The code numbers cover the following values:

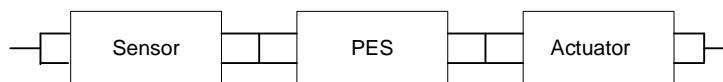
MTTFD = mean time to failure, the mean time until a danger imposing failure

DC avg = diagnostic covering (in average), the mean diagnostic coverage

CCF = common cause failure, a failure caused on a common cause

For an SRP/CS both the software and systematic faults must be taken into consideration.

An analysis of of the SRP/CS participating in the safety function must generally be performed in accordance with the schematic Sensor / PES / Actuator.



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## 14.3.4.2 Example for hardware specification

| Safety function |                 | Securely reduced speed   | SF 2.2      | Securely monitored limited speed with door open |               |           |        |                      |        |                      |   |
|-----------------|-----------------|--|-------------|---|---------------|-----------|--------|----------------------|--------|----------------------|---|
| Type            | Designation     | Function   | Designation | Characteristic data                             |               |           |        |                      |        |                      | Note                                    |
|                 |                 |  |             | Architecture                                    | MTTFD [Years] | PFH [1/h] | B10d   | Source               | DC [%] | Source               |   |
| Sensor          | Sensor 1        | Door lock – Monitoring of the access door                                  | A 3.1       | 4   |               |           | 100000 | Data sheet           | 99     | Inst. manual op. KSM |   |
|                 | Sensor 2.1      | Incremental encoder – Motor feedback SIN/COS                               | G 1.1       | 4   | 30            |           |        | Gen. specification   | 99     | Inst. manual op. KSM | Cat. 4 in connection with selection KSM |
| PES             | Safety PLC      | Central safety PLC for control and evaluation of safety relevant functions | A 4.1       |   |               | 1,4 E-8   |        | Data sheet KSM       |        |                      |   |
| Actuator        | STO             | Safe Torque Off on inverter  | A 5.1       | 4   | 150           |           |        | Data sheet inverter  | 99     | Inst. manual op. KSM | Cat. 4 in connection with dual-channel  |
|                 | Mains contactor | Contactore in mains line of inverter                                       | K 5.1       | 4   |               |           | 20 E6  | Data sheet contactor | 99     | Inst. manual op. KSM | Cat. 4 in connection with dual-channel  |



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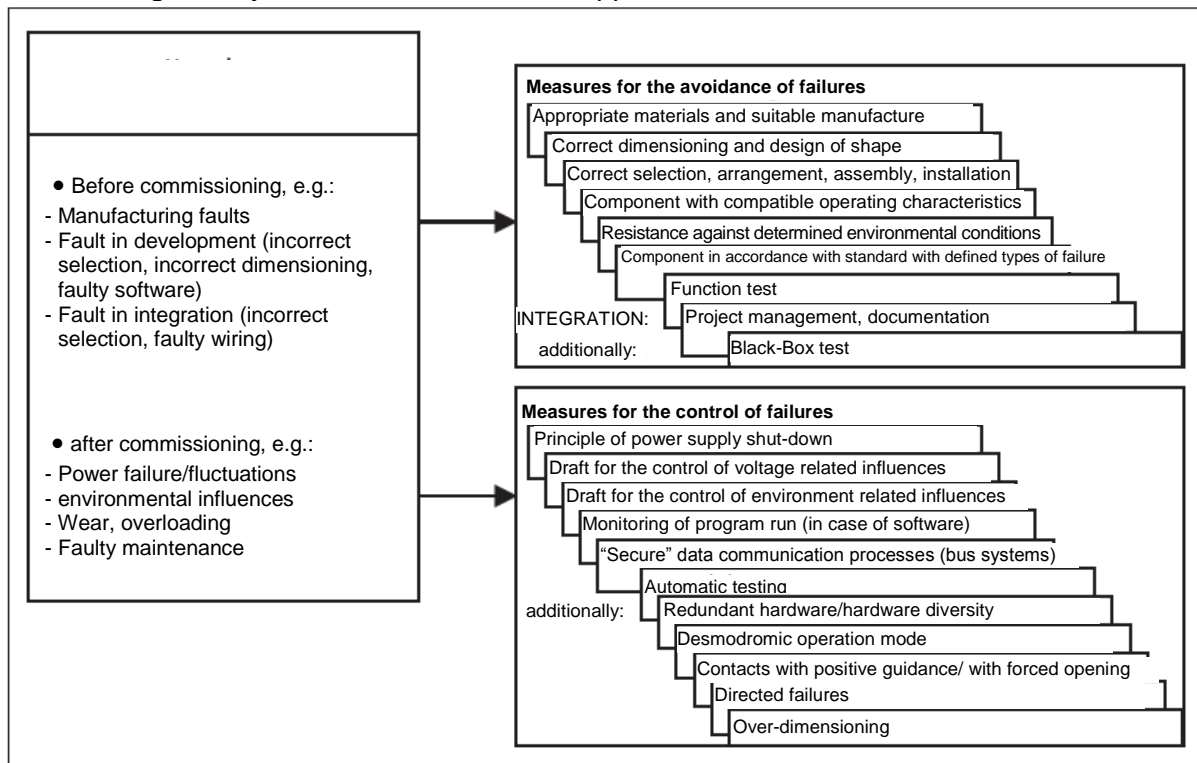
## 14.3.4.3 Consideration of systematic failures

Within the hardware specification one must also consider systematic failures.

Examples for measures against systematic failures:

Power drop during operation. If this causes a danger, a power drop must be considered an operating status. The SRP/CD must be able to cope with this condition, so that a secure state is maintained.

Measures against systematic failures acc. to appendix G DIN EN ISO 13849-9



Source BGIA Report 2/2008

### Fault exclusions:

If fault exclusions are made for certain devices or system components, these must be individually nominated and specified.

Fault exclusions may be e.g. mech. shaft breakage, sticking of switching contacts, short-circuits in cables and lines, etc.

The permissibility of fault exclusions must be justified, e.g. by referencing to permissible fault exclusions acc. to applicable standards, e.g. EN ISO 13849-1)

If these fault exclusions require special measures, these must be mentioned.

Examples for fault exclusions and associated measures:

Positive connection for mechanical shaft connections

Dimensioning based on sufficient theoretical bases in case of breakage of components in the safety chain.

Positively guided connection with forced separation in case of sticking of switching contacts.

Protected routing within switchgear in case of short-circuits in cables and lines

## 14.3.5 Hard and software design

The performance targets from the hardware and software specification are implemented in the actual system design.

The performance targets for the components to be used and their wiring from the hardware specification must also be met, the same applies for the performance targets for fault exclusions. Both must be achieved and documented with appropriate means.

In the software one must also account for and completely implement the targets from the software specification.

Furthermore one must consider the superimposed targets placed on the software by safety related programming. These are among others:

Modular and clear program structure

Assignment of functions to the safety functions

Understandable representation functions by:

Unambiguous designations

Understandable comments

Use of tested functions / function modules, as far as this is possible

Defensive programming

## 14.3.6 Testing of the hardware design

After completing the planning the hardware design must be examined for compliance with the targets from the hardware specification.

Furthermore, one must check the compliance with the specified safety level for each safety function by using suitable analyses. The analysis methods have been described in applicable standards (e.g. EN 13849-1).

### **Analysis of wiring diagram**

Compliance with the targets set under safety related aspects can be checked by means of the wiring diagram and the bill of materials. The following must be checked in particular:

the correct wiring of components as specified,

the dual-channel structure, as far as specified

the non-reactivity of parallel, redundant channels.

The use of components as specified

The checks should be made by understandable analysis.

### 14.3.6.1 Iterative testing of the achieved safety level

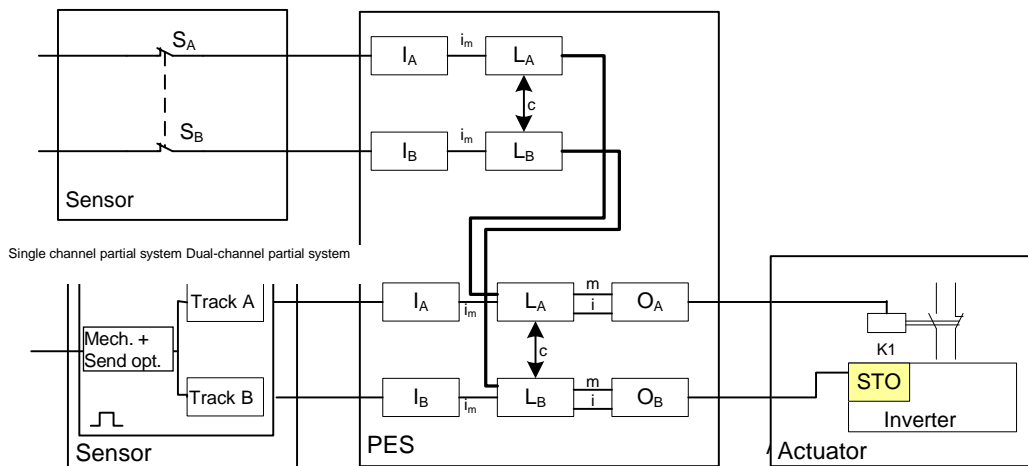
The achieved safety level must be determined by means of the circuit structure (= architecture single-channel (dual-channel / with or without diagnose), the characteristic device data (manufacturer's data or appropriate sources) and the diagnostic coverage (manufacturer's data PES or general sources). Appropriate measures can be taken from the underlying safety standard.

A calculation acc. to EN ISO 13849-1 shall serve as an example:

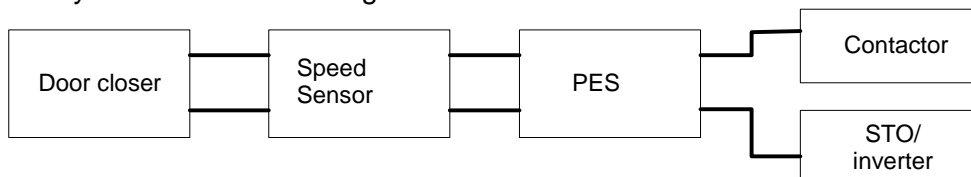
Safety function:

Securely reduced speed with access door open

structural diagram:



Safety related structural diagram:



Calculation acc. to EN 13849-1:

Channel A – shut-down via mains contactor:

| Component   | MTTFD [years]  | DC             |
|-------------|--|----------------|
| Door closer | B10d = 100000<br>Nop = 30/AT = 10000/year(309 AT/year) | DCSwitch = 99% |

$$MTTFD = \frac{B10d}{0,1 * Nop} = 100\text{Years}$$

|                  |                         |                 |
|------------------|-------------------------|-----------------|
| SIN/COS encoder: | MTTFD_SinCos = 30 years | DCEncoder = 99% |
|------------------|-------------------------|-----------------|

|     |                              |             |
|-----|------------------------------|-------------|
| PES | PFH = 1.4 * 10 <sup>-8</sup> | DCPES = 99% |
|-----|------------------------------|-------------|

$$MTTFD = \frac{1}{8760 * PFH} = 8115 \text{ Years}$$

|                 |   |             |
|-----------------|---|-------------|
| Mains contactor | B10d = 20 * 106<br>Nop = 20/AT = 3990/year(309 AT/year) | DCPES = 60% |
|-----------------|---|-------------|

$$MTTFD = \frac{B10d}{0,1 * Nop} = 55 \text{ kYears}$$

$$MTTFD\_A = \frac{1}{\frac{1}{MTTFD\_Türz} + \frac{1}{MTTFD\_SinCos} + \frac{1}{MTTFD\_PES} + \frac{1}{MTTFD\_Netzsch}} = 33 \text{ Years}$$

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Channel B – shut-down via STO/inverter:

|             |  |                |
|-------------|--|----------------|
| Component   | MTTFD [years]  | DC             |
| Door closer | B10d = 100000<br>Nop = 30/AT = 10000/year(309 AT/year) | DCSwitch = 99% |

$$MTTFD = \frac{B10d}{0,1 * Nop} = 100 \text{ Years}$$

|                  |                         |                 |
|------------------|-------------------------|-----------------|
| SIN/COS encoder: | MTTFD_SinCos = 30 years | DCEncoder = 99% |
|------------------|-------------------------|-----------------|

|     |                  |             |
|-----|------------------|-------------|
| PES | PFH = 1.4 * 10-8 | DCPES = 99% |
|-----|------------------|-------------|

$$MTTFD = \frac{1}{8760 * PFH} = 8115 = 1 \text{ k Years}$$

|               |                       |             |
|---------------|-----------------------|-------------|
| STO/ inverter | MTTFD_STO = 150 years | DCPES = 90% |
|---------------|-----------------------|-------------|

$$MTTFD\_A = \frac{1}{\frac{1}{MTTFD\_Türz} + \frac{1}{MTTFD\_SinCos} + \frac{1}{MTTFD\_PES} + \frac{1}{MTTFD\_Netzs}} = 20 \text{ Years}$$

Resulting PI for both channels:

Symmetry of both channels:

$$MTTFD = \frac{2}{3} \left[ MTTFD\_A + MTTFD\_B - \frac{1}{\frac{1}{MTTFD\_A} + \frac{1}{MTTFD\_B}} \right] = 27 \text{ Years}$$

DC mean value

$$MTTFD = \frac{DCSwitch}{\frac{1}{MTTFD\_Türz} + \frac{1}{MTTFD\_SinCos} + \frac{1}{MTTFD\_PES} + \frac{1}{MTTFD\_Netzs}} + \frac{DCSinCos}{\frac{1}{MTTFD\_SinCos} + \frac{1}{MTTFD\_PES} + \frac{1}{MTTFD\_Netzs}} + \frac{DCPES}{\frac{1}{MTTFD\_PES} + \frac{1}{MTTFD\_Netzs}} + \frac{DCSchütz}{\frac{1}{MTTFD\_Schütz} + \frac{1}{MTTFD\_Netzs}} + \frac{DC}{\frac{1}{MTTFD\_Netzs}}$$

= 98%

PI

MTTFD\_STO = 27 years = average  
DC avg = 98 % = average

PI = "d" (from TEN ISO 13849-1, tables 5, 6 and 7)

In this case the B10d value of the door monitoring feature is determining for PI. If an even higher safety level is to be reached a correspondingly higher qualitative switch is to be used.

**Note:**

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The PI can also be determined with the program tool “Sistema” from BGIA.

## 14.3.7 Verification software(program) and parameters

Verification takes place in two steps.

1. Checking the FUP with respect to the specified functionality.
2. Checking the FUP against the AWL-listing of the validation report, or the default parameters against the one listed in the validation report.

### 14.3.7.1 Checking FUP

The programmed FUP must be compared with the defaults in the specification.

Note:

The comparison is all the more efficient the more clearly the programming has been structured with respect to the safety functions.

#### Example:

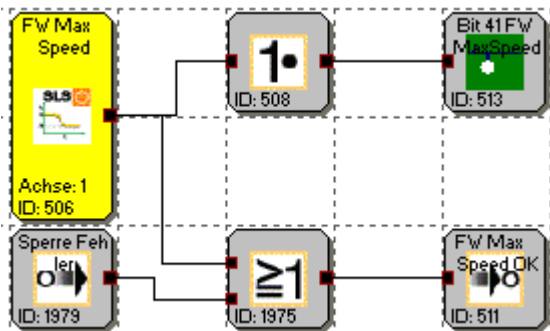
Safety function:

1.1 Limitation of the max. travel speed of the carriage to 1.1 VMax

Monitoring of the maximum speed to < 1.1 VMax

FW Max Speed OK (ID 548) (is bridged by available gap):

FW Max Speed is permanently activated and responds when a speed of 550mm/s is exceeded.



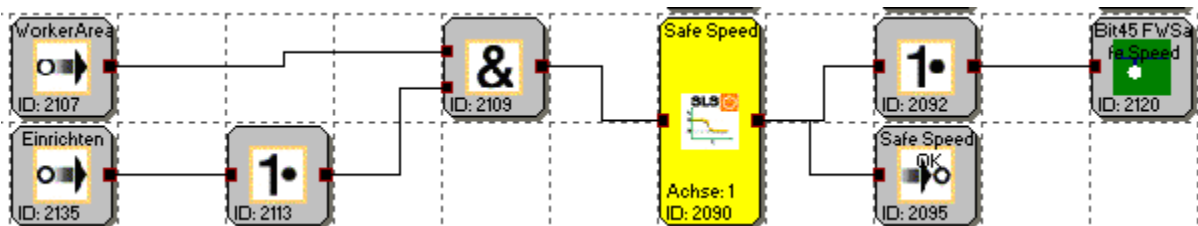
Safety function:

Limitation of max. travel speed in carriage in the worker's area:

Monitoring of the maximum speed to < 0.33 m/s

Safe Speed OK (ID 2124) (is bridged by available gap):

Safe Speed OK responds when the secure speed SLS (ID 2090) is exceeded in the worker's area and during setup work.



Parameter SLS Safe Speed:

60mm/s, no further parameters

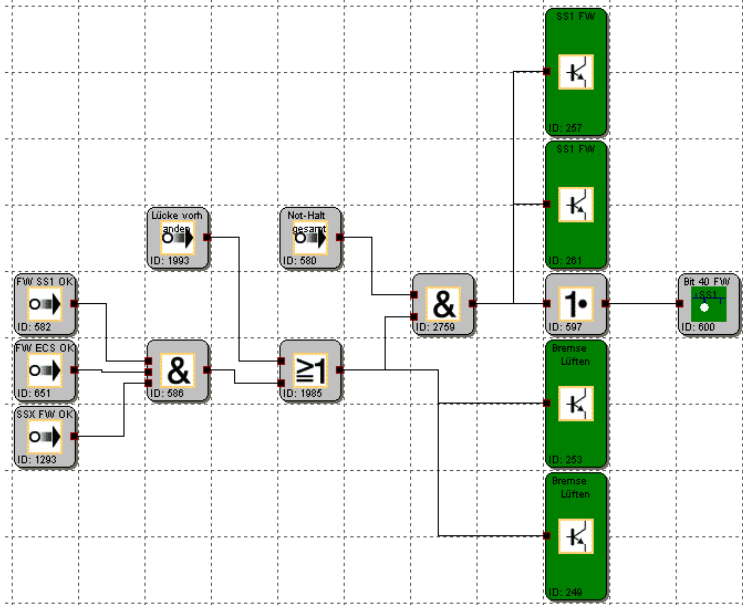
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Safety function:

## 1.7.3 Carriage shut.down

Shut down of travel system and deactivation of brakes

Shut down on carriage



The carriage is switched off via two outputs (EAA1.5 ID 257 and 1.6 ID 261).

The brakes are released via two outputs (EAA1.3 ID 253 and 1.4 ID 249).

The PLC receives a message concerning bit 50 (ID 600)

In case of an emergency stop the shut-down takes place immediately.

## Lift

### Safety function

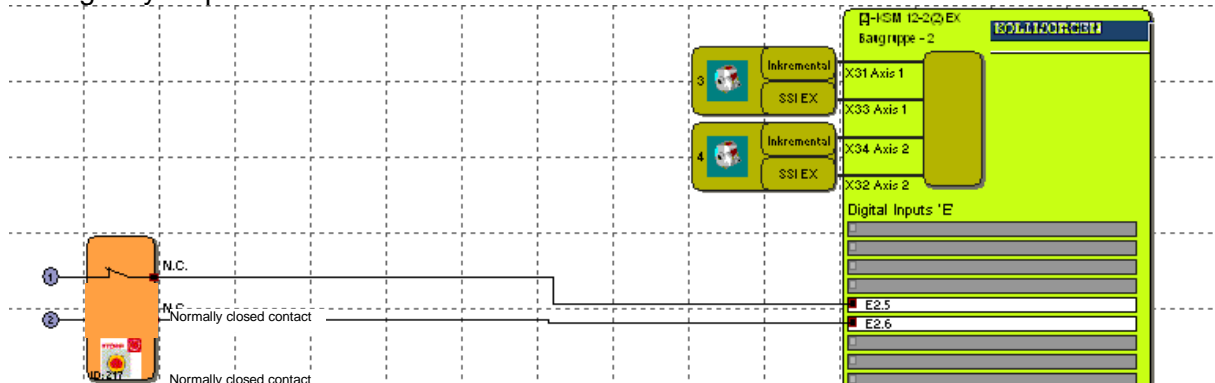
Emergency stop switch inputs and shut-down outputs.

#### 1.1 Emergency stop head control

Dual-channel emergency stop with pulse monitoring

If an emergency stop is triggered at the imposed control, this emergency stop can be bridged if the approval 'Bridge safety' has been issued.

Emergency stop button head control



Emergency stop contacts from emergency stop relay with pulsing from the KSM100

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### 14.3.7.2 Validation of FUP against AWL and parameters by means of validation report.

The programming that took place in the FUP must be compared with the AWL-listing of the validation report.

Example AWL-listing in validation report

#### Validation report

#### OLC-program

Name: <leer>

| Index | Command | Operand  | validated |
|-------|---------|----------|-----------|
| 1     | S1      | SLI_EN.1 |           |
| 2     | S1      | SLI_EN.2 |           |
| 3     | S1      | SLI_EN.3 |           |
| 4     | S1      | SCA_EN.1 |           |
| 5     | S1      | SCA_EN.2 |           |
| 6     | S1      | SCA_EN.3 |           |
| 7     | S1      | SLS_EN.2 |           |
| 8     | S1      | SCA_EN.4 |           |
| 9     | S1      | SLS_EN.3 |           |
| 10    | S1      | SLS_EN.4 |           |
| 11    | S1      | SLI_EN.5 |           |
| 12    | SQH     |          |           |
| 13    | LD      | E0.1     |           |
| 14    | ST      | MX.2     |           |
| 15    | SQC     |          |           |
| 16    | SQH     |          |           |
| 17    | LD      | E0.3     |           |
| 18    | AND     | E0.4     |           |
| 19    | ST      | MX.3     |           |
| 20    | SQC     |          |           |

Step-by-step testing is recommended. The test all the batter, the more structured the programming in FUP has been made.

After checking the program one must also check the parameters against the targets set in the specifications by means of comparison.

Example SLS:

#### Validation report

#### Safe Limited Speed (SLS)

| Index   | Parameters             | Value | validated |
|---------|------------------------|-------|-----------|
| SLS - 0 | Chosen axis:           | 1     |           |
|         | Speed threshold:       | 2     | 0         |
| SLS - 1 | Chosen axis:           | 1     |           |
|         | Speed threshold:       | 500   | 0         |
| SLS - 2 | Chosen axis:           | 1     |           |
|         | Speed threshold:       | 2     | 0         |
|         | Acceleration threshold | 2     | 0         |
| SLS - 3 | Chosen axis:           | 1     |           |
|         | Speed threshold:       | 2     | 0         |
|         | Assigned SSX-ramp      | 0     |           |



Example encoder configuration:

Validation report

Axis configuration / sensor interface

Axis 1

General parameters

Measuring distance: 500 0

Type: rotational

No

Position processing: Active

Maximum speed: 2000 0

Incremental shut-down: 10000 0

Shut-down speed: 100 0

|                        |              |               |              |               |
|------------------------|--------------|---------------|--------------|---------------|
| Sensors                | 0            |               | 0            |               |
| Type:                  | SSI-standard |               | SSI-standard |               |
| Format:                | Binary       |               | Binary       |               |
| Direction of rotation: | Ascending    |               | Ascending    |               |
| Supply voltage:        | 0            |               | 0            |               |
| Resolution:            | 1024         | Steps/1000 mm | 64           | Steps/1000 mm |
| Offset:                | 0            | Steps         | 0            | Steps         |

General parameters correctly configured

Parameter sensor 1 correct

Parameter sensor 2 correct

## 14.3.8 Performance of the system test / FIT (fault injection test)

For the FIT the manufacturer must prepare a complete list of the functions to be tested. This list includes the defined safety functions as well as the fault test for checking the right response of the SRP/CS to this fault

Example test list:

| No | Setup   | Test  | Result |
|----|---|---|--------|
| 1  | Test SLS for max. speed in setup operation<br>Activate setup operation<br>Travel with maximally allowed speed | - Diagnose of the actual speed versus the SLS limit<br>- Manipulation of the setup speed beyond the permitted reduced speed   |        |
| 2  | Test SSX for Stop-category 2<br>Travel with max. speed<br>Actuate the emergency stop                          | - Diagnose of the SSX-ramp against the actual deceleration ramp<br>- Setting an impermissible weak deceleration<br>- Moving the axis after standstill is reached by manipulating the drive  |        |
| 3  | Test of the dual-channel door monitoring<br>Select operating mode for setup operation                         | Diagnose of inactive monitoring with door closed (using diagnostics function FUP)<br>Diagnose of active monitoring with door open (using diagnostics function FUP)<br>Disconnecting one channel and opening the door<br>Generate cross-shortening between both inputs |        |

## Appendix A

### Classification of switch types

#### General note:

The individual switches of the following input elements can be assigned to the digital inputs DI1 to DI8 as desired.

#### Enable switch

| Switch type                      | Comment                           | Classification PI acc. to EN ISO 13849-1 | Classification SIL acc. to EN 61508 |
|----------------------------------|-----------------------------------|--|-------------------------------------|
| 1 normally closed                | Enable switch standard            | PI d                                     | SIL 2                               |
| 1 normally open                  | Enable switch standard            | PI d                                     | SIL 2                               |
| 2 normally closed                | Enable switch higher requirements | PI e                                     | SIL 3                               |
| 2 normally closed time monitored | Enable switch monitored           | PI e                                     | SIL 3                               |

#### Emergency Stop

| Switch type                      | Comment                            | Classification category | Classification SIL |
|----------------------------------|------------------------------------|-------------------------|--------------------|
| 1 normally closed                | Emergency Stop standard            | PI d <sup>1)</sup>      | SIL 2              |
| 2 normally closed                | Emergency stop higher requirements | PI e                    | SIL 3              |
| 2 normally closed time monitored | Emergency Stop monitored           | PI e                    | SIL 3              |

<sup>1)</sup> Fault exclusions and boundary conditions acc. to EN 13849-2 must be observed!

#### Door monitoring

| Switch type  | Comment                             | Classification category | Classification SIL |
|--|-------------------------------------|-------------------------|--------------------|
| 2 normally closed                                  | Door monitoring higher requirements | PI e                    | SIL 3              |
| 2 normally closed time monitored                   | Door monitoring monitored           | PI e                    | SIL 3              |
| 1 normally open + 1 normally closed                | Door monitoring higher requirements | PI e                    | SIL 3              |
| 1 normally open + 1 normally closed time monitored | Door monitoring monitored           |                         | SIL 3              |
| 2 normally open + 2 normally closed                | Door monitoring higher requirements | PI e                    | SIL 3              |
| 2 normally open + 2 normally closed time monitored | Door monitoring monitored           | PI e                    | SIL 3              |
| 3 normally closed                                  | Door monitoring higher requirements | PI e                    | SIL 3              |
| 3 normally closed time monitored                   | Door monitoring monitored           | PI e                    | SIL 3              |

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## Two-hand button

| Switch type      | Comment                             | Classification category | Classification SIL |
|------------------|-------------------------------------|-------------------------|--------------------|
| 2 two-way switch | Two-hand button higher requirements | Type III C PI e         | SIL3               |
| 2 normally open  | Two-hand button monitored           | Type III A PI e         | SIL1               |

Note: With these input elements a fixed pulse assignment takes place, which cannot be influenced by the user!

## Light curtain

| Switch type  | Comment                           | Classification category | Classification SIL |
|--|-----------------------------------|-------------------------|--------------------|
| 2 normally closed                                  | Light curtain higher requirements | PI e                    | SIL 3              |
| 2 normally closed time monitored                   | Light curtain monitored           | PI e                    | SIL 3              |
| 1 normally open + 1 normally closed                | Light curtain higher requirements | PI e                    | SIL 3              |
| 1 normally open + 1 normally closed time monitored | Light curtain monitored           | PI e                    | SIL 3              |

## Mode selector switch

| Switch type | Comment                        | Classification category | Classification SIL |
|-------------|--------------------------------|-------------------------|--------------------|
| 2 positions | Mode selector switch monitored | PI e                    | SIL 3              |
| 3 positions | Mode selector switch monitored | PI e                    | SIL 3              |

**Safety note:** When changing the status of the switch the SafePLC program to be created must ensure that the outputs of the module are deactivated (note: Standard 60204-Part1-Paragraph 9.2.3).

## Sensor

| Switch type  | Comment                          | Classification category | Classification SIL |
|--|----------------------------------|-------------------------|--------------------|
| 1 normally closed                                  | Sensor input standard            | PI d                    | SIL 2              |
| 1 normally open                                    | Sensor input standard            | PI d                    | SIL 2              |
| 2 normally closed                                  | Sensor input higher requirements | PI e                    | SIL 3              |
| 2 normally closed time monitored                   | Sensor input monitored           | PI e                    | SIL 3              |
| 1 normally open + 1 normally closed                | Sensor input higher requirements | PI e                    | SIL 3              |
| 1 normally open + 1 normally closed time monitored | Sensor input monitored           | PI e                    | SIL 3              |

## Start / reset element

| <b>Switch type</b> | <b>Comment</b>                                | <b>Classification category</b> | <b>Classification SIL</b> |
|--------------------|---|--------------------------------|---------------------------|
| 1 normally open    | Alarm reset standard (evaluation of edge)     | --                             | --                        |
| 1 normally open    | Logic reset standard                          | PI d                           | SIL 2                     |
| 1 normally open    | Start monitoring standard (optional function) | --                             | --                        |

### Note:

The alarm reset input can be operated with 24V continuous voltage and is edge triggered.

## Appendix B

### Approvals

The latest Certificates for Conformity to European Directives are located on the product DVD or can be downloaded from the Kollmorgen Website.

Existing documents:

- EU Declaration of Conformity according to EC Directives 2006/42/EC Appendix IV and 2004/108/EC
- Functional Safety Certificate according to EC Directive 2006/42/EC Appendix I

## About Kollmorgen

Kollmorgen is a leading provider of motion systems and components for machine builders. Through world-class knowledge in motion, industry-leading quality and deep expertise in linking and integrating standard and custom products, Kollmorgen delivers breakthrough solutions that are unmatched in performance, reliability and ease-of-use, giving machine builders an irrefutable marketplace advantage.

For assistance with your application needs, visit [www.kollmorgen.com](http://www.kollmorgen.com) or contact us at:

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