Installation Manual
for
SDC-Modules

Installation Manual for Extension Modules Type SDC

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

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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 may change. Please keep yourself informed about the currently valid version.

Device from

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1 Important notes

Definition of individual target groups

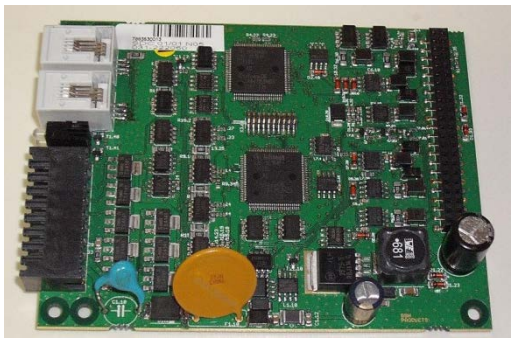
Project engineers for secure drive systems:
Engineers and technicians

Assembly, electric installation, maintenance and replacement of devices
Maintenance electricians and service technicians

Commissioning, operation and configuration:
Technicians and engineers

1.1 Definitions

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



Picture SDC module on its own

Note:
With Compax3M the SDC module is considered a safety option S3.

The term "safe" used in the following text in any case refers to the classification as a safe function for application up to PL e acc. to EN ISO 13849-1:2009 or SIL3 acc. to IEC 61508:2010.

The system software "SafePlcGRP" serves the purpose of configuring and programming the SDC module (S3 option). The SafePlcGRP software is invoked via the C3 ServoManager in menu "Safe Movement Functions".

The modules of the SDC 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

Description	***Reference***
Configuration of the SDC module for stand-alone applications without field-bus interfacing with the program 'SafePlcGRP'	'SafePlcGRP' programming manual
Validation report for implemented parameterization and PLC-program	Safety inspection with acceptance protocol
Acceptance test	TÜV certificate for product modules SDC

Note:

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

1.3 Abbreviations used

Abbreviation	***Meaning***
AC	Alternating voltage
IL	Instruction list
ELIA	Employer's liability insurance association
CLK	Clock (cycle)
CPU	Central Processing Unit
SMF11..SMF42, E0.5, E0.6	Digital Input
DIN	Deutsches Institut für Normung (German Institute for Standardization)
DO	Digital Output
EMU	Emergency Monitoring Unit
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

Abbreviation	*Meaning*
SLP	Safety-Limited Position
PIA	Process image of outputs
PII	Process image of inputs
PES	Programmable electronic system
P1,P2	Pulse outputs
PLC	Programmable Logic Controller
SCA	Safe Cam
SELV	Safety Extra Low Voltage
SDC	Safety Drive Core
SDDC	Safe Device To Device Communication (Session Layer)
SRP/CS	Safety-related parts of control system
SSI	Synchronous Serial Interface
VDE	Verband der Elektrotechnik, Elektronik und Informationstechnik e.V. (association for electrical engineering, electronics and information technology)

2 Safety regulations

2.1 Intended use

The extension module type SDC is a programmable safety control for the creation of safety shut-downfeatures and safety functions. The module is intended for use:

- emergency stop facilities
- as safety component as defined by the EC machine directive 2006/42/EC
- as PES for risk reduction as defined by IEC 61508:2010
- in safety circuits acc. to EN 60204-1:2006 and EN 60204-32:2006
- as PES for functional safety as defined by EN IEC 62061:2005
- as SRP/CS as defined by EN 13849:2009
- as safety related component in a PDS(SR) for the creation of safety functions acc. to IEC 61800-5-2: 2006
- as logic unit for converting and processing signals in two-hand control acc. to EN 574

CE The extension module type SDC is a safety component as specified in appendix IV EC machinery directive 2006/42/EC. It has been developed, designed and manufactured in compliance with the above mentioned directive as well as the EC-directive EC-EMC directive 2004/108/EC

Note:

The standard IEC 61800-5-1:2006 "Electric Safety" and IEC 61800-3:2006 "EMC Requirements and Test Methods" were additionally applied for the development and manufacture of the SDC module.

2.2 General safety regulations

⚠ **Safety note:**

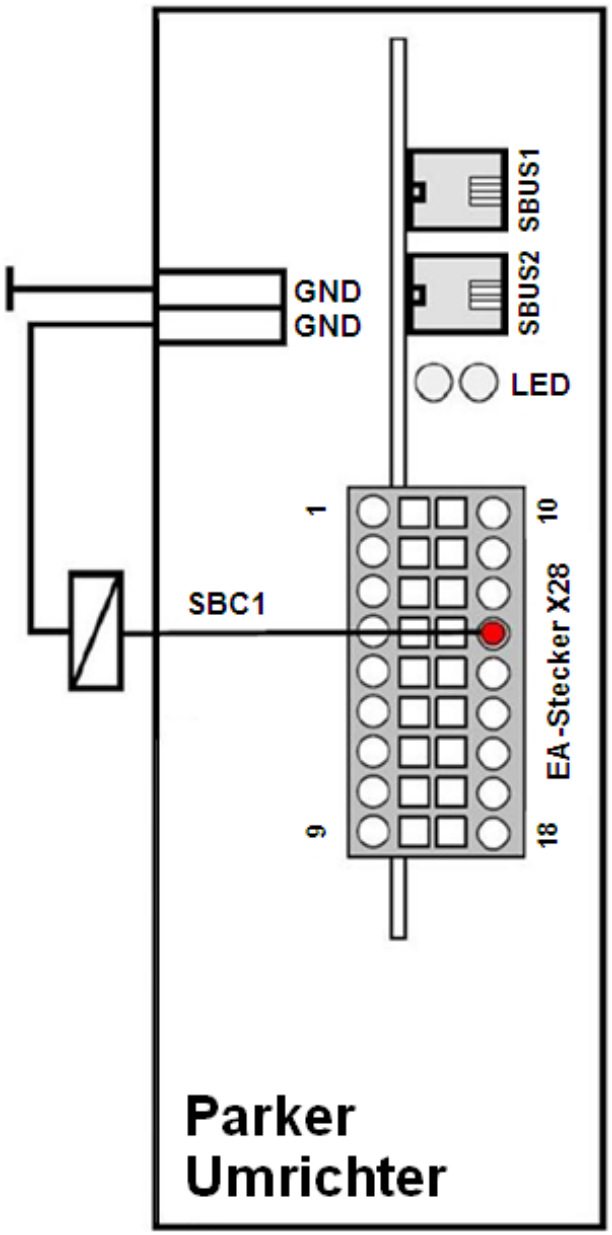
- In order to avoid damage to persons and property only qualified personnel with profound electrical engineering skills is entitled to work on the device.
- The qualified person must become familiar with the operating instructions (see IEC364, DIN VDE0100).
- The qualified must have profound knowledge 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 in section "Techn. characteristic data" (Table 1) must also be observed.
- The contents of this installation manual is restricted to the basic function of the device or its installation. The "Programming manual SDC" contains a more detailed description concerning 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 EN 55011:2007 + 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 "Techn. characteristic data" (Table 1) 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.
- As the safety function STO is released as last action in error status or where safety limits are exceeded, the safety instructions and conditions of use of the safety functions STO (see chapter 4.2) must be adhered to as well.
- The Comapx3M S3 must be installed in a protected place (control cabinet IP54).
- When braking by using a mechanical brake, both the safety category and the performance level depend on the condition of the brake. Caution, the holding brakes integrated in the Parker motors are no safety brakes.
- The digital I/Os on plug X12 are no secure I/Os.
- A fault diagnose can be made through the C3 objects SafetyMonitor_AlarmCode and SafetyMonitor_Error-Code. However, both the Alarm and the Error Codes can also be displayed directly via the message window of SafePLC or through the C3 status values under Safe Movement Functions.
- Please note that the Power-On time is approx. 10 seconds long.

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 the manufacturer.

2.3 Avoidance of malfunction in case of a loss of ground ('Loss of GND')

In order to prevent uncontrolled offset voltages on a safe output in case of an interruption of the ground connection "Loss of GND" for the auxiliary voltages of the servo drive, the wiring is to be based on the following basic circuitry:



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 complied with.

3 Device type

3.1 General notes

The S3-option is only available for F11/F12 and T30/T40 Comapx3M drives. Devices with S3-option can be recognized by their type designation (e.g. C3M050D6F11I11T30M00**S3**). These devices have no UL certification.

The S3 option comes with the safety relevant platform SDC (Save Drive Core) This enables reliable monitoring of movement functions. Depending on the necessary Performance Level a SINCOS encoder on the encoder interface x13 may be sufficient. Should a second encoder (redundant encoder) be required, it must be connected to the encoder interface X11.
The machine design engineer has to consider the total probability of failure of the entire system. Parker Hannifin is only able to specify the probability of failure for the drive itself. Detailed information concerning encoder variants can be found in this manual.

No special interface needs to be configured for the S3 option, because the entire communication is already controlled via the C3 ServoManager.
After installing the C3 ServoManager or PIET the Paker SafePLC needs to be installed.

In order to support the user, the Compax3 units already have a Safety I/O Profile installed when they leave the factory. The profile is described in the document “192_120212_Description_of_the_S3_Standard_IO_Profile_for_Option_S3_Compax3M.pdf”. The machine design engineer is solely responsible for the adequate use and the correct functioning of the machine. This means, that he must also test or validate the function before the machine is delivered.

Editing or debugging of own SafePLC application programs (I/O profiles) requires a USB license dongle. This is available from the company Paker Hannifin.
For the USB license dongle the appropriate driver needs to be resident on the PC. If this is not the case, it needs to be installed via inf_inst.exe (see after installation of the Parker SafePLC in the program directory under \Parker Hannifin\SMX_SDC\hrdLock\).

The type of reliable monitoring must generally be programmed by the user via a Safety I/O Profile in the SafePLC level. For this purpose Parker can also supply ready made SafePLC application programs (Safety I/O Profile), if demanded by the customer.

Due to this dual structure 2 separate configurations must always be performed, one for movement monitoring (SDC) and one for Compacx3 to set the correct movement. This also applies for the encoder configuration. Each encoder used must be configured once in the SafePLC and once in the Compax3 configuration.

3.2 SDC

The module type SDC is a compact fail-safe control system with integrated drive monitoring for one axis. The device is freely programmable for safe 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 safe inputs for max. 6* input elements and max. 8* shut-down circuits.
For the safe detection of speed and/or position 1-encoder solutions (incremental TTL, incremental SIN/COS) and also 2-encoder solutions (e.g. incremental TTL/ incremental TTL, incremental SINCOS/SSI or, incremental SINCOS/PROXI) are supported.

Device design
Design of module with the following periphery: 2 sensor interfaces 4x2 *) maximum number: grouped safe digital inputs (SMF1...SMF3, SMF4*) 2x1 safe but non-grouped digital inputs (monitoring) (E0.5/E0.6) 2 pulse outputs 6* maximum number: HISIDE safety outputs (SBC1/2, DO1/2, DO_0.1/2*) 2 Release outputs (internal STO-shut-off channels) (FS_CH1/2) 1 diagnostic and configuration interface 1 CAN-interface for transverse bus communication 2 Status-LEDs

*) With these data please note that SMF41 and SMF42 are configured optionally as safe grouped input or as 2 safe outputs by using the SafePlcGRP-Software. This means that maximum 6 input elements (grouped or non-grouped) and 6 shut-down channels or 5 input elements and 8 shut-down channels are available.

3.2.1 Characteristics of the module

- Logic processing up to PL e acc. to EN ISO 13849-1:2009 or SIL 3 acc. to IEC 61508:2010
- Freely programmable small control system for up to 500 IL instructions
- Logic diagram oriented programming
- Pulse outputs for cross-shorting detection of digital input signals
- Safety function of external contact monitoring for connected switchgear
- Monitored HISIDE outputs for safety relevant functions

3.2.2 Table 1: Technical characteristic data

Safety related characteristic data	
PL as per EN 13849:2009	PL e
PFH / architecture	PFH_{SYS} = 1.19 E-9 / Architecture class 4
SIL as per EN ISO 61508:2010	SIL 3
Proof test interval	20 years = max. utilization period
General data	
Safe digital input grouped/non-grouped	4(3) *) /2
Secure digital outputs	4(6) *)
Approved outputs (internal STO shut-down channels)	2
Pulse outputs	2
Encoder interface **X13**	Incremental (SIN/COS, RS442)
Encoder interface **X11**	Incremental RS422, SSI absolute encoder
Encoder interface **E.05**	PROXI-Switch
Max. frequency incremental (SIN/COS, TTL)	250 kHz
Cycle frequency/mode SSI	Slave Mode 300 kHz
Type of connection	Servo drive interface
Proxi-Input (E0.5)	Max. 250 kHz
Electrical data	
Power supply	24 V 1.5 A (SELV/PELV)
Current consumption	1.5 A
Backup fuse	3.15 A
Ratings digital I	24 VDC; 20 mA, Type1 acc. to EN61131-2
Ratings digital O	24 VDC; 500 mA (SBC1/2) 30 mA (FS_CH1/2)
Pulse outputs	Max. 100 mA
Environmental data	
Temperature	0° to 80° operating temperature -10° to +70° storage temperature
Class of protection	IP 52
Climatic category	3 K3 EN 60721-3
EMC	In accordance with DIN EN 55011:2007, EN 61000-6-2 EN IEC 62061:2005 and IEC 61800-3:2006

Table 1: Technical characteristic data

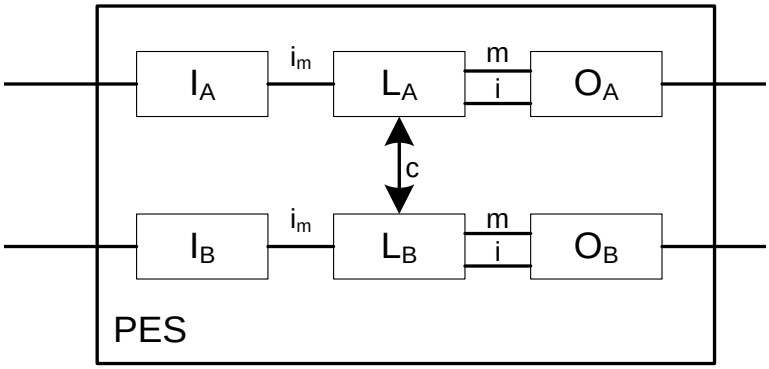
*) SMF41/SMF42 optionally configurable as safe grouped input or as 2 safe outputs.

4 Safety related characteristics

4.1 General design, safety related architecture and characteristic data

The internal structure of the SDC-series consists of two separate channels with reciprocal comparison of results. 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 13849-1:2009.



The overall architecture therefore corresponds with the following structure:

Dual reading of each input and diagnose by transverse differential

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

The characteristic data (Table 1) specified in chapter 3 (e.g. PL e and PFH- value acc. to the table as evidence acc. to table EN 13849:2009) for the partial system PES can be used for the safety related assessment of the overall system.

Characteristic data:

Max. obtainable safety class	• SIL 3 as per IEC 61508:2010 • Category 4 acc. to EN ISO 138491:2009 • Performance-Level e acc. to EN ISO 13849-1:2009
System structure	2-channel with diagnose (1002) acc. to IEC 61508:2010 Architecture category 4 acc. to EN 13849-1:2009
Rating of operating mode	"high demand" acc. to IEC 61508:2010 (high demand rate)
Probability of an endangering failure per hour (PFH-value)	see table 1
Proof test interval (IEC 61508:2010)	20 years, after this time the module must be replaced

Safety note:

- The specific safety related characteristic data of the module can be taken from the technical characteristic data (Table 1) 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.
- 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 13849-2:2008.
- The characteristic data (Table 1) specified in chapter 3 for the partial system PES (e.g. PL e and PFH-value acc. to the table as evidence acc. to EN 13849:2009)

The following examples and their characteristic architecture are mainly responsible for the assignment to a category acc. to EN ISO 13849-1:2009.

The maximum possible Performance Levels acc. to EN 13849:2009 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 Function STO/SS1

The safety function STO/SS1 can actively be triggered via safe inputs X28 of the safety option card. The safety IO profile R0110001xx available in the servo drive provides the emergency stop inputs SMF.41 and SMF.42. The inputs can be wired to an emergency stop device directly, thus the safety function SS1 is triggered by opening the contacts. Then the SS1 function starts to monitor a preset brake ramp ((1200 rpm)/sec). Afterwards the torque of the motor is switched off by 2 channels.

t_delay = t_latency1 + t_monitoring brake ramp + t_latency2 + t_final stage

The application is described in the document 19x-120212 Nx description of standard profile R0110001xx for option S3 Compax3M.

In order to enable the actual speed to pass within the preset monitoring curve and to prevent an instant switch-off, the user must take care in the IEC programming (non-safety part) that first a stop is actively carried out by the servo drive and secondly that the stop ramp passes within the monitoring curve. The application is described in the document 192_120212_Description_of_the_S3_Standard_IO_Profile_for_Option_S3_Compax3M.pdf and 192-120104 C3T30 or 192-120108 C3T40. Because the safety IO profile can be programmed by the user as well, the design engineer has the possibility to change customized modifications, e.g. function of the inputs. Details for programming are described in the programming manual 192-120211 Safety Option S3 for Compax3M.

Safety characteristics	
PL to EN 13849:2009	**e**
Category	4
$MTTFd_{STO}$ & DC_{STO}	$MTTFd_{STO}$=140 years; DC_{STO}=99%
⇨ PFH_{STO} incl. safety option board	1.85 E-8*
$PFH/architecture_{SDC}$ (safety option board)	PFH_{SYS} = 1.19 E-9* / Architecture Class 4
SIL according to IEC 61508:2010	SIL 3
Proof-Test-Interval	20 years = mission time
Max. Reaction time SS1/STO	See above

*External sensors and switches are not considered. The ratings of the external components must still be considered by the user for the definition of a total failure probability (see calculation example in chapter 18.3.6).

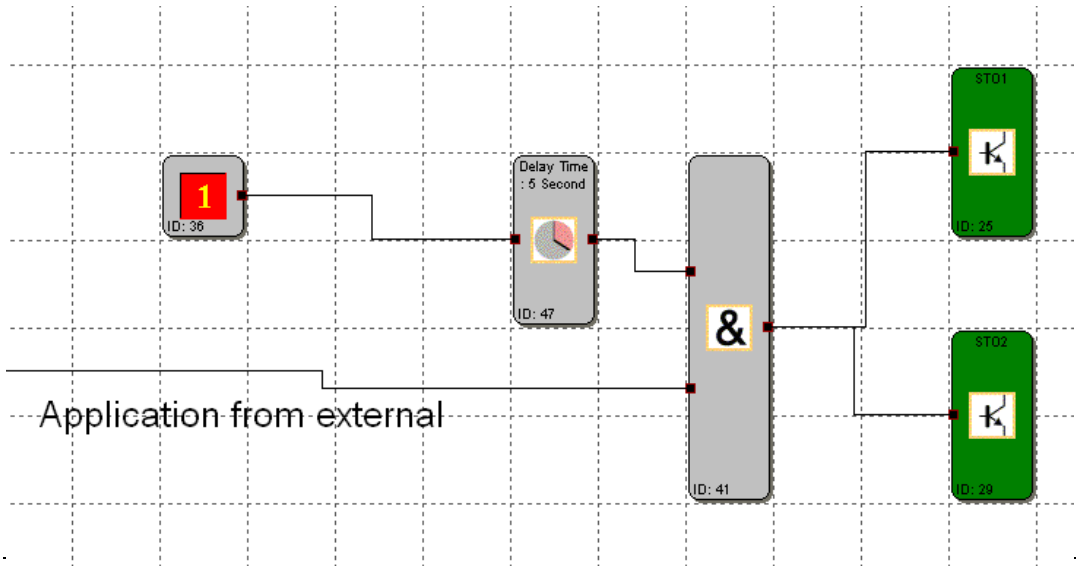
By causing the Compax3 error messages 0x5493 or 0x5494 the safety of the safety function STO is not longer ensured. In this case it is recommended to prevent further operation of the machine.

⚠ **Safety notes:**

- With activated STO, no galvanic isolation in accordance with EN 60204-1 Section 5.5 is guaranteed. This means that the entire system must be disconnected from the mains power supply with an additional main switch or mains power contactor for repair jobs. Please note in this context, that even after the power is disconnected, dangerous electrical voltages may still be present in the Compax3 drive for about 10 minutes.
- With synchronous motors operated in the field weakening range, the triggering of the STO function may lead to over speed and destructive, life-threatening over voltages as well as explosions in the servo drive. Therefore, never use the STO function with synchronous motors in the field-weakening range.

Conditions of utilization for the Safety Function STO:

- It must generally be ensured that STO (or SS1) is requested at least once a week. If it isn't activated by the process, e.g. by opening the safety gate regularly, it must be forced with the help of the external plc
- Category 4 is only reached if
  - Compax3 Software Release > R09-41 is used
    - STO (or SS1) after each power-on is used. With the safety IO profile R0110001xx version >=06 available in the the servo drive, an internal STO switch-off is always forced for 5 seconds after power-on for diagnostic purposes. If own user profiles are used, this function must be realized. The value shouldn't fall below the 5 seconds.
      Note: During the power on time, the STO signals in Compax3 are principally always logical ‚0', i.e. the message 0x5492 'STO active' will always be reported. However the timer cannot be eliminated even with ‚STO active' message, because the internal diagnostic process begins only after the power on time. Otherwise only category 3 is reached.



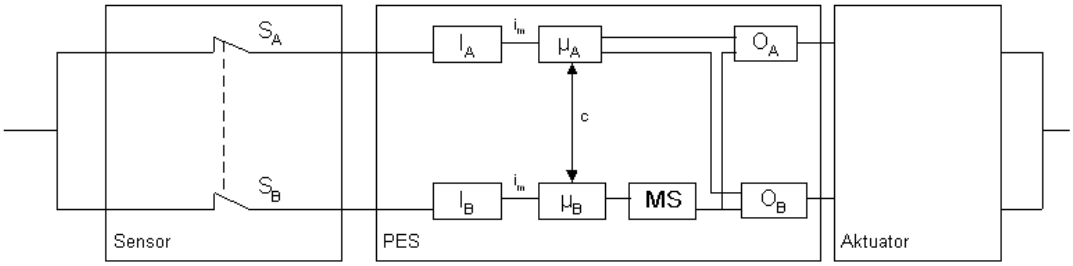
- When external forces are applied to the drive axes, additional measures (e.g. additional brakes) are to be taken. Please note in particular the effects of gravity on suspended loads! This must be respected above all for vertical axes without self-locking mechanical devices or weight balance.
- When using synchronous motors, a short movement over a small angle is possible, if two errors occur simultaneously in the power section. It depends on the number of pole pairs of the motor (rotary types: 2-poles = 180 °, 4-poles = 90 °, 6-poles = 60 °, 8-poles = 45 °; linear motors: 180° electric).

4.3 Safety related characteristic data and wiring for the connected sensors

4.3.1 Safety related characteristic data and wiring of the input elements

The SDC module has two types of safety inputs with different characteristics.

Grouped inputs (SMF11/12..SMF41/42):

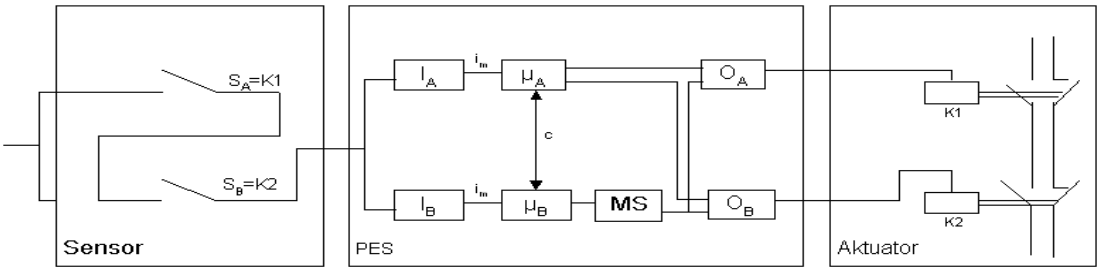


Signal processing in two channels and diagnose by transverse differential in the PES

Grouped inputs are intended for use with 2-channel sensors/control units in safety applications

Note:
Grouped inputs can be used like not non-grouped inputs by parallel arrangement of the two assigned inputs.

Non-grouped inputs (E05, E06):

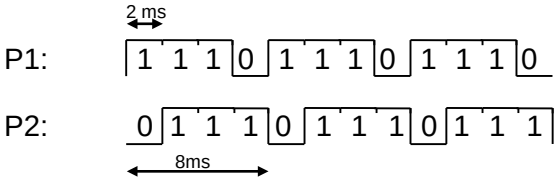


Dual reading and signal processing in two channels, diagnose by transverse differential in the PES

In safety applications non-grouped inputs are intended for use with single or dual channel sensors/control units wired in series.

The SDC module ensures far reaching diagnostics functions for the partial input system. These are performed permanently or optionally (cross-shorting monitoring by means of pulse identifier).

Signature of pulses:



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

Digital input signals:

Measure	DC	Note	Use
Cyclic test pulse by dynamic change of input signals	90	Only effective if pulse assignment is active	Cross-shorting monitoring for single channel sensors
Cross-comparison of input signals with dynamic test, if short-circuits cannot be detected (for multiple inputs/outputs)	90	Cyclic change of input signals required, e.g. by the process or by regular actuation	Monitoring of dual channel sensors
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 effective if pulse assignment is active	Monitoring of dual channel sensors
Plausibility test, e.g. use of normally open and normally closed contacts of positively driven relays	99	Only effective in connection with activated monitoring function for input element	Monitoring Dual channel, complementary sensor

⚠Safety note:

- The manufacturer's data ($MTTF_D$, 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.

4.3.1.1 Classification of digital inputs

Digital inputs	Max. achievable performance level	Comment
SMF11/SMF12 . . SMF41/SMF42	PL e	Suitable for any kind of input element, with/without pulse, achievable PL depending on $MTTF_d$ of the input elements as well as, as well as fault exclusion in the external wiring.
E0.5, E0.6	PL d	- Limitation in disconnection, - Fault detection upon request

4.3.1.2 Wiring of inputs

4.3.1.2.1 Single-channel sensor, without cross-shorting test

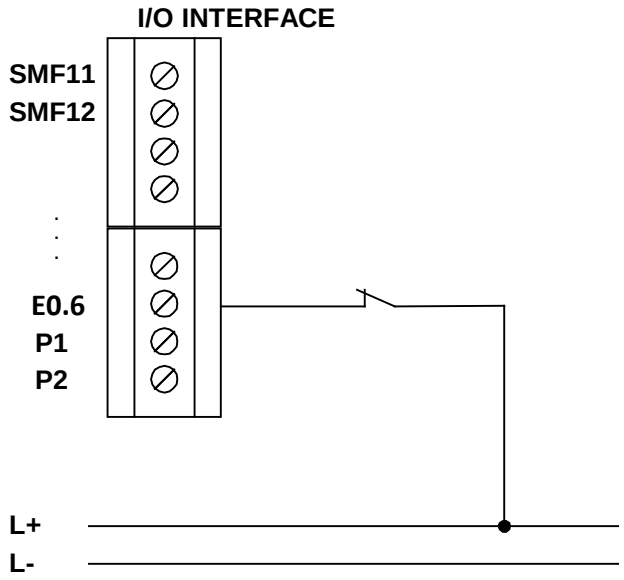


Fig.: Single-channel sensor, without cross-shorting test

The single-channel sensor without clock or without cross-shorting test is connected to the SDC. This design is not recommended for safety applications. PL b acc. to EN ISO 13849-1:2009 can maximally be reached.

4.3.1.2.2 Dual-channel sensor, without cross-shorting test

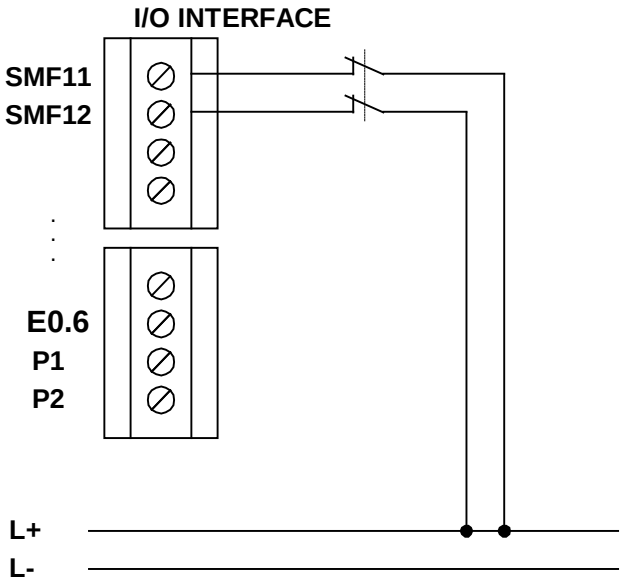


Fig.: dual channel sensor without cross-shorting test, homogeneous

The use of dual channel sensors without clock or without cross-shorting test may probably lead to problems. A short circuit in the signal line of the dual-channel sensor, e.g. in a cable, cannot be detected. Safe operation can only be achieved by separated wiring and exclusion of a short circuit on the terminals. This type of connection is not to be recommended for use in safety applications outside the control cabinet. Under due consideration of the fault exclusion cross-shorting, up to PL d acc. to EN ISO 13849-1:2009 can be achieved.

4.3.1.2.3 Dual-channel sensor, without cross-shorting test complementary

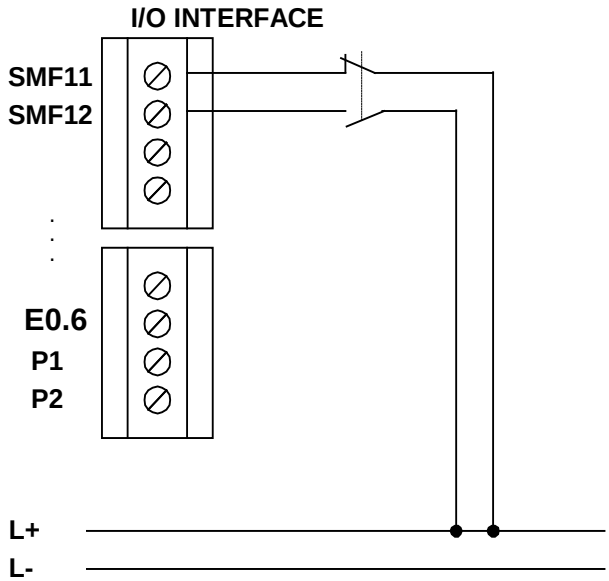


Fig.: Dual-channel sensor, without cross-shorting test complementary

The use of dual-channel complementary sensors without clock, or without cross-shorting test can be safely processed by the SDC module. Under due consideration of the fault exclusion cross-shorting, up to PL e acc. to EN ISO 13849-1:2009 can be achieved.

4.3.1.2.4 Single-channel sensor with cross-shorting test

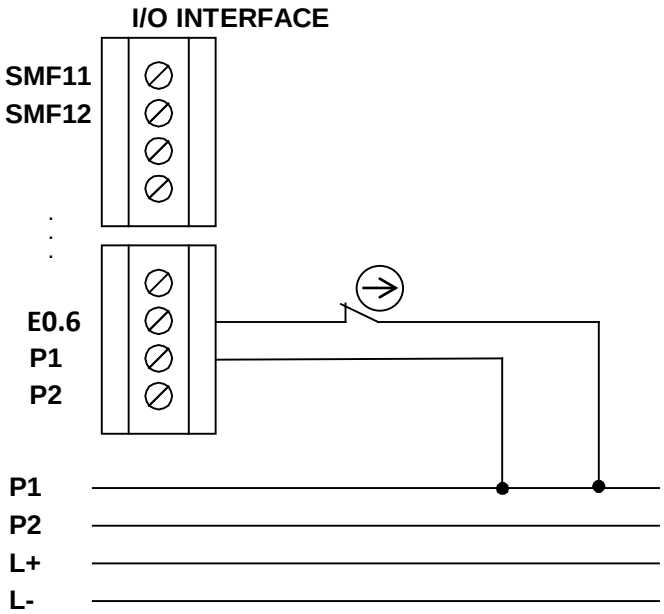


Fig.: Single-channel sensor with cross-shorting test

When using a single-channel sensor with clock one output is connected to the clock output P1 or P2. The clock assignment to the SDC must subsequently take place.

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 E0.6 is also not detected.
PL d acc. to EN ISO 13849-1:2009 can be achieved by using a suitable switching element and with cautious wiring of the sensor.

Note:
PL e acc. to EN ISO 13849-1:2009 is achieved if the short-circuit between E0.6 and P1, and the short-circuit between the sensor connections can be excluded. Here must take care that the in a fault scenario the switch must be positively opening. The sensor must additionally be triggered in regular intervals and the safety function requested. Fault exclusions can be achieved in accordance with EN ISO 13849-2:2008, table D8.

4.3.1.2.5 Non-grouped input with cross-shorting test to monitor a downstream device with safety function

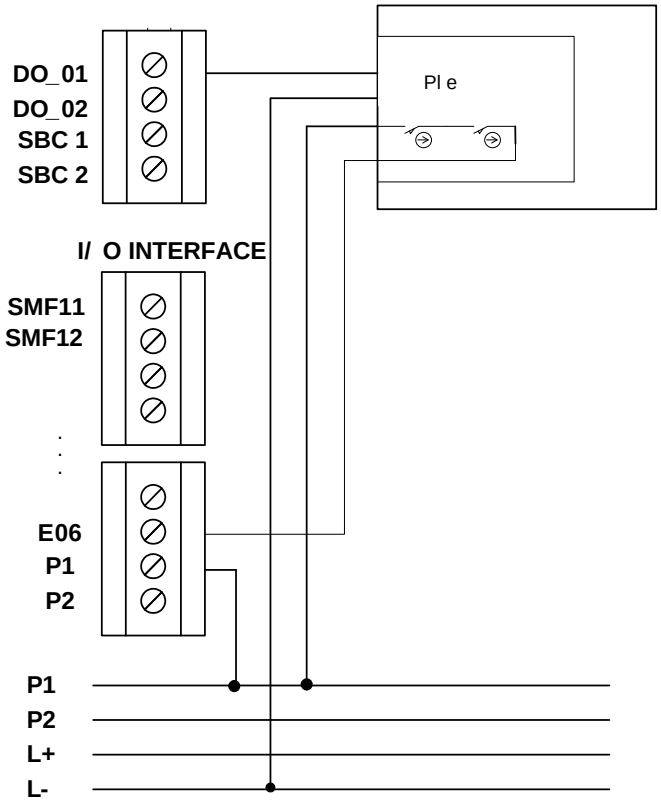


Fig.: Monitoring of a device with safety function with clock

Non-grouped inputs can be used to monitor devices with safety functions.

The use of a non-grouped input with clock to monitor the downstream safety equipment detects:

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

The achievable PI depends on the safety level of the downstream device with safety function.

Note:
PL e acc. to EN ISO 13849-1:2009 is achieved if the short-circuit between E0.6 and P1, and the short-circuit between the sensor connections of the downstream safety equipment can be ruled out. Here one must make sure that in a fault scenario the switch must be positively opening. The monitoring must additionally be triggered in regular intervals and the safety function requested. Fault exclusions can be achieved in accordance with EN ISO 13849-2:2008, table D8.

4.3.1.2.6 Non-grouped input with cross-shorting test to monitor a shut-down circuit

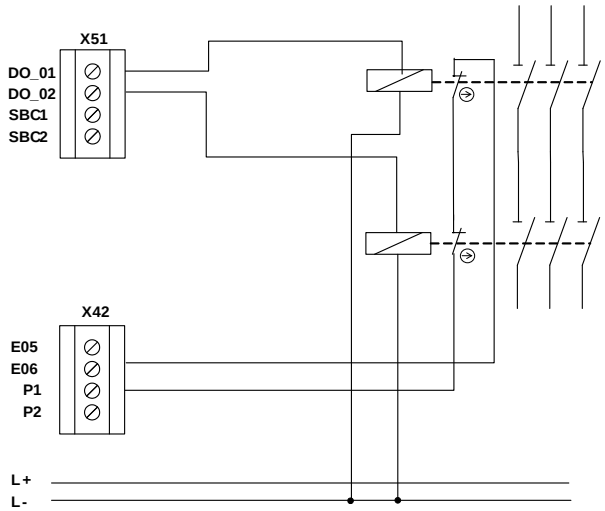


Fig.: Monitoring of a shut-down circuit with safety function with clock

Non-grouped inputs can be used to monitor shut-down circuits with safety functions.

The use of a non-grouped input with clock to monitor the downstream safety equipment detects:

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

The achievable PI depends on the safety level of the downstream shut-down circuit (see notes under 4.3 Safety related characteristic data and wiring of outputs)

Note:
PL e acc. to EN ISO 13849-1:2009 is achieved if the short-circuit between E0.6 and P1, and the short-circuit between the monitoring contacts in the shut-down circuit can be ruled out. Here one must make sure that in a fault scenario the monitoring contacts must be positively opening. The monitoring must additionally be triggered in regular intervals and the safety function requested. Fault exclusions can be achieved in accordance with EN ISO 13849-2:2008, table D8.

4.3.1.2.7 Dual-channel sensor without time-out without 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.

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

PL 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.

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

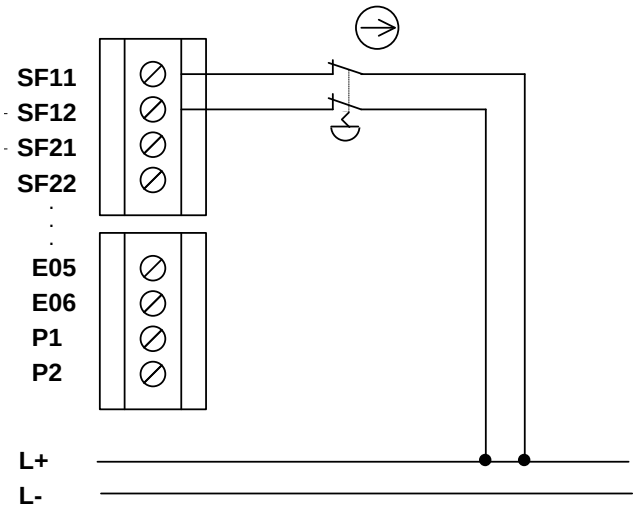


Figure: dual-channel sensor homogeneous without clock, with positive disconnection

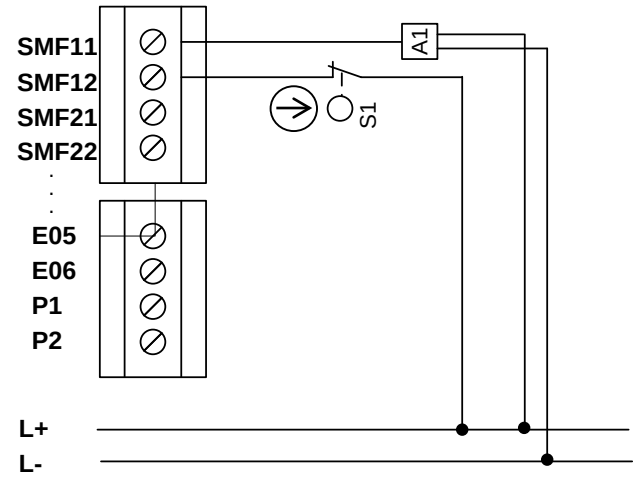


Figure: dual-channel input element diversitary, without clock

⚠**Safety note:**

- PL 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.

4.3.1.2.8 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.

PL 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.

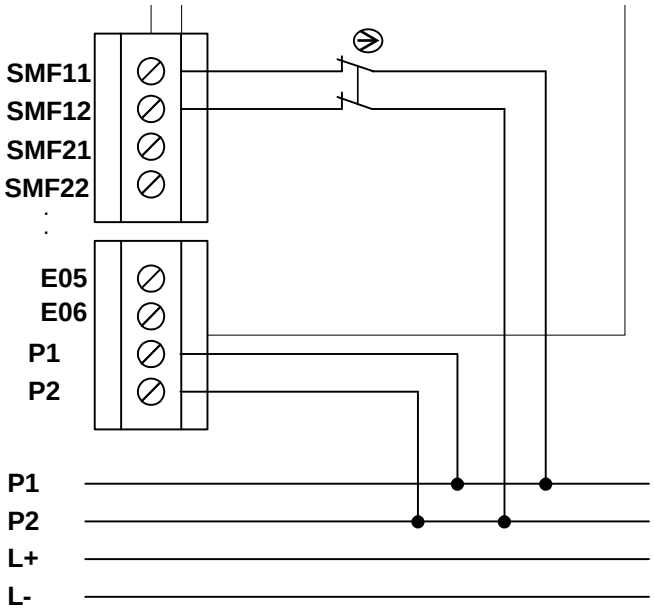


Figure: two-channel sensor, homogeneous with clock

⚠Safety note:

- PL 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, PL 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.

4.3.1.2.9 Dual-channel sensor complementary

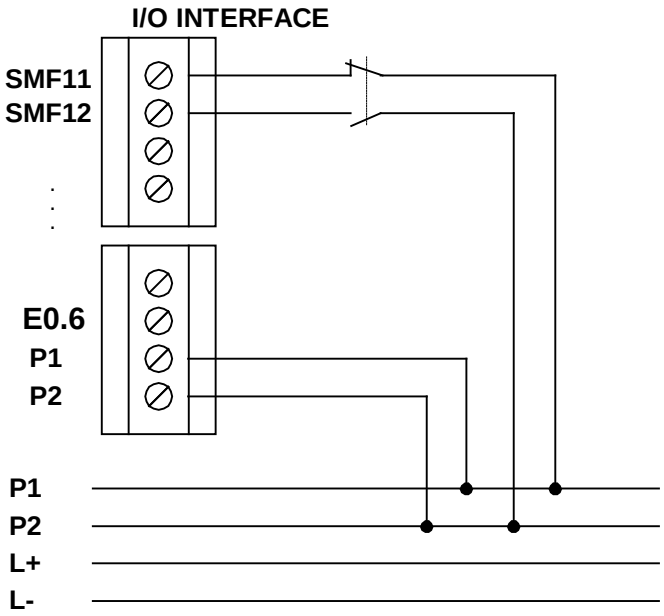


Fig.: Dual-channel sensor complementary

When connecting a complementary sensor you must make sure that only the opening contact with clock is permanently tested. As with the homogeneous sensor, all fault types in the supply line are detected.

When using approved, positively opening switching elements, PL e4 acc. to EN ISO 13849-1:2009 can be achieved.

⚠Safety note:

- PL e acc. to EN ISO 13849-1:2009 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 make sure that the in a fault scenario the switch must be positively opening. The sensor must additionally be triggered in regular intervals and the safety function requested. Fault exclusions can be achieved in accordance with EN ISO 13849-2:2008 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 safety related use of the inputs is generally only intended in connection with the pulse outputs.

4.3.1.2.10 Dual-channel sensor with time-out and cross-shorting test

Faults on sensor /control unit as well as cross-shorting and connections to DC 24 V and DC 0 V can be detected by using time-out and two independent clock signals on the homogeneous sensor.

PL 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.

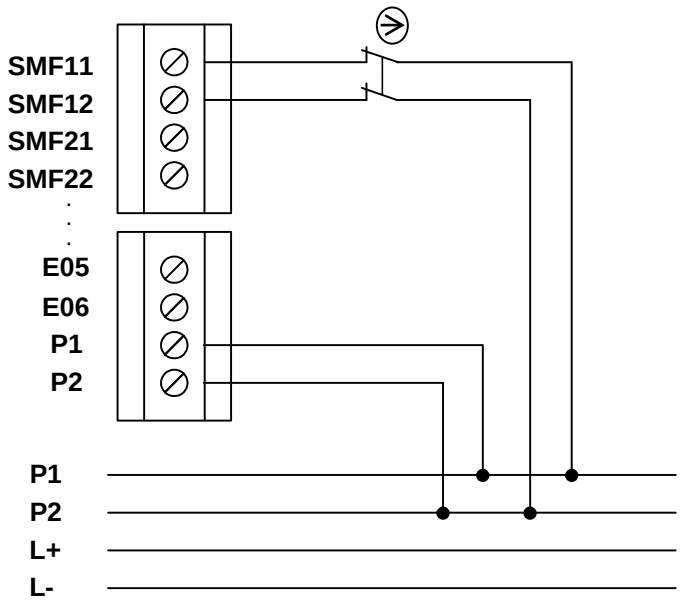


Figure: two-channel sensor, homogeneous with clock

⚠Safety note:

- PL d or higher in accordance with EN ISO 13849-1 is achieved by using switching elements / sensors with positive actuation
- When using two independent sensors with independent actuation, PL 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.

4.3.1.3 Overview of achievable PL for digital safety inputs

Type of sensor / input element	InPort	Parameterized / operational tests				Achievable PL acc. to EN ISO 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	E05, E06					b		Operation proven input element
	E05, E06			O	O	d	All faults at the input element Short-circuit between input/signal line and signal supply	$MTTF_D$ = high Connection in control cabinet or protected routing
	E05, E06					e	All faults at the input element Short-circuit between input/signal line and signal supply	Input element does not comply with min. PIr Connection in control cabinet or protected routing
	E05, E06 or SMF11/12 up to SMF41/42 in parallel wiring	X				d	Getting caught Short-circuit between input/signal line and signal supply	Mainly High-Level required (THigh > 100 * TLow). Positively disconnecting MTTFD = high Connection in control cabinet or protected routing
		X		O	O	e	All faults at the input element Short-circuit between input/signal line and signal supply	Input element does not comply with min. PIr Connection in control cabinet or protected routing $MTTF_D$ = high
Dual-channel parallel	SMF11/12 up to SMF41/42					d	Short-circuit between input/signal line and signal supply	Connection in control cabinet or protected routing $MTTF_D$ = medium
		X				e		$MTTF_D$ = high
Dual-channel parallel	SMF11/12 up to SMF41/42		X			e	Short-circuit between input/signal line (only with common switching elements = 2xNO or 2xNC) and signal supply	Connection in control cabinet or protected routing MTTFD = high

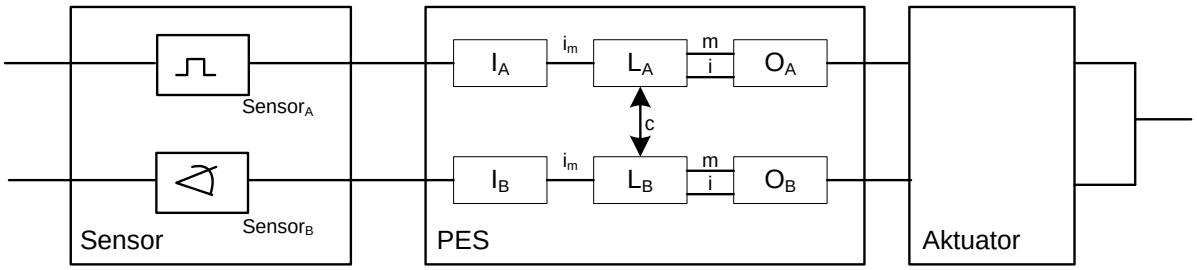
Type of sensor / input element	InPort	Parameterized / operational tests				Achievable PL acc. to EN ISO 13849-1	Fault exclusion for input element	Condition for input element
		Cross-shorting test	With time-out	Start test	Cyclic test during operation			
Dual-channel serial	E05, E06					d	Short circuit via input element/sensor and short circuit between input/signal line and signal supply Getting caught / positively disconnecting	Connection in control cabinet or protected routing $MTTF_D$ = medium
				O	O	e	Short-circuit between input/signal line and signal supply	Connection in control cabinet or protected routing $MTTF_D$ = high
	E05, E06			O	O	d	Short-circuit between input/signal line and signal supply	Connection in control cabinet or protected routing $MTTF_D$ = medium
		X		O	O	e		$MTTF_D$ = high

X: Diagnostic measure activated
O: min. 1 diagnostic measure activated

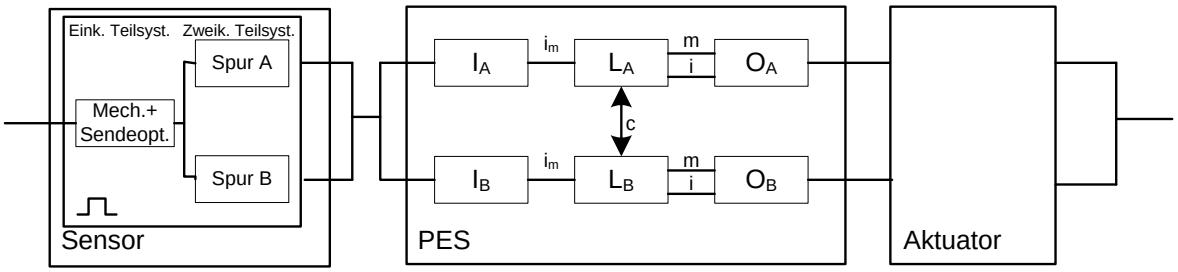
4.3.2 Sensors for speed and/or position detection

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

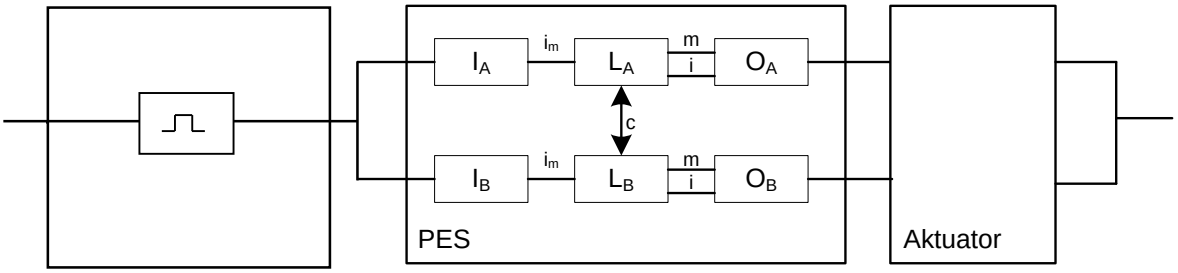
The SDC module has two encoder interfaces
Depending on encoder type and combination, different safety levels can be reached. The following system reflection results for the corresponding partial system:



Dual-channel sensor system with separate signal processing in two channels, diagnose by cross-comparison in the PES (PL e).



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 (PL d).



Sensor system with single and dual-channel partial system and integrated diagnose (example SIL3 SINCOS-encoder). Diagnose in PES by separate signal processing in two channels and cross-comparison in the PES as well as further specific diagnoses (PL e).

4.3.2.2 General diagnostic measures for encoder interface

For fault detection in the sensor system, a number of diagnostic measures are implemented, depending on the chosen encoder type or its combination. These diagnostic measures 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:

Measure	**DC**	**Note**	**Use**
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: - dual-channel sensor systems (2 separate sensors), - the dual channel partial system of single channel sensors (incremental encoder) - Diagnose for the single and dual-channel partial system of specially suitable sensor systems (SIN/COS-encoder) - Dynamic operation / no standstill monitoring	Monitoring of 2-channel sensor systems or the corresponding partial system of sensors for dynamic operation 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 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

4.3.2.3 Encoder types and their combination, diagnostic data

Type Process encoder (X13)	***Type Reference encoder (X11)***	***Type Proxi to E0.5***	***Safe speed***	***Safe direction***	***Safe position***	***Fault exclusion***	***Architecture acc. to EN13849-1***	***DC***		
								1-channel partial system	2-channel partial system dynamic	2-channel partial system non-dynamic (standstill monitoring)
Inc(TTL)	NC	NC	X			Fault exclusion mech. shaft breakage, positive encoder shaft connection required	3	60%	99%	80-90%
Inc(TTL)	Inc(TTL)	NC	X	X			4	n.a.	99%	95%
Inc(TTL)	NC	Proxi	X				4	n.a.	99%	90-95%
Inc(SIN/COS)	NC	Proxi	X				4	n.a.	99%	90-95%
Inc(TTL)	SSI	NC	X	X	X		4	n.a.	99%	90-95%
Inc(SIN/COS)	NC	NC	X	X		Fault exclusion mech. shaft breakage, positive encoder shaft connection required	3	90%	99%	90-95%
Inc(SIN/COS)	Inc(TTL)	NC	X	X			4	n.a.	99%	99%
Inc(SIN/COS)	SSI	NC	X	X	X		4	n.a.	99%	99%

4.3.2.4 Specific diagnostic measures with regard to the encoder type used

Encoder type	Supply voltage monitoring	Differential level monitoring	SIN/COS plausibility monitoring	Monitoring of the count signal separately for track A/B (Proxi: CPU A/B)
Inc(TTL)	X	X		X
Inc(SIN/COS)	X	X	X	X
SSI	X	X		
PROXI 1 x counting input				X

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

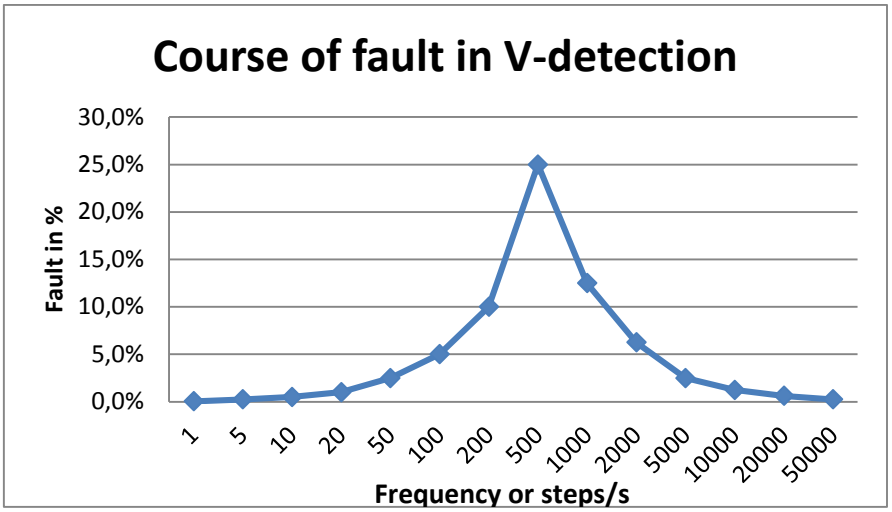
Plausibility tests with the current position and speed values are performed between both measuring channels A and B of the SDC module as a basic measure, which are then checked against parameterizable thresholds.

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 "SafePlcGRP".

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



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 (see chapter 11).
- The manufacturer's data ($MTTF_D$, 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 a s 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.

4.3.2.6 Safety related assessment of encoder types or there combination

Due to the monitoring functions implemented in the SDC-module, 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 4.2.2.3 "Encoder types and their combination, diagnostic data" 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 4.2.2.3 "Encoder types and their combination, diagnostic data" must also be observed.

PL 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 PL 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.

Note:
With a combination of two encoders of different technology, a minimum $MTTF_D$ = 30 years can be assumed as general rule.

⚠ 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 SDC-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 4.2.2.3 "Encoder types and their combination, diagnostic data".
- 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 SDC 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 corresponding diagnostic measures are listed hereunder

⚠**Safety note:**

- The diagnostic measures obviously have tolerances because of measuring inaccuracies. These tolerances must b e 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.

4.4 Safety related characteristic data and wiring of the outputs

The SDC module has maximum 8**) safe outputs.

Output	*Architecture acc. to EN ISO 13849-1:2009*	*Comment*
SBC1, SBC2	4	Complete shut-down channel in compliance with architecture category 4 acc. to EN ISO 13849-1:2009
FS_CH1, FS_CH2 (analog STO1/2)	4	Complete shut-down channel in compliance with architecture category 4 acc. to EN ISO 13849-1:2009
MDO_0.1, MDO_0.2 *)	4	Complete tripping channel in compliance with architecture category 4 acc. to EN ISO 13849:2009
DO_0.1, DO_0.2	4	Complete tripping channel in compliance with architecture category 4 acc. to EN ISO 13849:2009

*) Connections configurable as 2 safe outputs or as group input.

The safe 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 off for a testing period of maximum TT < 400 µs.

⚠Safety note:

- When using external switching amplifiers (contactors, relays), the switching ability in applications with frequent emergency shut-down requests must be tested in shorter intervals, e.g. at the beginning of a shift, 1 x per week. However, a test should at least be carried out cyclically 1 x year.

- The test function for the safe outputs will always be executed.

Note:

- The outputs are periodically tested with respect to their shut-down ability. For this purpose the output is deactivated for max. 400 µs. The downstream consumer must tolerate this test by using appropriate wiring.

- Inductive and capacitive loads have a negative effect on the wave form of the cyclic test and are therefore limited in height. Typical values are 500 mH for inductive loads and 20 nF for capacitive loads.

The outputs can be loaded as follows:

Output	*Voltage*	*Current*
MDO_0.1, MDO_0.2	24 VDC	500 mA
SBC1, SBC2	24 VDC	500 mA
DO_0.1,DO_0.2	24 VDC	500 mA
FS_CH1,FS_CH2 = STO output	5 VDC	30 mA

Note:
The total current of the outputs is max. 1.5 A.

⚠Safety note:

- For safety relevant applications only external switching elements with a minimum withstand current of > 1.2 mA and a pick-up voltage of > 5 V 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 shut-down circuit.

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

Diagnoses in the shut-down circuit:

Measure	**DC**	**Note**	**Use**
Cross-comparison of output signals with immediate and intermediate results in the logic (L) in case of 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	Monitoring of outputs with direct safety circuit function Monitoring of safety circuits with elements for switching amplification in connection with readback function of the outputs

4.4.1 Wiring examples of outputs

4.4.1.1 Single-pole switching HISIDE output without cross-shorting testing

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 SDC module will not recognize bonding of one or several external contacts. The following circuitry example is not suitable for safety applications!

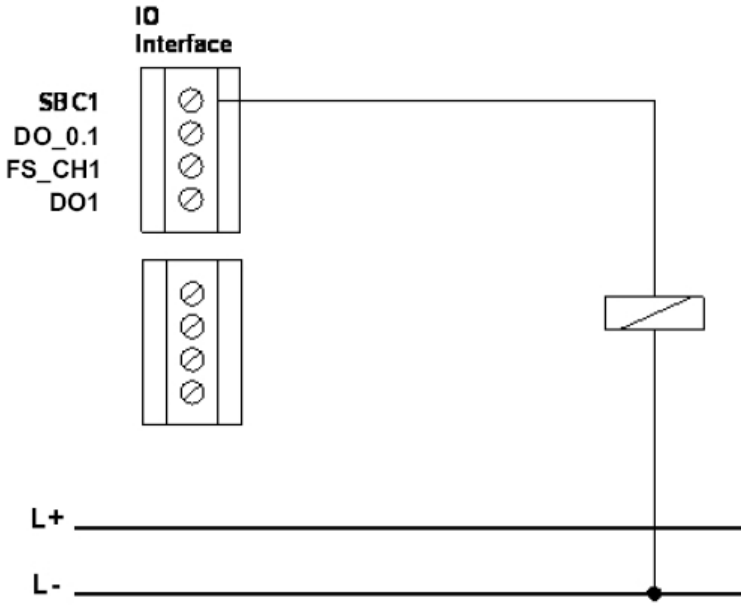


Fig.: Single-pole switching P-output

4.4.1.2 Single-pole output with safe shut-down circuit

For safety applications from PL c and higher acc. to EN ISO 13849-1:2009. The external circuit is controlled directly via an output. The achievable PL acc. to EN ISO 13849-1:2009 depends on the use of dynamic testing and the PL of the downstream device.

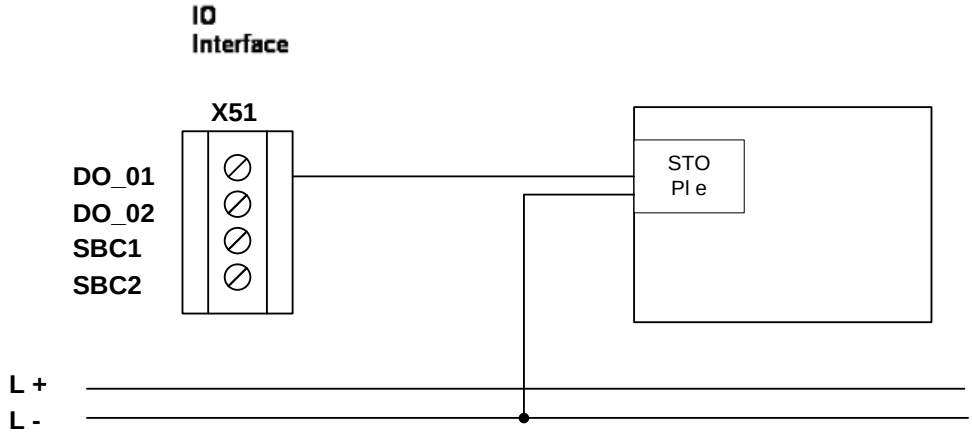


Fig.: Single-pole semi-conductor output in connection with downstream device with internally tested shut-down

4.4.1.3 Single-pole switching output with dual-channel shut-down circuit

Suitable for PL d or higher acc. to EN ISO 13849-1:2009. Use of an output DO_1/2, SBC1/2 or MD_0.1/2 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 $MTTF_D$-value of the external channel. PL e acc. to EN 13849-1:2009 can maximally be reached.

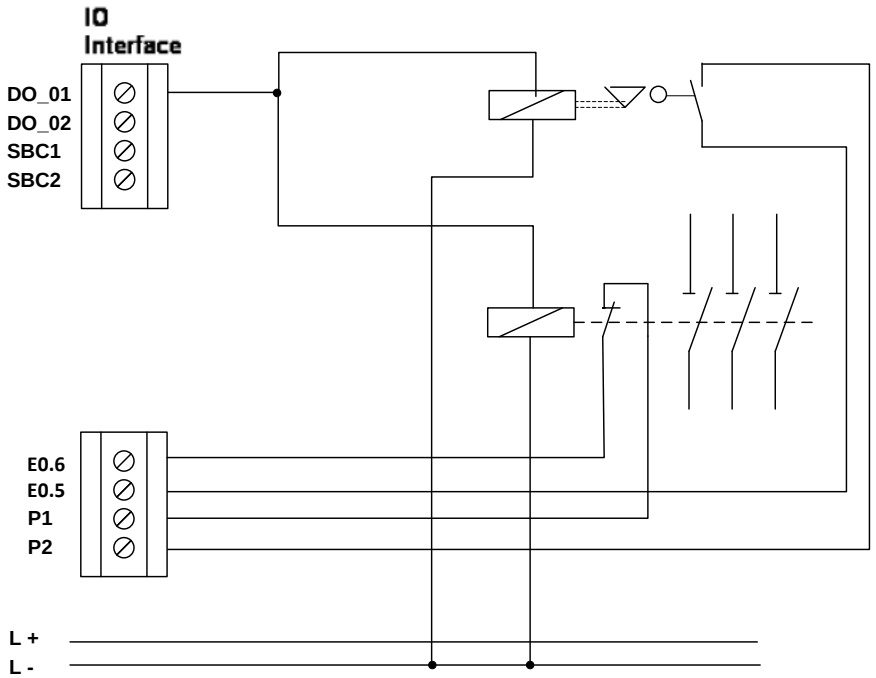
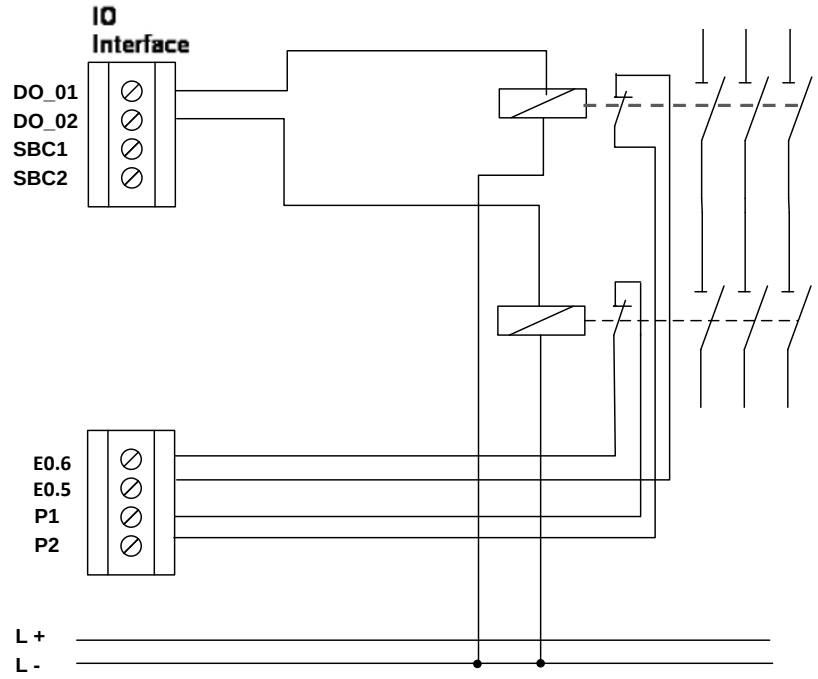


Fig.: Single-pole semi-conductor output in connection with dual-channel shut-down circuit with testing.

4.4.1.4 Dual-channel output

Suitable for PL d or higher acc. to EN ISO 13849-1:2009. Use of two outputs DO_1/2, SBC1/2 or MD_0.1/2 in connection with a dual-channel external wiring with testing.



⚠Safety note:

- For a safety related assessment of the partial system output the data issued by the respective manufacturer ($MTTF_D$, 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.

5 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. You should in any case disconnect 230 VAC voltages from low voltage power lines, if these voltages are used in connection with the application.

The cable lengths for digital inputs and outputs must normally not exceed **30 m**.
If the cable lengths exceeds 30 m 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 SDC 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:**

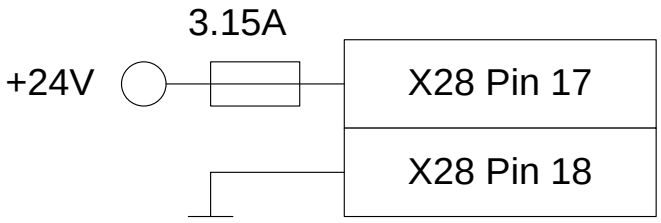
- Electric power supply lines and "discontinuous-action lines" of the drive must be isolated from each other.
- Signal lines and power lines of the servo drives must be routed through separate cable ducts. The distance between the cable ducts should be minimum 10 mm.
- Only shielded cables must be used 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 in the DSUB-sockets X11 and X13 for the position and speed sensors is correctly connected. Only metal or metal coated plugs are permitted.
- The shielding on the sensor side must comply with appropriate methods.
- EMC-compliant installation of the servo drive technology in the environment of the 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 servo drive manufacturer is mandatory.
- All contactors in the environment of the drive must be equipped with appropriate suppressor circuits.
- Suitable measures to protect against overvoltages must be applied.

- The component needs a power supply of 24VDC via a mains module with SELV/PELV according to DIN EN 50178:1998. When install the foreseen mains module, the following boundary conditions are to be taken into consideration:

The minimum and maximum tolerance of the power supply must be considered.

Nominal voltage of the inputs	***24 V DC Bus***
Minimum: 24 VDC – 15%	20.4 VDC
Maximum: 24 VDC + 20%	28.8 VDC

The supply of the component must be fused with a back-up fuse 3.15 A.



5.2 Connection of encoder supply voltage

The SDC module supports encoder voltages of 5 V, 8 V, 10 V, 12 V and 24 V, which are internally monitored in accordance with the chosen configuration.

The corresponding supply voltage must be configured for each encoder system in the encoder dialog of the "SafePlcGRP" user interface.

The encoder supply must be protected with a fuse of max. 3.15 A within the servo drive.

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

Nominal voltage	***Minimum voltage***	***Maximum voltage***
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	29.5 VDC

Permitted power supply for the encoder connections of the Compax3 pins X13 and X11:

C3MxxxD6**F11**I11TxxMxx S3:

Sensor 1 (X13)	Sensor 2 (X11)
10 V: Inc(SIN/COS)	24 V: Inc(TTL) 24 V: SSI

C3MxxxD6**F12**I11TxxMxx S3:

Sensor 1 (X13)	Sensor 2 (X11)
5 V: Inc(TTL) 5 V: Inc(SIN/COS)	24 V: Inc(TTL) 24 V: SSI

5.3 Connection of digital inputs SMF11...SMF42 and E0.5/E0.6

The SDC module comes with 4 SMF-inputs, one E0.5- and one E0.6-input. These are suitable for connecting dual (SMF) or single-channel (DIxS) signals, with and without cycling, or without cross-shorting test.

The connected signals must have a "High" level of
DC 24 V (DC +14 V...+ DC 30 V) and a "Low" level of
DC -3 V... DC +4 V, type1 acc. to EN61131-2:2003.
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 SDC into an alarm status. At the same time all outputs of the SDC are rendered passive.

Besides the actual signal inputs, the SDC module holds two clock outputs P1 and P2 available. The clock outputs are switching-type 24 VDC outputs.
The clock outputs are solely intended as test signal source for monitoring the digital inputs (SMF and E0.x) and cannot be used for any other functions within the application.

The switching frequency of both cycled outputs is 125 Hz. In the planning stage one must bear in mind that the cycled outputs may only be loaded with a total current of max. 100 mA.

Furthermore, approved OSSD-outputs can be connected to the inputs without limitation.

Short circuits in the external wiring between different inputs and against the supply voltage for the SDC must be ruled out by external measures, appropriate routing of cables in particular.

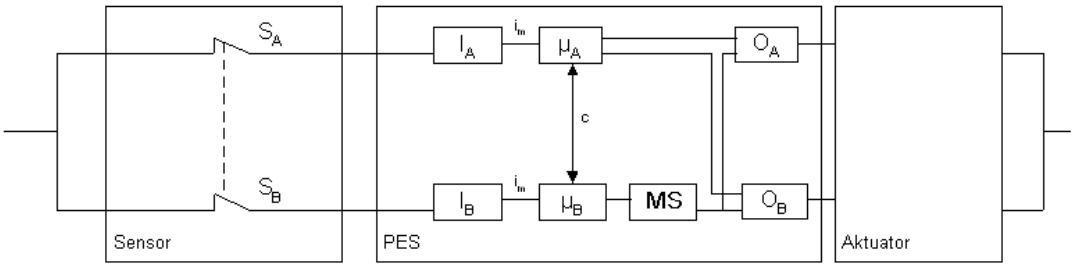
Each input of the SDC module can be configured individually for the following signal sources:

Input assigned to pulse P1
Input assigned to pulse P2
Input assigned to continuous voltage DC 24 V
Proxy input as special function of E0.5 (single input)

The internal structure of the SDC module corresponds with category 4 of EN 13849-1:2009 with respect to architecture and function. Each input has the following internal architecture:

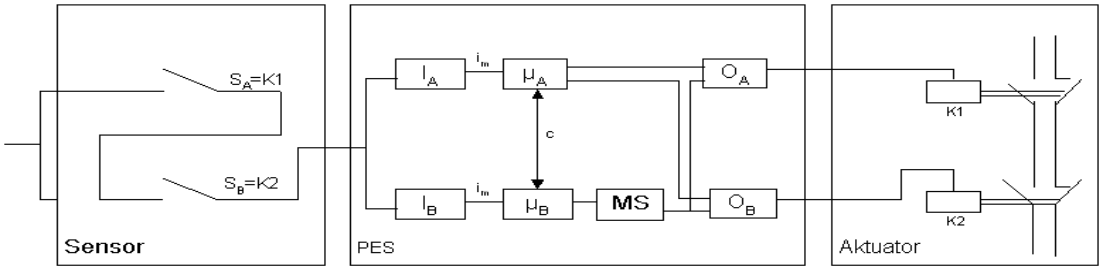
As an example, the following types of wiring are permissible on each input:

Grouped inputs:



Signal processing in two channels and diagnose by cross-comparison in the PES for grouped inputs

Non-grouped inputs:

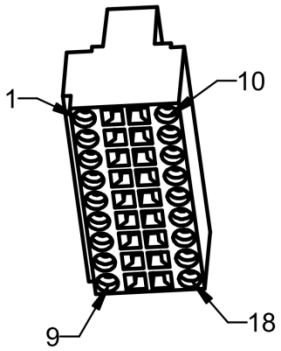


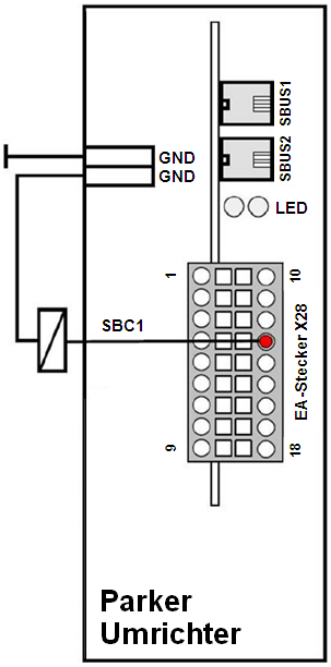
Dual reading and signal processing in two channels, diagnose by cross-comparison in the PES for non-grouped inputs

5.3.1 IO-PLUG (X28 (X1.2)

5.3.1.1 Contacts

On X28 wires can be wired in cross-sectional area of 0,14mm^2 to 1mm^2 (AWG 28-18).





5.3.2 Pin assignment

Pin	IO-Type	Name	Function
1	Grouped Input	SMF11	Safe Module Function 1 SEL1 – grouped with SMF12
2	Grouped Input	SMF12	Safe Module Function 1 SEL2 – grouped with SMF11
3	Grouped Input	SMF21	Safe Module Function 2 SEL1 – grouped with SMF22
4	Grouped Input	SMF22	Safe Module Function 2 SEL2 – grouped with SMF21
5	Grouped Input	SMF31	Safe Module Function 3 SEL1 – grouped with SMF32
6	Grouped Input	SMF32	Safe Module Function 3 SEL2 – grouped with SMF31
7	Grouped Input	SMF41/MDO_0.1*)	Safe Module Function 4 SEL1 – grouped with SMF42
8	Grouped Input	SMF42/MDO_0.2*)	Safe Module Function 4 SEL2 – grouped with SMF41
9	Input	E0.6	Safety Input
10	Input	E0.5	Safety Input
11	Output	DO_0.1	Safety Output 1
12	Output	DO_0.2	Safety Output 2
13	Output	SBC1	Safe Output - Reserved for Safe Brake Control 1
14	Output	SBC2	Safe Output - Reserved for Safe Brake Control 2
15	Output	P1	Pulse 1 Output
16	Output	P2	Pulse 2 Output
17	Supply	U24EXT	Power Supply 24V
18	GND	GND	GND

*) SMF41/SM42 either as safe grouped input or as 2 safe outputs configurable

5.4 Connection of position and speed sensors

5.4.1 General notes

The SDC has 2 encoder interfaces for the connection of industrial incremental and absolute encoders. The encoder interfaces can be configured as incremental, SIN/COS, or as absolute SSI-encoders.
It is additionally possible, to use the non-grouped input E0.6 of the SDC module as counting input for a PROXI sensor (counting signal generating proximity switch).

IMPORTANT:

The encoder supply voltages from X11 and X13 and higher are internally monitored by the SDC module (S3 option).

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).

If the second encoder input X11 is used for the purpose of safety monitoring (redundant encoder evaluation), this input must not be used at the same time for encoder simulation or as another physical signal source. The C3 ServoManager must be configured accordingly. In order to ensure this shut-down, the simulated signals in the simulation lines are suppressed by the SDC module (S3 option) by means of suitable hardware – this suppression is monitored by the SDC module (S3 option) by readback.

If in a dual-channel monitoring design (sensors) one of the two sensors is directly connected to the facility to be monitored, the second sensor may be installed after wear susceptible components. With respect to the sensors, this arrangement corresponds with the architecture Cat. 4 acc. to EN 13849:2009.

The usability of position processing requires the use of at least one absolute encoder.

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).

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 additionally applies when using absolute encoders:

The SDC module solely works in Slave operation when in SSI-mode. The cycle signal is generated by the drive and read in with the data signal from the SDC module.

This type of scanning causes a beat which results in a Scanning fault of the following magnitude:

Scanning fault $F_A = T_A / T_Z * 100\% = 2$ [ms] / 8 [ms] * 100% = 25%
(Scanning time T_A of the encoder by external system 2 [ms] / cycle time T_Z (= 8 [ms]) * 100 %)

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

5.5 Connection of PROXIMITY SWITCH

The connection is made via the IO-plug X28 on digital input E0.6 with a signal level of 0 V / 24 V.

5.6 Combination of different encoder types

For applications with encoder systems please note that, due to the implemented monitoring features, the SDC module does not place any particular requirements on the internal structure of the encoder electronics, i.e. standard encoders are normally sufficient. The following limitations do exist:

⚠ **Safety note:**

- 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 corresponding certificates and test reports are available in the market.
- Compact encoder with 2 x SSI or SSI + incremental: Also here the freedom of counteraction between the two inner encoder units as well as an appropriate internal mechanical design for the PL_r must be demonstrated.
- If only one encoder (e.g. compact 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 SDC module 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, partly fixed. The diagnostic coverages resulting from this must be assessed in relation to the application and included in the safety related overall assessment.

- 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 encoder types, together with the limiting parameters.

5.7 Usable encoder / encoder combination

Type Process encoder (X13)	***Type Reference encoder (X11)***	***Type Proxi to E0.5***	***Architecture acc. to EN13849-1***	***Max. achievable PL***
Inc(TTL)	NC	NC	3	d
	NC	Proxi	3	d
	Inc(TTL)	NC	4	e
	SIN/COS	NC	4	e
	SSI	NC	4	e
SIN/COS	NC	NC	3	d[1)]
	NC	Proxi	4	e
	Inc(TTL)	NC	4	e
	SIN/COS	NC	4	e
	SSI	NC	4	e

[1)] PL e can be achieved with certification of SIL3 SINCOS encoder

6 Configuration of measuring distances

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 PL e acc. to EN 13849-1:2009. For possible single-channel components (e.g. mechanical connection of the sensors/encoders with only one shaft/fastening) fault exclusions acc. to EN ISO 13849-2:2008 may be used, if this should be necessary. For PL d acc. to EN 13849-1:2009 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 13849-2:2008.

Further configuration is described in the programming manual:
37380-820-01-SDC programming manual.

7 Sensor type

Absolute encoders and incremental measuring systems are possible:
As well as counting pulse generating proximity switches (PROXI-Switch).

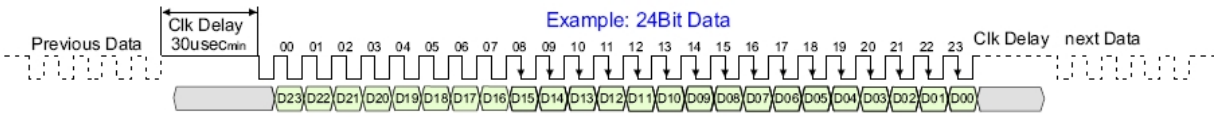
7.1 Absolute encoder

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 listing operation	(Slave operation):
External cycle rate	300 kHz (see table 1)
Min. clock pause time	30 µsec
Max. clock pause time	1 msec

Diagnoses: Absolute encoder

Diagnose	**Parameters**	**Fault threshold**
Supply voltage monitoring	Fixed values 24V	+/- 20% +/-2%(measuring tolerance)
Monitoring of differential level on input	Fixed value RS 485-level	+/- 20% +/-2%(measuring tolerance)
Plausibility Speed vs. position (max. position change in dependence on speed and cycle time)	Fixed value	$\triangle P < 2 * V * T$ with Time T = 8 ms (cycle time), Speed V

$\triangle P$ = Position change/position jump



Note:
Only encoders with data bits justified right may be used!
All SSI configuration data must also be specifically configured for the SDC module (S3 option) in the corresponding encoder dialog.

7.2 Incremental encoder

Physical Layer:	RS-422 compatible
Measuring signal A/B.	Track with 90 degree phase difference
Maximum frequency of the input cycles	see table 1

7.2.1 Diagnoses

Diagnose	Parameters	Fault threshold
Supply voltage monitoring	Fixed values 5V, 24V	+/-20% (Fault tolerance threshold: +/-22%)
Monitoring of differential level on input	Fixed value RS 485-level	+/-20% (Fault tolerance threshold: +/-22%)
Monitoring of the counting signal separated for each track A/B	Fixed value	$\triangle$P > 4 increments

7.3 SinusCosinus encoder – standard mode

Physical Layer:	+/- 0.5 Vss (without voltage offset)
Measuring signal A/B.	Track with 90 degree phase difference
Maximum frequency of input clock pulses.	250 kHz (see table 1)

7.3.1 Diagnoses

Diagnose	Parameters	Fault threshold
Supply voltage monitoring	Fixed values 10V	Peermissible range: +/-20% (Fault tolerance threshold: +/-22%)
Monitoring of amplitude SIN^2+COS^2	Fixed value $1V_{SS}$	Minimum value: 65% of 1 V_{SS} (Fault tolerance threshold: 62.5%)
Monitoring of phases A/B	Fixed value 90°	Peermissible range: +/-30° (Fault tolerance threshold: +/-35°)

7.4 Proximity switch

Signal level.	24 V / 0 V
Max. counting frequency.	250 kHz (see table 1)
Circuit logic de-bounced	

8 Response times of the SDC

The response time is a very important safety related characteristic and must be strictly observed for each application or 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.

8.1 Response times in standard operation

The cycle time of the SDC system serves as basis for calculating the response times. In operation this is **T_cycle = 8 ms**. The specified response times comply with the corresponding maximum running time for the actual application within the SDC 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	***Response time [ms]***	***Explanation***
Activation of a monitoring function by means of ENABLE with subsequent shut-down via digital output	24 ****)***	Activation of a monitoring function by means of the ENABLE signal.
Response of an already activated **monitoring function** including PLC editing in case of position and speed processing via digital output	16 ****)***	With a monitoring function that has already been activated via ENABLE, the module requires one 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	16	Activation of an input and switching of the output
Deactivation of digital output via digital input	16	Deactivation of an input and thus deactivation of the output

Mean value filter (Setting see Encoder dialog PLC)	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.

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

8.2 Response time for FAST_CHANNEL

FAST_CHANNEL describes a characteristic of SDC to respond quicker to speed requirements than this would be possible with the execution of the safety programs in normal cycle (= 8 msec). The sensing time of FAST_CHANNEL is 2 msec.

The following response times can be specified:

- 4 msec (typ.)

⚠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.

8.3 Response times for fault distance monitoring

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

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

For the Worst Case assessment it is assumed that the drive will initially move exactly to the parameterized threshold v0 with a speed v(k) and then will accelerate to the maximum possible value a0.

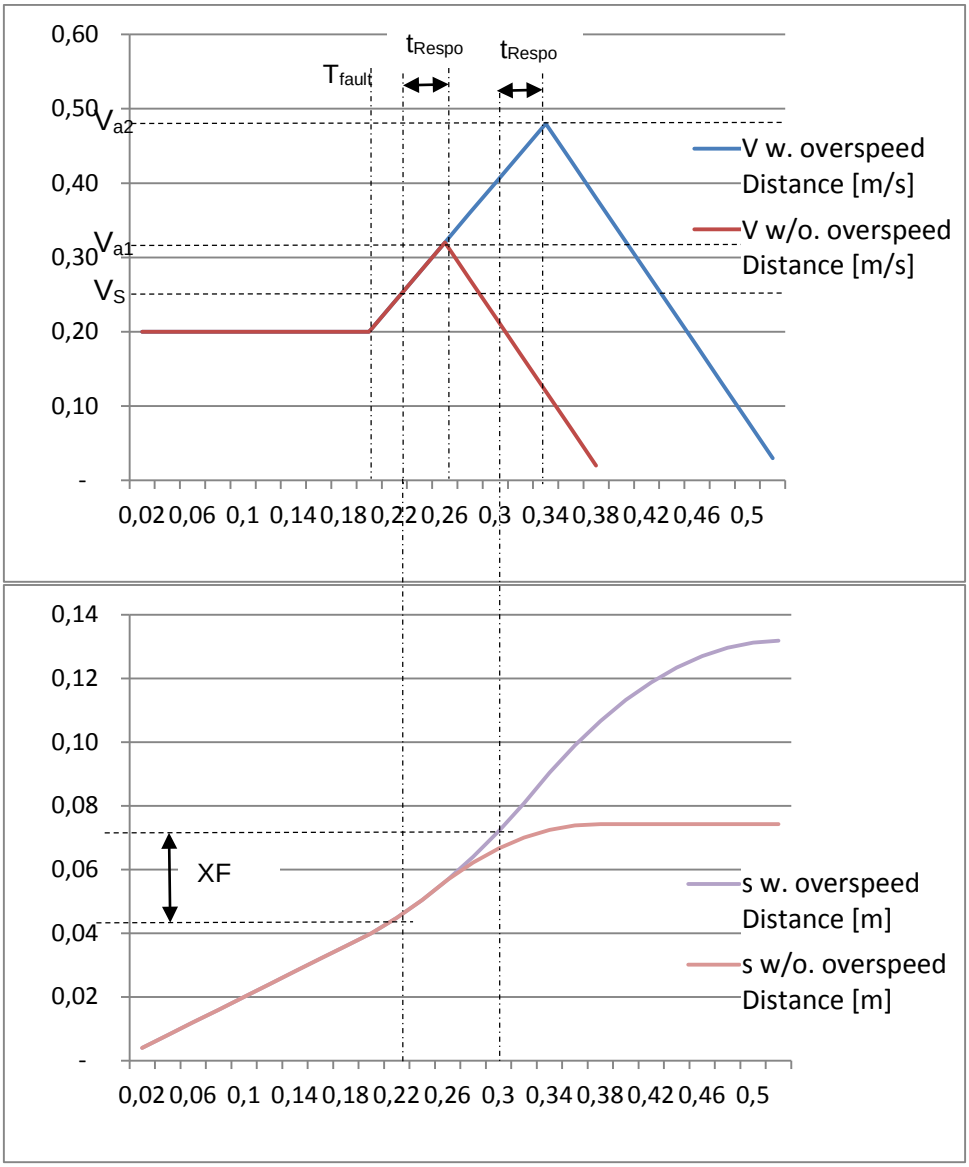


Diagram: Behaviour of the drive with / without overspeed distance

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 + deceleration time in external shut-down chain	Deceleration time in external shut-off chain derived from relay/contactor 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
$t_{Response}$	Value from the specified response time + deceleration time in external shut-down chain	Deceleration time in external shut-off chain derived from relay/contactor and brake data, etc. issued by the manufacturer
a_F, a_V	n.a.	Estimation of the application
V_{a2}	$= a_F * t_{Response} + (V_S^2 + 2 * a_F * XF)^{1/2}$	

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 (Treact = T_{SDC} + Tfilter), as well as the speed at shut-down by the module resulting from this.

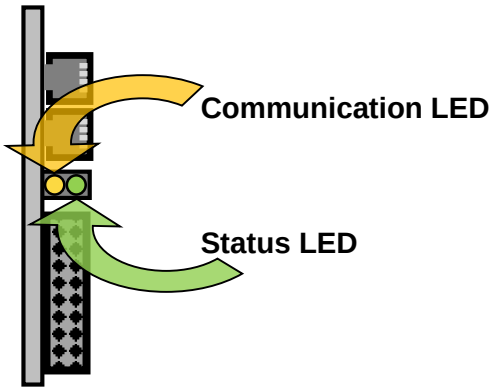
9 Start-up

9.1 Procedure

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

9.2 LED Displays

The SDC module has two LEDs: Communication LED and status LED.



The communication LED (directly on the PCB) shows the status of communication by yellow flashing (frequency depending on data rate) during active communication.

The status LED (outside) indicates the status of the module.

The following phases are passed through and displayed by the status LED after each new start and fault-free running of the module:

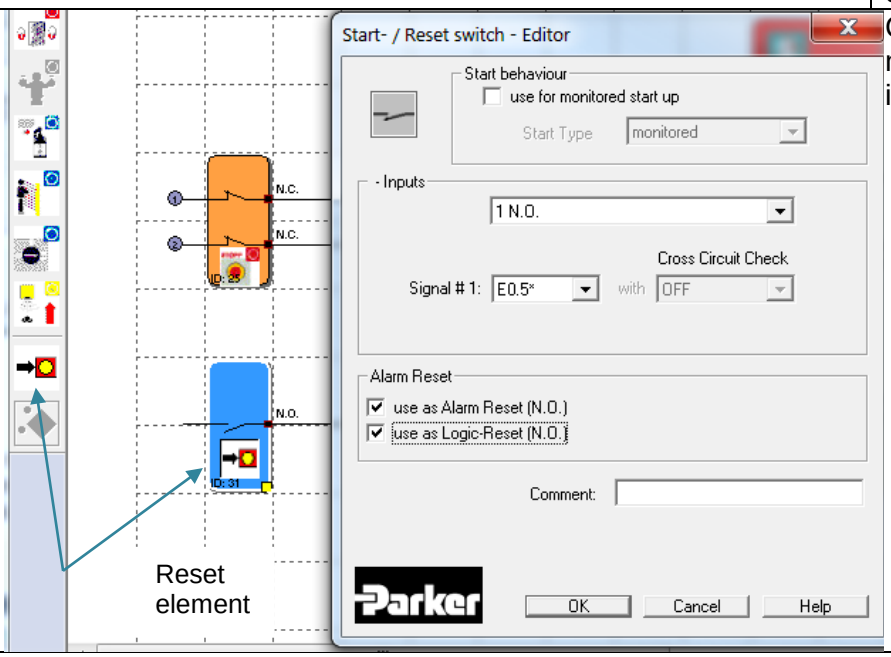
Mode	***Description***	***LED display***
STARTUP	Synchronization between both processor systems and checking of configuration/firmware data	Off
RUN	Normal system operation. All outputs are switched according to the current logic status.	Configuration not locked: Green / yellow flashing 1 Hz Configuration locked: Permanently green
STOP	In stop mode parameter and program data can be loaded externally.	Red/green flashing 1 Hz
ALARM	Alarms can be reset via the digital input.	Configuration not locked: Red/yellow flashing 1 Hz Configuration locked: Red flashing (1 Hz)
Fault	Fault can only be reset via ON/OFF of the module.	Permanently red

9.3 Reset behaviour

The reset function is differentiated into a start-up function after voltage reconnection = General Reset and a status/alarm reset = Internal Reset. The latter is triggered via a correspondingly configured input = reset element with activater "Alarm reset" function.

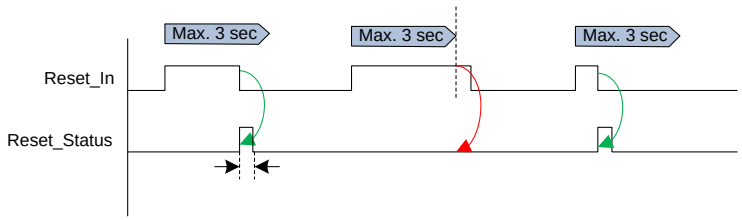
The following table provides an overview over the reset functions and their effect.

9.3.1 Reset types and triggering element

Reset type	Triggering element	Comment
General Reset	Voltage reconnection / equipment start	Reset function after a complete switch off/on of the device
Internal Reset		Configuration of a reset input

Reset Timing

The reset input for the internal reset is temporally monitored in "RUN" mode. An internal reset is triggered by the descending flank of the reset input provided that the condition T < 3 sec. between ascending and descending flank is true.

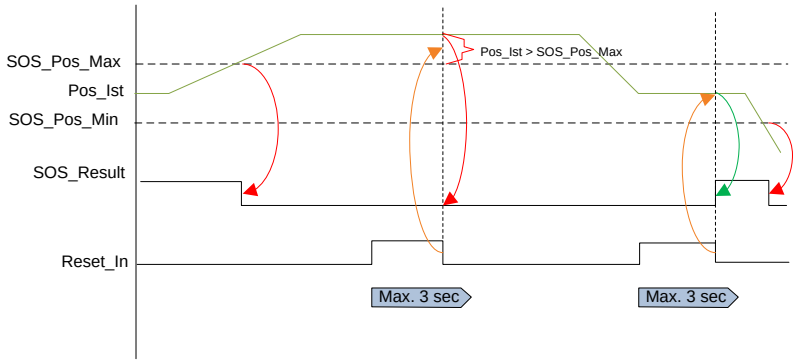


9.3.2 RESET function

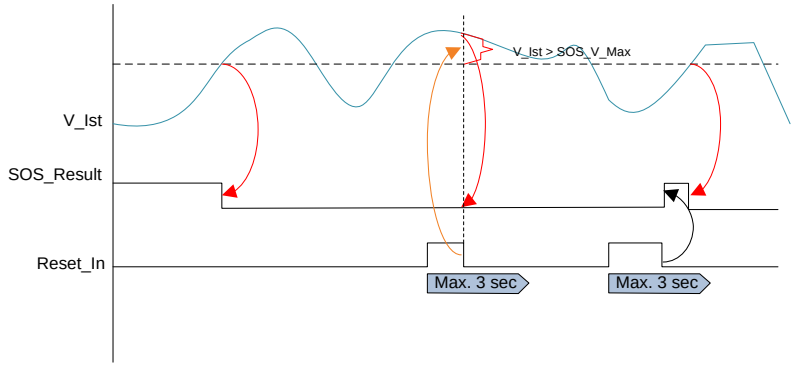
Functional unit	General Reset	Internal Reset	Function
Fatal Error	X		Fault reset
Alarm	X	X	Alarm reset
Monitoring functions	X	X	Resetting a tripped monitoring function
Flip-Flop	X	X	Dominant reset for 1 cycle
Timer	X	X	Timer = 0

The status of the monitoring function is generated new after a reset.

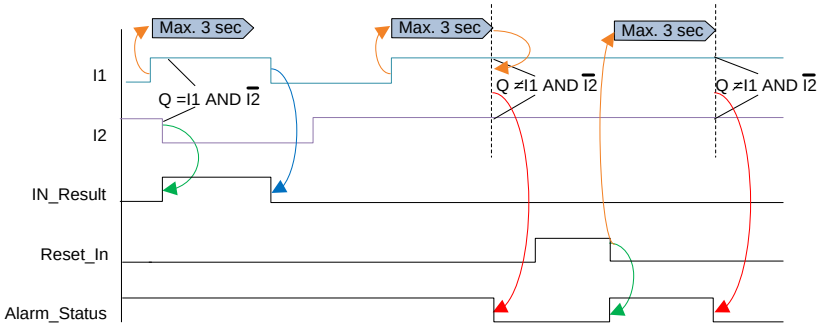
- ⇨ When exceeding the parameterized limits, the process values will not cause any change in the output state of the monitoring function
- ⇨ Time based functions - timers cause resetting of the output state of the monitoring function. Tripping will only occur if the parameterized limit values are exceeded again



Process value (position) => no change in the output state in case of a reset in alarm condition



Process value (speed) => no change in the output state in case of a reset in alarm condition



Time based function => resetting of the output state , response if the limit is exceeded again

⚠Safety note:

- In case of time-based functions, e.g. temporal monitoring of complementary input signals, the output status is reset and a faulty condition will only be detected, if the (temporal) limit value is exceeded again.
- As a safeguard against improper use, e.g. repetitive triggering of the reset function in order to bypass a state of alarm, one must probably apply application related measures in the PLC-programming.

9.3.2.1 Example reset function with safeguarding against improper use

Function:

On a machine the danger zone is to be safeguarded in normal operation by means of a separating guard system and in setup mode by an enable switch in connection with standstill monitoring and safely reduced speed.

The presence of the separating guard system is monitored by an electric sensor. With the guard system opened, traversing is only possible with the enable switch held depressed.

In the program this is realized by a "Safety door" function (dual-channel with timeout) and an "Acceptance" function.

The logic signal "Safety door" is generated by means of input pre-processing with complementary inputs and timeout. The timeout for this element is fixed to 3 seconds.

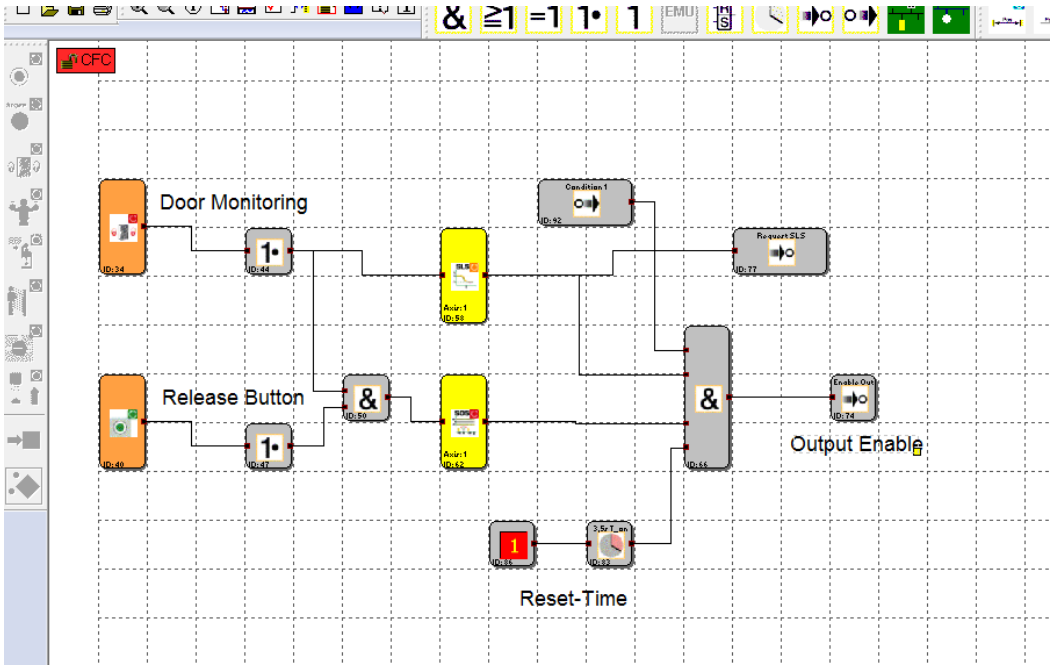
With the safety door open (signal "LOW" on switch output (ID 369)) the axis can be traversed with reduced speed, when the acceptance (ID 318) is active.

Problem definition:

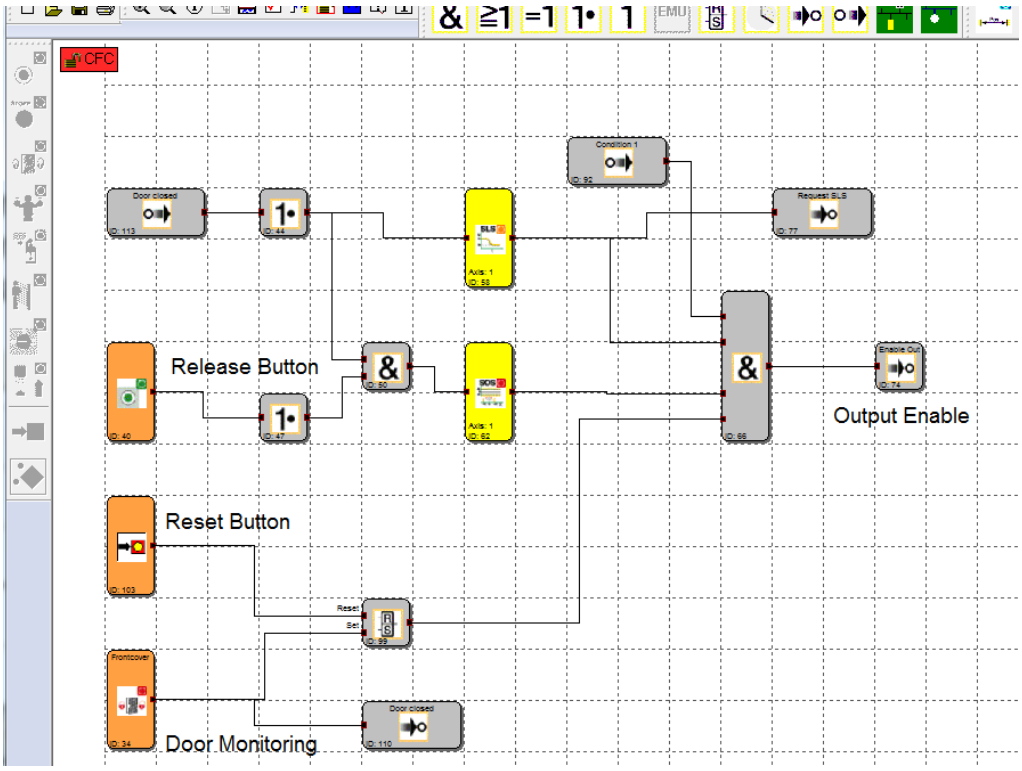
If a "Cross-shorting" fault is simulated on the safety door input, the module will show the alarm 6701.
This can be acknowledged and the "Safety door" signal (ID 369) will remain correctly at "0".
After the timeout of 3 seconds the alarm 6701 will be triggered again.
If the acceptance is actuated within this time, the axis can be traversed for another 3 seconds.

Applicative measure:

Logic operation within the PLC program prevents the activation of outputs by temporally bypassing of the alarm state.



Example 1: The enable function for outputs (ID 88) is additionally linked with a "Reset Timer". This prevents the activation of outputs after a reset for t > 3 seconds => the temporal monitoring is once again effective.



Example 2: The enable function for outputs (ID 88) is additionally linked with a FF (Flip-Flop). This prevents the activation of outputs after a reset and existing faults in the input circuit. The outputs will only be enabled after a one-time application of a error-free input signal.

9.4 Parameterization

Parameterization takes place via the program SafePlcGRP.
Single parameters can also be edited with the program SafePMT.

Parameterization is described in the *programming manual.*

9.5 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)

9.6 Validation

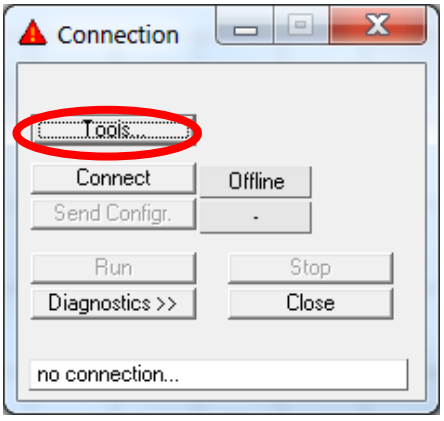
In order to assure the reliability of the implemented safety functions the user must check and document the parameters and links after the start-up and parameterization has taken place. This is supported by a validation assistant in the programming desktop (see chapter "Safety related examination").

9.6.1 Generation of the report

First one must make sure that the SDC has been equipped with a configuration and that the associated SafePLC configuration in SafePLC has been opened, because the data from SDC and SafePLC will be compared.

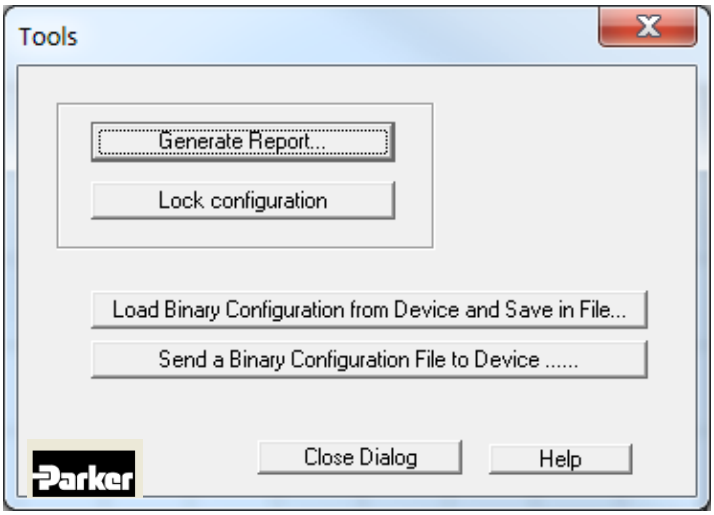
For the comparison of data a validation report must first be created. This report consists of a text file. which contains the CRC and program data.

The connection dialog must be open in SafePLC to be able to create this report. Then a connection to SDC must be set up via "**Connect**", because the data for the report are taken from the SDC-module. The display will then change from "offline" (grey) to "online" (green) and the symbol in the window bar changes from  to  .



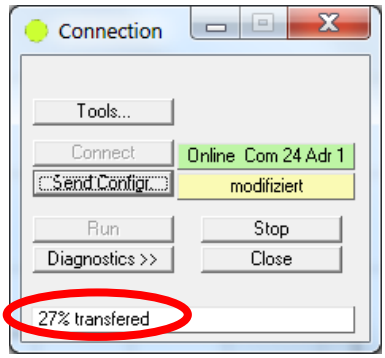
- With "**Tools…**" you open the validation dialog

The option "Create report..." is in this case needed to create the report – therefore please choose this option.

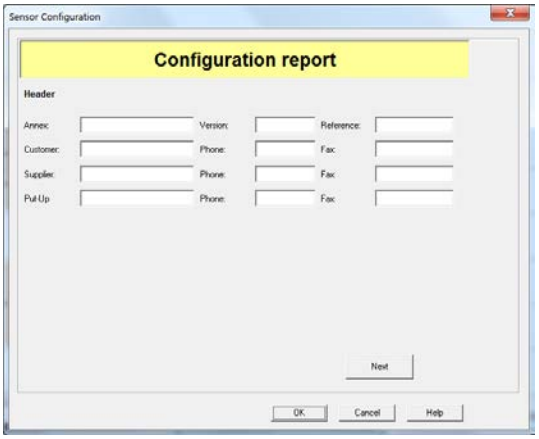


The following options are also available in this dialog:

- "**Lock configuration**" serves the purpose of closing the validation of the current configuration
- "**Read and save binary configuration from device…**" enables the reading and saving of the binary file from the SDC module for programming further modules with the same configuration.
- "**Transfer binary configuration to device…**" enables the programming of further modules with a saved configuration by using the binary file.
- "**Create report**" starts the **generation of the validation report**.
  The data transfer for the report from the module starts immediately. The status of this transfer is indicated in the connection dialog in %.

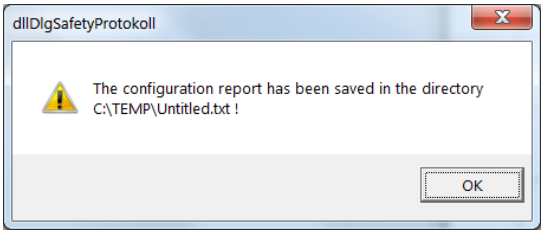


Once the configuration has been read in by the SDC module, a wizard will gather the required data for a head sheet from the user.
All parameters set by the logic diagram are automatically determined and entered into the report.



By clicking on "Continue" or "Back" one can manoeuvre through the wizard. On the last page the generation of the report is finalized and saved by clicking on the "Save" button.

Once the wizard has completed its work, the report is saved as a text file in the same directory as the project file.



By generating the report one has created the basis for validation and validation can be started.

9.6.2 Validation – adjustment of data

The report can be opened with any text editor, e.g. the Windows Notepad.

```
5 Inspection of System Functions

Position and Speed Monitoring

  Parameter sensor interface 1
 ------------------------------
  Type of measuring section                 : linear                        correct / incorrect
  unit                                      : mm/s                          correct / incorrect
  Monitoring of measuring section activated : yes                           correct / incorrect
  measured section                          : 10000 mm                      correct / incorrect
  Max. speed                                : 2000 mm/s                     correct / incorrect
  Deactivation Threshold Incremental        : 10 mm                         correct / incorrect
  Speed Deactivation Threshold              : 100 mm/s                      correct / incorrect
  Speed Filter                              :  off                          correct / incorrect
  Parameter Sensor 1
 --------------------
  Interface Type                            : Inkremental                   correct / incorrect
  Data Format                               : keines                        correct / incorrect
  Direction of Rotation                     : increasing                    correct / incorrect
  Voltage                                   : 24 V                          correct / incorrect
  SSI-Interface                             : keines                        correct / incorrect
  Datenbr.SSI                               : no                            correct / incorrect
  Resolution                                : 1024 Steps/1000mm             correct / incorrect
  Offset                                    : 0 Steps                       correct / incorrect
  Parameter Sensor 2
 --------------------
  Interface Type                            : Absolut                       correct / incorrect
  Data Format                               : SSI-Binär                     correct / incorrect
  Direction of Rotation                     : increasing                    correct / incorrect
  Voltage                                   : 24 V                          correct / incorrect
  SSI-Interface                             : Masterclock                   correct / incorrect
  Datenbr.SSI                               : 24                            correct / incorrect
  Resolution                                : 1024 Steps/1000mm             correct / incorrect
  Offset                                    : 0 Steps                       correct / incorrect
```

The opened report is a filled text file, which consists of several sections:

- **Header**
- **Equipment description**
- **Single verification of technical components**
- **Individual test of components and functions used**
- **System function monitoring**
- **Monitoring functions**
- **Function test PLC-part**

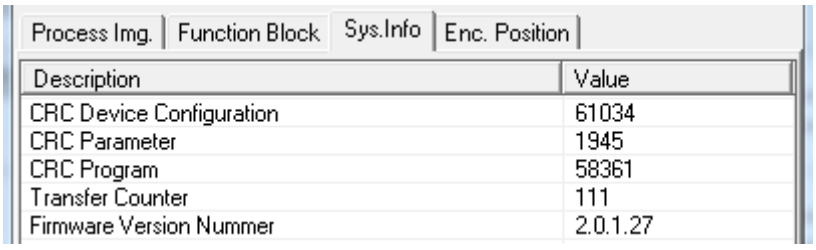
9.6.2.1 Entering and testing the CRCs

The sections "Header" and "Equipment description" provide the possibility to enter date, customer, project, inspector, signatures, contacts and equipment information.

In the section "Single verification of safety related components" one must enter device specific data, especially the checksums:

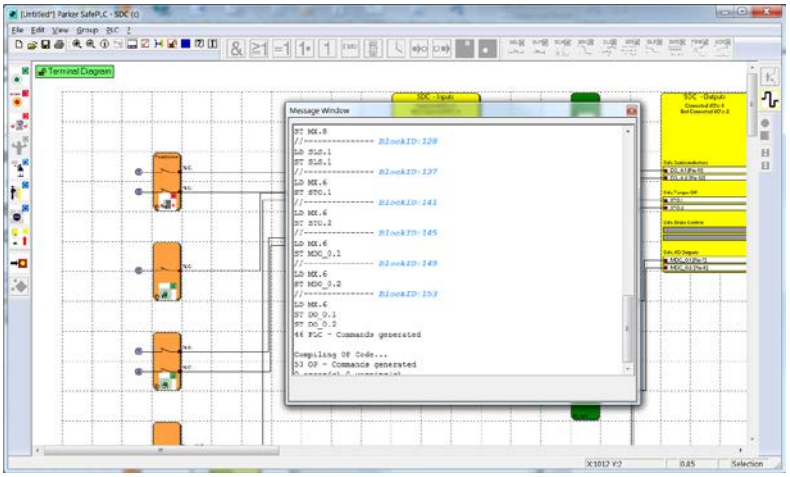
- Device type
- Serial number
- Overall CRC configuration
- CRC configuration data
- CRC program

These data must be adjusted against the data in the program, which are displayed in the "**Connection dialog"** of SafePLC under "Diagnose":



9.6.2.2 Comparison of PLC data

The PLC-table contains the program code of the configuration; this has been transferred to the module and must be identical with the original code. In order to obtain the original code, a configuration with the icon ☑ is compiled and the program code of the configuration is subsequently displayed – you may probably have to scroll up a bit.



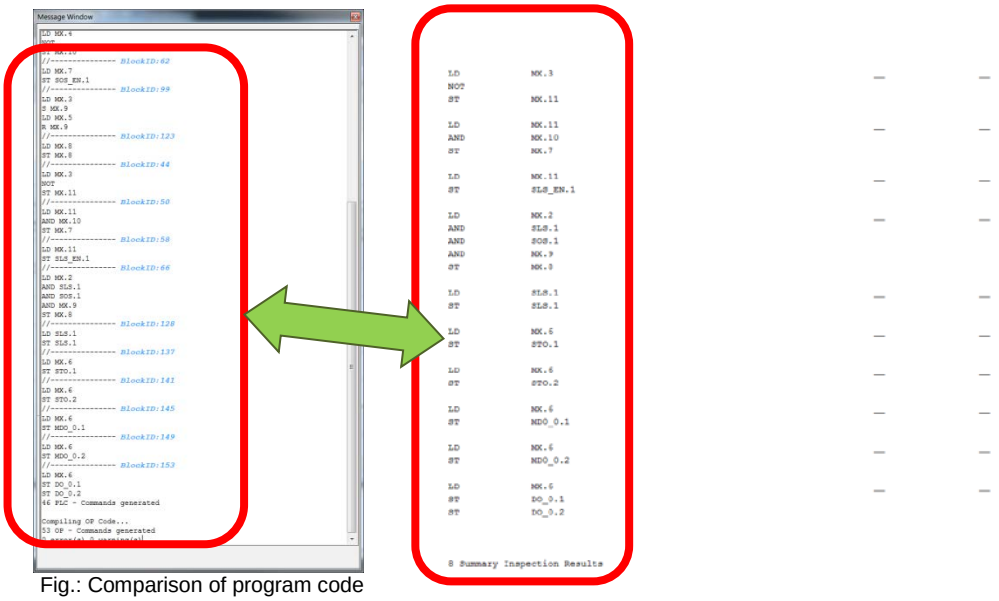


Fig.: Comparison of program code

When comparing the program code, all code lines must be identical – only this ensures that the configuration has been completely and correctly transferred.

9.6.2.3 Comparison of the configuration

In section "5 Checking the system functions" the inputs and outputs, the sensor configuration and all safety functions used are listed.

All these settings must be compared and marked accordingly.

Example: Encoder configuration

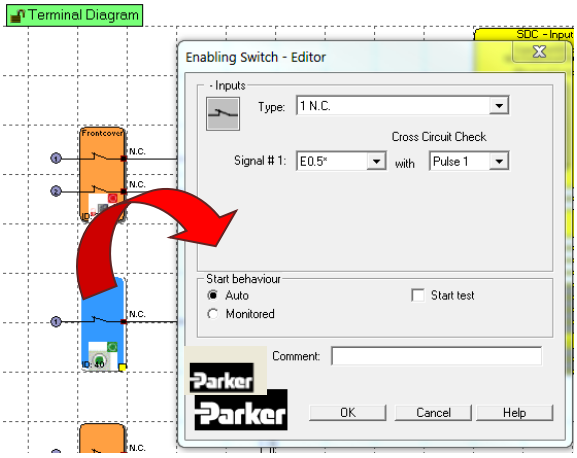
```
5 Inspection of System Functions

Position and Speed Monitoring


  Parameter sensor interface 1
 ------------------------------
  Type of measuring section                  : linear                        correct / incorrect
  unit                                       : mm/s                          correct / incorrect
  Monitoring of measuring section activated  : yes                           correct / incorrect
  measured section                           : 10000 mm                      correct / incorrect
  Max. speed                                 : 2000 mm/s                     correct / incorrect
  Deactivation Threshold Incremental         : 10 mm                         correct / incorrect
  Speed Deactivation Threshold               : 100 mm/s                      correct / incorrect
  Speed Filter                               :  off                          correct / incorrect
  Parameter Sensor 1
 --------------------
  Interface Type                             : Inkremental                   correct / incorrect
  Data Format                                : keines                        correct / incorrect
  Direction of Rotation                      : increasing                    correct / incorrect
  Voltage                                    : 24 V                          correct / incorrect
  SSI-Interface                              : keines                        correct / incorrect
  Datenbr.SSI                                : no                            correct / incorrect
  Resolution                                 : 1024 Steps/1000mm             correct / incorrect
  Offset                                     : 0 Steps                       correct / incorrect
  Parameter Sensor 2
 --------------------
  Interface Type                             : Absolut                       correct / incorrect
  Data Format                                : SSI-Binär                     correct / incorrect
  Direction of Rotation                      : increasing                    correct / incorrect
  Voltage                                    : 24 V                          correct / incorrect
  SSI-Interface                              : Masterclock                   correct / incorrect
  Datenbr.SSI                                : 24                            correct / incorrect
  Resolution                                 : 1024 Steps/1000mm             correct / incorrect
  Offset                                     : 0 Steps                       correct / incorrect
```

Example: SLS monitoring function

```
Function: Speed monitoring                              - Safe Limited Speed SLS 1

  [Basic Settings]
    Selected Axis                            : Axis 1                        correct / incorrect

    Speed tolerance
    ----------------
    Speed threshold                          : 2 mm/s                        correct / incorrect
    Use Fast Channel                         : no                            correct / incorrect

  [Extendes Settings]
    Overspeed Distance activated             : no                            correct / incorrect
    Overspeed Distance                       : 2 mm                          correct / incorrect

                                                                    OK         not applicable

                                                                    OK         not applicable

    > Thresholds are detected as expected                                 __    __

    > Monitoring functions react as expected                              __    __

    > Feedback to superordinated system as expected                       __    __

    > Action of assigned Cutoff Chanel completely tested                  __    __
```

The inputs and outputs contained in the section "Assignment of digital inputs" must also be adjusted against the terminal plan in SafePLC.

Here each output in the terminal plan must be listed in the table with its properties (cross-shorting test, reset alarm, EMU-monitoring, type)



Double clicking on any of the inputs or outputs displays the related attributes.

Mapping of digital inputs

Digital input	Pulse 1	Pulse 2	24 V	Reaction Time [ms]	within Safety Concept
SMF.11	X			500	__
SMF.21	X				__
E0.5	X				__
E0.6			X		__

Each input and output must be separately confirmed in the report by an entry in the column "acc. to safety concept".

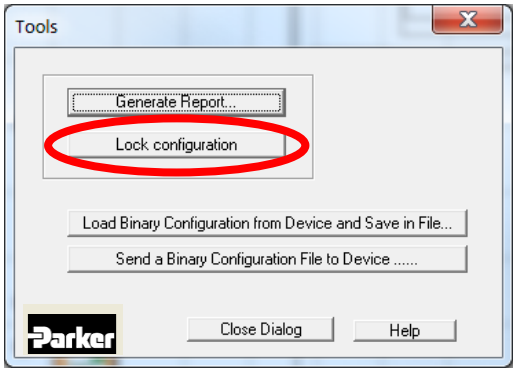
9.6.3 Documentation of validation

Documentation of the validation takes place by a note in the printout of the report and the entry of data as well as the signature.

⚠ Safety note:
This printout must be kept in a safe place!

Validation is completed by confirming the validation by clicking on the button "**Lock configuration**" in the validation dialog.

NOTE:
The wording "Lock" is historical and can in this case be taken for "Validation".

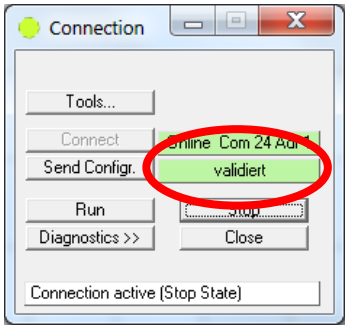


Click on button "**Lock configuration**" to validate the configuration.

You will subsequently be asked to confirm the validation.
After confirming with "Yes", the validation will be executed in the program SafePLC and in the SDC module.

This has the following effect:

The **Display** in the connection dialog of SafePLC changes from "**Modified**" to "**Valid**" – the background colour of this field changes to green.



10 Transverse communication

10.1 General

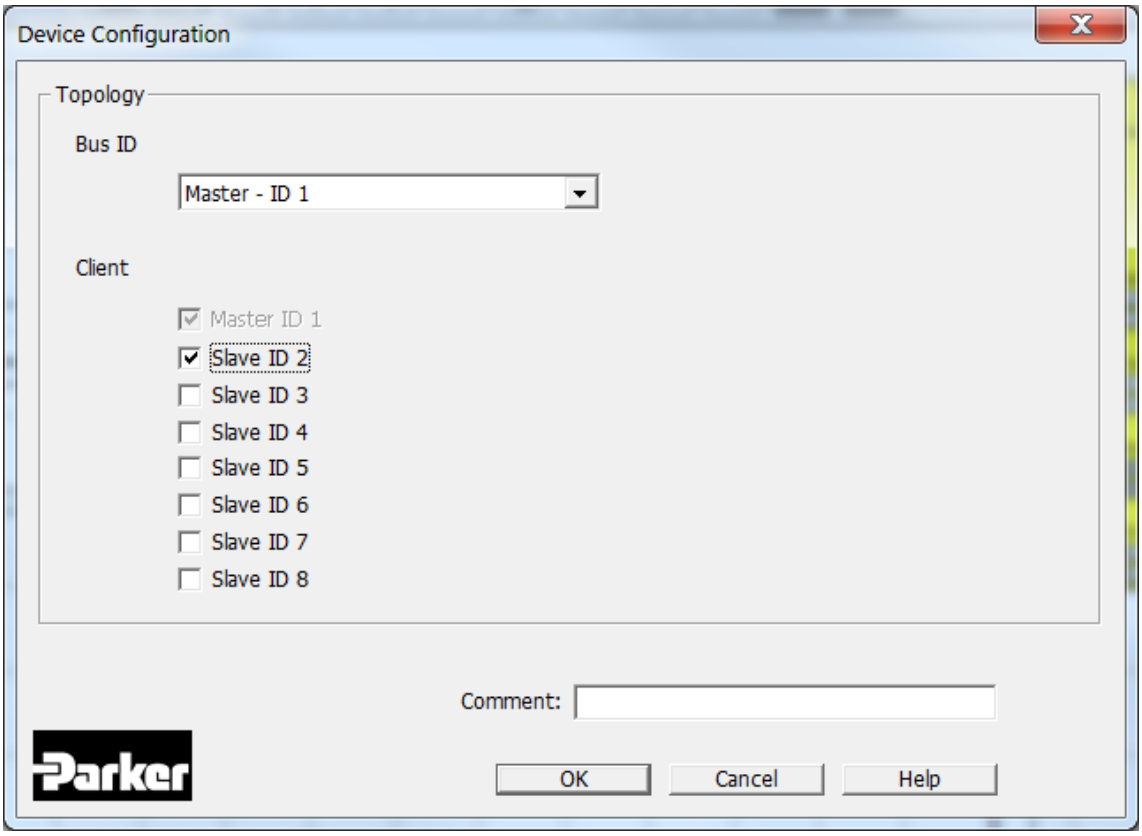
Up to 8 SDC modules can be combined with SDDC-CAN. This means that the user has the possibility to use any input data within a cluster of up to 8 axes.
The maximum permissible cable length in transverse communication is 2 m.

The SDC system bus consist of a Master, which always has the lowest address ("**MasterID-1**") and up to 7 Slave modules. The addresses are set via the SafePLC user interface, whereby each subscriber can choose an address for himself and then select further subscribers from a list box, whereby his address will no longer be available, so that the assignment of addresses is clearly defined. The user of the SafePLC user interface is **himself** responsible for the assignment of addresses.

10.2 Configuration of bus subscribers

The user can configure the individual bus subscribers via the user interface and subsequently use the extended inputs in SafePLC.

The following configuration dialog appears when the user double-clicks on the yellow main block "SDDC inputs" in the terminal plan.



Once the own DeviceID has been defined, the area below will become active.

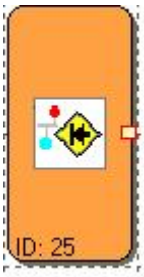
This has previously been deactivated. Now the user can assign up to 7 addresses to the current subscriber.

Note:
In order to be able to successfully complete the configuration, the configuration must always contain the address 0x1 (lowest address, corresponds with the Master address), for the selection to become valid. Otherwise a corresponding error message will appear.

10.3 Configuration of the extended inputs

The user can configure up to 4 grouped inputs (SMF1-SMF4) and 2 individual inputs (E.05 and E.06) per subscriber.
This results in a total of up to 7 * 6 = 42 (extended) available inputs. These are displayed in the process representation.

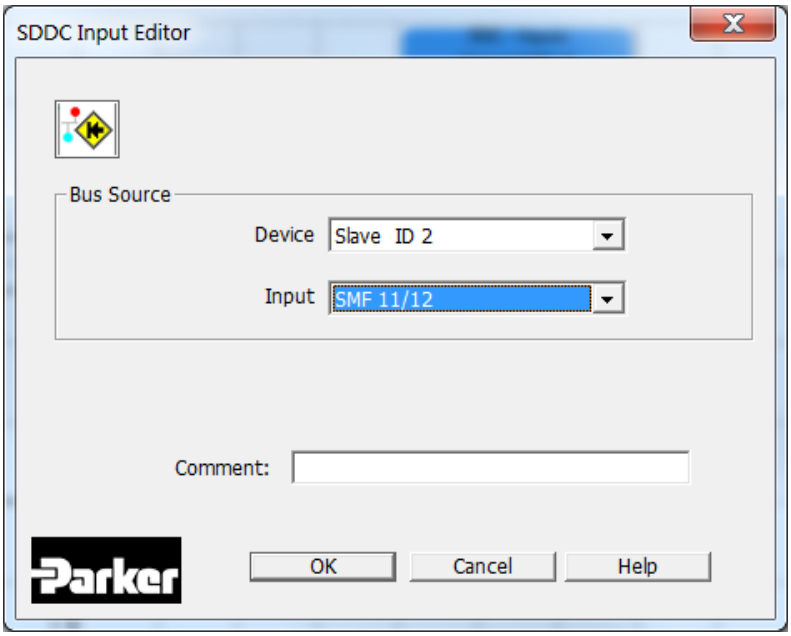
The symbol for the extended input = input connector is defined as follows:



Selection of the extended inputs

Each input to be used in a module must first be activated. This takes place in the periphery context by setting the input connector. After choosing and setting the corresponding symbol the following context menu will pop up:

Assigning the input to the corresponding module:



Here the user can first choose the bus subscriber and then the corresponding input (SMF1 to SMF4, E0.5, E0.6). This process must be repeated for each extension input used.

10.4 Utilization in the program

After their configuration the extended inputs are displayed in the left column and can then be included in the contact plan, just like the inputs on the own device.

10.5 Monitoring/dependability

All configured bus subscribers monitor themselves reciprocally in each cycle (8 msec).
The cycle time is 8 msec., the fault reaction time will therefore be max. 16 msec.
If the telegram of a subscriber does not arrive or is recognized as being faulty, all subscribers in the group will shut down.

Boundary conditions:
All subscribers must pass through the start-up phase together.
Outputs can only be activated after all subscribers have switched over to the run phase.
If a subscriber is switched off, all other subscribers will become inactive. After the restart of a single subscriber an acknowledgement must be made on the Master.

No CAN specific configurations, like e.g. a baud rate setting, are required for the bus. The baud rate is fixed to 1 MBit.

11 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 parameterizing software "SafePlcGRP"
(see programming manual: 'Validation report').

The first two pages can be used to enter general information to the system. 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 shown in the report, is identical with the CRC saved in the SDC module – this CRC is indicated in the programming interface.

Once all header data have been entered, the validation report can be generated by pressing the control button "Save". The parameterization software 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 SDC 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".

12 Maintenance

12.1 Modification / handling changes to the device

Repair
Repair work on the servo drive can only be performed in the factory.

Warranty
By opening the servo drive without permission the warranty will become null and void.

Note:
By modifying the servo drive the safety approval will become null and void!

12.2 Replacing a servo drive

The following should be noted when replacing a servo drive:

- Disconnect the servo drive 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.
- Pack up the servo drive EMC compatibly.
- Install the servo drive.
- Reconnect all connections.
- Switch on the servo drive.
- Switch on all supply voltages.
- Configure the device.
- Run a function test
- Run a CRC-comparison

Note:
Pluggable connections of the servo drive must generally not be disconnected or connected in live condition.

There is a danger of sensor damage, particularly with connected position or speed sensors.

12.3 Maintenance intervals

Replacement of servo drive	At the latest after 20 years
Function test	See chapter "Start-up"

13 Technical data

13.1 Environmental conditions

Class of protection	IP 52
Ambient temperature	0 °C ... 80 °C
Climatic category	3 K3 acc. to EN 60721-3
Lifetime	90000 h at 50 °C ambient

13.2 Safety related characteristic data

Max. obtainable safety class	• SIL 3 as per IEC 61508:2010 • Category 4 acc. to EN ISO 13849-1:2009 • Performance-Level e acc. to EN ISO 13849-1:2009
System structure	2-channel with diagnose (1002)
Rating of operating mode	"high demand" acc. to IEC 61508:2010 (high demand rate)
Probability of an endangering failure per hour (PFH-value)	see table 1
Proof test interval (IEC 61508:2010)	20 years, after this time the module must be replaced

14 Error types SDC

The SDC generally differentiates between two types of faults as per assignment below:

Fault type	Description	Effect on the system	Reset condition
Fatal Error	Severe exceptional fault caused by the program run in the SDC. Cyclic program sequence is no longer possible for safety related reasons. The last active process is the operation of the 7-segment display by system A.	All outputs are switched off!	Possibility to reset by switching the SDC(POR) off/on.
Alarm	Functional fault, caused by an external process. Both system continue to run cyclically and serve all requests from the communication interfaces. Sensing of the external process is also maintained.	All outputs are switched off!	Reset via parameterizable inPort
ECS-Alarm	When using the ECS function in the programming desktop, the encoder alarm messages are marked "E" instead of "A".	ECS function block delivers "0" as a result.	Reset via parameterizable inPort

Recognizing faults system, A and system B:

- System A: odd-numbered
- System B: even numbered

15 Alarm List SDC

Alarm code	A 3001 / A 3002
Alarm message	Internal fault – please contact the manufacturer!

Alarm code	A 3101
Alarm message	Pulse1 plausibility fault on input SMF11
Cause	Supply voltage does not comply with configured Pulse 1 voltage
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 3117
Alarm message	Pulse2 plausibility fault on input SMF11
Cause	Input voltage does not comply with the configured Pulse 2 voltage
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 3159
Alarm message	Faulty 24V signal on input SMF11
Cause	No permanent 24V voltage applied to this input
Remedy	Check the voltage on the digital input! Check wiring Check whether Pulse1 or Pulse2 is applied

Alarm code	A 3102
Alarm message	Pulse1 plausibility fault on input SMF 12
Cause	Supply voltage does not comply with configured Pulse 1 voltage
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 3118
Alarm message	Pulse2 plausibility fault on input SMF12
Cause	Input voltage does not comply with the configured Pulse 2 voltage
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 3160
Alarm message	Faulty 24V signal on input SMF12
Cause	No permanent 24V voltage applied to this input
Remedy	Check the voltage on the digital input! Check wiring Check whether Pulse1 or Pulse2 is applied

Alarm code	A 3103
Alarm message	Pulse1 plausibility fault on input SMF21
Cause	Supply voltage does not comply with configured Pulse 1 voltage
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 3119
Alarm message	Pulse2 plausibility fault on extension input SMF11
Cause	Input voltage does not comply with the configured Pulse 2 voltage
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 3161
Alarm message	Faulty 24V signal on digital input SMF21
Cause	No permanent 24V voltage applied to this input
Remedy	Check the voltage on the digital input! Check wiring Check whether Pulse1 or Pulse2 is applied

Alarm code	A 3104
Alarm message	Pulse1 plausibility fault on digital input SMF22
Cause	Supply voltage does not comply with configured Pulse 1 voltage
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 3120
Alarm message	Pulse2 plausibility fault on digital input SMF22
Cause	Input voltage does not comply with the configured Pulse 2 voltage
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 3162
Alarm message	Faulty 24V signal on digital input SMF22
Cause	No permanent 24V voltage applied to this input
Remedy	Check the voltage on the digital input! Check wiring Check whether Pulse1 or Pulse2 is applied

Alarm code	A 3105
Alarm message	Pulse1 plausibility fault on digital input SMF31
Cause	Supply voltage does not comply with configured Pulse 1 voltage
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 3121
Alarm message	Pulse2 plausibility fault on digital input SMF31
Cause	Input voltage does not comply with the configured Pulse 2 voltage
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 3163
Alarm message	Faulty 24V signal on digital input SMF31
Cause	No permanent 24V voltage applied to this input
Remedy	Check the voltage on the digital input! Check wiring Check whether Pulse1 or Pulse2 is applied

Alarm code	A 3106
Alarm message	Pulse1 plausibility fault on digital input SMF32
Cause	Supply voltage does not comply with configured Pulse 1 voltage
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 3122
Alarm message	Pulse2 plausibility fault on digital input SMF32
Cause	Input voltage does not comply with the configured Pulse 2 voltage
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 3164
Alarm message	Faulty 24V signal on digital input SMF32
Cause	Supply voltage does not comply with configured Pulse 1 voltage
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 3107
Alarm message	Pulse1 plausibility fault on digital input SMF41
Cause	Supply voltage does not comply with configured Pulse 1 voltage
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 3123
Alarm message	Pulse2 plausibility fault on digital input SMF41
Cause	Input voltage does not comply with the configured Pulse 2 voltage
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 3165
Alarm message	Faulty 24V signal on digital input SMF41
Cause	No permanent 24V voltage applied to this input
Remedy	Check the voltage on the digital input! Check wiring Check whether Pulse1 or Pulse2 is applied

Alarm code	A 3108
Alarm message	Pulse1 plausibility fault on digital input SMF42
Cause	Supply voltage does not comply with configured Pulse 1 voltage
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 3124
Alarm message	Pulse2 plausibility fault on digital input SMF42
Cause	Input voltage does not comply with the configured Pulse 2 voltage
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 3166
Alarm message	Faulty 24V signal on digital input SMF42
Cause	Supply voltage does not comply with configured Pulse 1 voltage
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 3109 / A 3110
Alarm message	Pulse1 plausibility fault on the digital input E0.5 (E0.6)
Cause	Input voltage does not comply with the configured Pulse 2 voltage
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 3125 / A 3126
Alarm message	Pulse2 plausibility fault on the digital input E0.5 (E0.6)
Cause	Input voltage does not comply with the configured Pulse 2 voltage
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 3167 / A 3168
Alarm message	Faulty 24V signal on digital input E0.5 (E0.6)
Cause	No permanent 24V voltage applied to this input
Remedy	Check the voltage on the digital input! Check wiring Check whether Pulse1 or Pulse2 is applied

Alarm code	A 3111 / A 3112
Alarm message	Pulse1 plausibility fault on the digital input E0.6 (E0.5)
Cause	Input voltage does not comply with the configured Pulse 2 voltage
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 3127 / A 3128
Alarm message	Pulse2 plausibility fault on the digital input E0.6 (E0.5)
Cause	Input voltage does not comply with the configured Pulse 2 voltage
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 3169 / A 3170
Alarm message	Faulty 24V signal on digital input E0.6 (E0.5)
Cause	No permanent 24V voltage applied to this input
Remedy	Check the voltage on the digital input! Check wiring Check whether Pulse1 or Pulse2 is applied

Alarm code	A 3191 / A 3192
Alarm message	Short circuit between digital inputs
Cause	Short circuit between the digital inputs within the module
Remedy	Contact the manufacturer

Alarm code	A 3197 / A 3198
Alarm message	Faulty test voltage (UZ (DI_TEST)
Cause	Test voltage UZ shows incorrect value
Remedy	Check the 24V input voltage on all OSSD inputs

Alarm code	A 3209 / A 3210
Fault message	Encoder supply voltage encoder 1 (X1.1/U_SENS_A) faulty
Cause	Encoder supply voltage does not comply with configured threshold. Component fault in module
Remedy	Check configuration. Check encoder supply voltage. Switch device off/on.

Alarm code	A 3213 / A 3214
Fault message	Encoder supply voltage encoder 2 (X1.1/U_SENS_B) faulty
Cause	Encoder supply voltage does not comply with configured threshold. Component fault in module
Remedy	Check configuration. Check encoder supply voltage Switch device off/on.

Alarm code	A 3229 / A 3230
Fault message	Plausibility test for encoder supply voltage faulty
Cause	Measuring value/encoder supply voltage
Remedy	Check encoder voltage supply Check wiring of encoder voltage supply

Alarm code	A 3237 / A 3238
Fault message	Internal fault – please contact the manufacturer!

Alarm code	A 3239 / A 3240
Fault message	Internal fault – please contact the manufacturer!

Alarm code	A 3301 / A 3302
Alarm message	Plausibility fault speed detection
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 Check the speed sensor

Alarm code	A 3303 / A 3304
Alarm message	Plausibility fault position detection
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 of the sensor setting. Check the position signal. Are all signals on the encoder plug correctly connected? Check the encoder plug for correct wiring

Alarm code	A 3307 / A 3308
Alarm message	Plausibility error faulty position range
Cause	The current position is outside the configured measuring length
Remedy	Check the theory of the distance using the configured data of the sensor setting. Check the position signal, if necessary correct the offset

Alarm code	A 3309 / A 3310
Alarm message	Plausibility error faulty speed
Cause	The current speed is outside the configured maximum speed
Remedy	The drive moves outside the permissible and configured speed range. Check configuration. Use the SCOPE function to analyse the course of speed

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

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

Alarm code	A 3317 / A 3318
Fault message	Incremental encoder not correct
Cause	Track A not in relation to track B
Remedy	Check encoder wiring Check encoder configuration

Alarm code	A 3321 / A 3322
Fault message	Plausibility fault: Speed detection
Cause	The speed difference between the two sensors is higher than the configured speed shut-down threshold.
Remedy	Check the theory of the configured shut-down threshold by comparing the data for the sensors. Check the encoder. Adjustment of the configuration (control for coverage by means of the SCOPE speed signal).

Alarm code	A 3323 / A 3324
Fault message	Plausibility fault: Position detection
Cause	The position difference between the two sensors is higher than the configured speed shut-down threshold.
Remedy	Check the theory of the configured shut-down threshold by comparing the data for the sensors. Check the encoder. Are all signals correctly connected to the 9-pole sensor plug connector? Check the correct wiring of the sensor plug connector. Have PROXI encoders been used: are they correctly connected? Adjustment of the position signals by using the SCOPE function for coverage.

Alarm code	A 3327 / A 3328
Fault message	Plausibility fault: Position range not correct
Cause	The current position is outside the configured measuring distance
Remedy	Check the theory of the measuring distance by comparing with the configured data in the sensor setting. Check the position signal, if necessary correct the offset. Read out the position by using the SCOPE function. Adjust the configured values with the associated resolution

Alarm code	A 3329 / A 3330
Fault message	Plausibility fault speed detection
Cause	The current speed is higher than the configured maximum speed
Remedy	The drive works outside the acceptable/configured speed range. Check configuration. Analyse the course of speed by using the SCOPE

Alarm code	A 3331 / A 3332
Alarm message	Acceleration outside the valid parameters
Cause	The current acceleration is outside the configured acceleration range
Remedy	Check the configured maximum speed Analyse the course of speed/acceleration by using the SCOPE

Alarm code	A 3333 / A 3334
Alarm message	Plausibility fault of SinCos encoder
Cause	Wrong encoder type connected
Remedy	Check encoder configuration Check encoder assignment

Alarm code	A 3337 / A 3338
Alarm message	Incremental encoder not correct
Cause	Track A not in correct ratio to track B
Remedy	Check encoder connection Check encoder wiring

Alarm code	A 3407 / A 3408
Alarm message	Difference level RS485 driver 1 fault INC_B or SSI_CLK faulty
Cause	No encoder connection Wrong encoder type connected
Remedy	Check encoder connection Check encoder wiring

Alarm code	A 3409 / A 3410
Alarm message	Difference level RS485 driver 2 fault INC_A or SSI_DATA faulty
Cause	No encoder connection Wrong encoder type connected
Remedy	Check encoder connection Check encoder wiring

Alarm code	A 3411 / A 3412
Fault message	Fault Sine/Cosine plausibility encoder 1
Cause	Plausibility monitoring of individual tracks faulty
Remedy	Check encoder wiring Amplitude/Sine- to Cosine- track must be linear

Alarm code	A 3413 / A 3414
Fault message	Fault Sine/Cosine plausibility encoder 2
Cause	Plausibility monitoring of individual tracks faulty
Remedy	Check encoder wiring Amplitude/Sine- to Cosine- track must be linear

Alarm code	A 3509 / A 3510
Fault message	Timeout SSI-Listener plausibility encoder
Cause	Plausibility monitoring of SSI-Listener faulty Wrong encoder connected SSI-cycle does not match the encoder configuration
Remedy	Check encoder wiring Check encoder configuration

Alarm code	A 4001 / A 4002
Alarm message	CCW and CW rotation monitoring SDI.1 activated at the same time
Cause	Multiple activation
Remedy	In programming make sure that only one "Enable" is activated at a time

Alarm code	A 4003 / A 4004
Alarm message	CCW and CW rotation monitoring SDI.2 activated at the same time
Cause	Multiple activation
Remedy	In programming make sure that only one "Enable" is activated at a time

Alarm code	A 4601 / A 4602
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

Alarm code	A 4603 / A 4604
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

Alarm code	A 4605 / A 4606
Alarm message	SLP1 Teach In status fault
Cause	SET and QUIT input have a faulty switching sequence
Remedy	Check the input configuration Check the switching sequence

Alarm code	A 4607 / A 4608
Alarm message	SLP2 Teach In status fault
Cause	SET and QUIT input have a faulty switching sequence
Remedy	Check the input configuration Check the switching sequence

Alarm code	A 4609 / A 4610
Alarm message	SLP1 Teach In position fault
Cause	Teach In position outside measuring range
Remedy	Check transfer position

Alarm code	A 4611 / A 4612
Alarm message	SLP2 Teach In position fault
Cause	Teach In position outside measuring range
Remedy	Check transfer position

Alarm code	A 4613 / A 4614
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 Check whether SOS has already triggered

Alarm code	A 4615 / A 4616
Alarm message	SLP2 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 Check whether SOS has already triggered

Alarm code	A 4901 / A 4902
Alarm message	CCW and CW rotation monitoring SLI.1 activated at the same time
Cause	Multiple activation
Remedy	In programming make sure that only one "Enable" is activated at a time

Alarm code	A 4903 / A 4904
Alarm message	CCW and CW rotation monitoring SLI.2 activated at the same time
Cause	Multiple activation
Remedy	In programming make sure that only one "Enable" is activated at a time

Alarm code	A 5001 / A 5002
Alarm message	Fault in shut-down test/digital inputs
Cause	Input stays active after deactivation
Remedy	Check input wiring

Alarm code	A 5003 / A 5004
Alarm message	Fault on grouped input SMF1
Cause	Plausibility test of grouped input failed
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 5005 / A 5006
Alarm message	Fault on grouped input SMF2
Cause	Plausibility test of grouped input failed
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 5007 / A 5008
Alarm message	Fault on grouped input SMF3
Cause	Plausibility test of grouped input failed
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 5009 / A 5010
Alarm message	Fault on grouped input SMF4
Cause	Plausibility test of grouped input failed
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 5011 / A 5012
Alarm message	Timeout fault/grouped inputs
Cause	Timeout when handling grouped inputs
Remedy	Check the wiring of the digital inputs Check the configuratiohn of the digital inputs

Alarm code	A 5013
Alarm message	Plausibility fault on individual input SMF11
Cause	Plausibility test of individual input failed
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 5014
Alarm message	Plausibility fault on individual input SMF12
Cause	Plausibility test of individual input failed
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 5015
Alarm message	Plausibility fault on individual input SMF21
Cause	Plausibility test of individual input failed
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 5016
Alarm message	Plausibility fault on individual input SMF22
Cause	Plausibility test of individual input failed
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 5017
Alarm message	Plausibility fault on individual input SMF31
Cause	Plausibility test of individual input failed
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 5018
Alarm message	Plausibility fault on individual input SMF32
Cause	Plausibility test of individual input failed
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 5019
Alarm message	Plausibility fault on individual input SMF41
Cause	Plausibility test of individual input failed
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 5020
Alarm message	Plausibility fault on individual input SMF42
Cause	Plausibility test of individual input failed
Remedy	Check the configuration of the digital input acc. to planning and circuit diagram. Check wiring

Alarm code	A 6701 / A 6702
Alarm message	Timeout fault MET
Cause	Fault in time monitoring/input processing
Troubleshooting	Check the input wiring Check the time parameters in the configuration Defective input (hardware)

Alarm code	A 6703 / A 6704
Alarm message	Timeout fault MET
Cause	Fault in time monitoring/two-hand operation
Troubleshooting	Check the input wiring Defective input (hardware)

Alarm Code	A 7401
Fehler Meldung	Master in alarm status. For slaves in alarm.
Ursache	STOP/RUN request
Fehlerbeseitigung	BUS-Restart through Reset

Alarm code	A 9101 / A 9102
Alarm message	SDDC signature fault
Cause	Configuration fault bus communication
Remedy	Switch device off/on

16 Fatal Error Liste SDC

Fatal Error Code	F 1001
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.

Fatal Error Code	F 1003
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.

Fatal Error Code	F 1007
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.

Fatal Error Code	F 1307 / F1308
Fault message	Fault when deleting configuration data from the Flash Memory
Cause	
Remedy	Send configuration again

Fatal Error Code	F 1311 / F1312
Fault message	Flash Blank Check Error
Cause	
Remedy	Send configuration again

Fatal Error Code	F 1314
Fault message	Flash Offset Error
Cause	
Remedy	Send configuration again

Fatal Error Code	F 1330
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 1401 / F 1402
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 1403 / F 1404
Fault message	CRC of configuration data invalid!
Cause	Configuration data were incorrectly transferred
Remedy	Transfer the configuration data again

Fatal Error Code	F 1406
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 1407 / F 1408
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 1501 / F 1502
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 1503 / F 1504
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 1505 / F 1506
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 1601 / F 1602
Fault message	Range test of device description is faulty

Fatal Error Code	F 1603 / F 1604
Fault message	Range test of Access Data faulty

Fatal Error Code	F 1605 / F 1606
Fault message	Range test of EMU faulty

Fatal Error Code	F 1607 / F 1608
Fault message	Range test of PSC faulty

Fatal Error Code	F 1609 / F 1610
Fault message	Range test SS1, SS2 faulty

Fatal Error Code	F 1611 / F 1612
Fault message	Range test SPLA faulty

Fatal Error Code	F 1613 / F 1614
Fault message	Range test OLC faulty

Fatal Error Code	F 1615 / F 1616
Fault message	Range test SOS faulty

Fatal Error Code	F 1617 / F 1618
Fault message	Range test SLS/SLA faulty

Fatal Error Code	F 1619 / F 1620
Fault message	Range test SDI faulty

Fatal Error Code	F 1621 / F 1622
Fault message	Range test SLI faulty

Fatal Error Code	F 1623 / F 1624
Fault message	Range test of PLC faulty

Fatal Error Code	F 1625 / F 1626
Fault message	Range test of shut-down channel faulty

Fatal Error Code	F 1627 / F 1628
Fault message	Range test of outputs faulty

Fatal Error Code	F 1629 / F 1630
Fault message	Range test of digital inputs faulty

Fatal Error Code	F 1633 / F 1634
Fault message	Range test of encoder type faulty

Fatal Error Code	F 1635 / F 1636
Fault message	Range test of encoder processing faulty

Fatal Error Code	F 1637 / F 1638
Fault message	Range test of encoder position faulty

Fatal Error Code	F 1639 / F 1640
Fault message	Range test of PDM faulty

Fatal Error Code	F 1641 / F 1642
Error message	Range test of adder faulty

Fatal Error Code	F 1645 / F 1646
Fault message	Range test of diagnose faulty

Fatal Error Code	F 1649 / F 1650
Fault message	Range test of PLC timer faulty

Fatal Error Code	F 1651 / F 1652
Fault message	Range test of system faulty

Fatal Error Code	F 1653 / F 1654
Fault message	Range test of reference table faulty

Fatal Error Code	F 1655 / F 1656
Fault message	Range test SCA faulty

Fatal Error Code	F 1657 / F 1658
Fault message	Range test of diagnose faulty

Fatal Error Code	F 2001 / F 2002
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 2003 / F 2004
Fault message	Timeout when transmitting configuration and firmware data

Fatal Error Code	F 2005
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 2007
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 2009
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 2011
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 2013 / F 2014
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 3001 / F 3002
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 3201 / F 3202
Fault message	5V0PA outside defined range
Cause	Supply voltage for module not correct! Component fault in module
Remedy	Check device supply voltage! Switch device off/on.

Fatal Error Code	F 3203
Fault message	Supply voltage 24V module faulty
Cause	Supply voltage for module not correct! Component fault in module
Remedy	Check device supply voltage! Switch device off/on.

Fatal Error Code	F 3204
Fault message	Internal supply voltage 6.0V faulty
Cause	Supply voltage for module not correct! Component fault in module
Remedy	Check device supply voltage! Switch device off/on.

Fatal Error Code	F 3205
Fault message	Plausibility fault differential voltage encoder 1
Cause	Encoder defective Component fault in module
Remedy	Encoder or device exchange Switch device off/on

Fatal Error Code	F 3206
Fault message	Plausibility fault differential voltage encoder 1
Cause	Encoder defective Component fault in module
Remedy	Encoder or device exchange Switch device off/on

Fatal Error Code	F 3207
Fault message	Plausibility fault differential voltage encoder 2
Cause	Encoder defective Component fault in module
Remedy	Encoder or device exchange Switch device off/on

Fatal Error Code	F 3208
Fault message	Plausibility fault differential voltage encoder 2
Cause	Encoder defective Component fault in module
Remedy	Encoder or device exchange Switch device off/on

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

Fatal Error Code	F 3219
Fault message	Internal supply voltage 12V0 faulty
Cause	Supply voltage for module not correct! Component fault in module
Remedy	Check device supply voltage! Switch device off/on.

Fatal Error Code	F 3237 / F 3238
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 3239 / F 3240
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 3306
Alarm message	Plausibility fault position switching
Cause	During position switching SOS, SLI or SDI is permanently activated.
Remedy	Check activation of SOS Check activation of SLI Activation of SDI (only for monitoring via position)

Fatal Error Code	F 3316
Fault message	Fault encoder alignment
Cause	Incorrect position triggering by system A
Remedy	Check encoder configuration Switch device off/on.

Fatal Error Code	F 3602
Fault message	Faulty switching of output STO.1 (static test)
Cause	Switching state of output faulty
Remedy	Exchange device because the internal safety function is not longer functioning

Fatal Error Code	F 3603
Fault message	Faulty switching of output STO.2 (static test)
Cause	Switching state of output faulty
Remedy	Exchange device because the internal safety function is not longer functioning

Fatal Error Code	F 3604
Fault message	Faulty testing of output STO.1 (static test)
Cause	Switching state of output faulty
Remedy	Exchange device because the internal safety function is not longer functioning

Fatal Error Code	F 3605
Fault message	Faulty testing of output STO.2 (static test)
Cause	Switching state of output faulty
Remedy	Exchange device because the internal safety function is not longer functioning

Fatal Error Code	F 3606
Fault message	Faulty switching of output SBC.1 (static test)
Cause	Output for state of operation is defect, wiring is defect
Remedy	Remove defect wiring, then switch device off/on

Fatal Error Code	F 3608
Fault message	Faulty switching of output SBC.2 (static test)
Cause	Output for state of operation is defect, wiring is defect
Remedy	Remove defect wiring, then switch device off/on

Fatal Error Code	F 3610
Fault message	Faulty switching of output DO_0.1 (static test)
Cause	Output for state of operation is defect, wiring is defect
Remedy	Remove defect wiring, then switch device off/on

Fatal Error Code	F 3612
Fault message	Faulty switching of output DO_0.1 (static test)
Cause	Output for state of operation is defect, wiring is defect
Remedy	Remove defect wiring, then switch device off/on

Fatal Error Code	F 3614
Fault message	Faulty static test of input/output MDO-0.2 (static test)
Cause	Output for state of operation is defect, wiring is defect
Remedy	Remove defect wiring, then switch device off/on

Fatal Error Code	F 3616
Fault message	Faulty testing of input/output MDO.1q (static test)
Cause	Output for state of operation is defect, wiring is defect
Remedy	Remove defect wiring, then switch device off/on

Fatal Error Code	F 3617
Fault message	Faulty testing of MainSwitch (static test)
Cause	Switching state of MainSwitch faulty
Remedy	Switch device off/on

Fatal Error Code	F 3618
Fault message	Faulty switching of output STO1 (dynamic test)
Cause	Switching state of output faulty
Remedy	Exchange device because the internal safety function is not longer functioning

Fatal Error Code	F 3619
Fault message	Faulty switching of output STO2 (dynamic test)
Cause	Switching state of output faulty
Remedy	Exchange device because the internal safety function is not longer functioning

Fatal Error Code	F 3620
Fault message	Faulty switching of output SBC1 (dynamic test)
Cause	Output for state of operation is defect, wiring is defect
Remedy	Remove defect wiring, then switch device off/on

Fatal Error Code	F 3622
Fault message	Faulty switching of output SBC2 (dynamic test)
Cause	Output for state of operation is defect, wiring is defect
Remedy	Remove defect wiring, then switch device off/on

Fatal Error Code	F 3624
Fault message	Faulty switching of output DO_0.1 (dynamic test)
Cause	Output for state of operation is defect, wiring is defect
Remedy	Remove defect wiring, then switch device off/on

Fatal Error Code	F 3626
Fault message	Faulty switching of output DO_0.2 (dynamic test)
Cause	Output for state of operation is defect, wiring is defect
Remedy	Remove defect wiring, then switch device off/on

Fatal Error Code	F 3628
Fault message	Faulty switching of input/output MDO_0.1 (dynamic test)
Cause	Output for state of operation is defect, wiring is defect
Remedy	Remove defect wiring, then switch device off/on

Fatal Error Code	F 3630
Fault message	Faulty switching of input/output MDO_0.2 (dynamic test)
Cause	Output for state of operation is defect, wiring is defect
Remedy	Remove defect wiring, then switch device off/on

Fatal Error Code	F 3631
Fault message	Faulty testing of MainSwitch (static test)
Cause	Switching state of output faulty
Remedy	Switch device off/on

Fatal Error Code	F 3633
Fault message	Faulty testing of upper limit of the VCC supply voltage (dynamic test)
Cause	Supply voltage faulty
Remedy	Check supply voltage

Fatal Error Code	F 3634
Fault message	Faulty testing of lower limit of the VCC supply voltage (dynamic test)
Cause	Supply voltage faulty
Remedy	Check supply voltage

Fatal Error Code	F 3701 / F 3702
Alarm message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 4501 / F 4502
Fault message	Faulty calculation of SSX deceleration ramp
Cause	Incorrect configuration
Remedy	Check configuration Consult the manufacturer

Fatal Error Code	F 6801 / F 6802
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 6803 / F 6804
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 6805 / F 6806
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 6807 / F 6808
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 6809 / F 6810
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 6811 / F 6812
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 6813 / F 6814
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 8205 / F 8206
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 8207 / F 8208
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 8213 / F 8214
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 8220
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 8221 / F 8222
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 8223 / F 8224
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 8225
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 8227
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 8228
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 9001 / F 9002
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 9007 / F 9008
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 9009 / F 9010
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 9011 / F 9012
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 9013 / F 9014
Fault message	Internal fault – please contact the manufacturer!

Fatal Error Code	F 9015 / F 9016
Fault message	Internal fault – please contact the manufacturer!

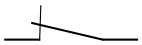
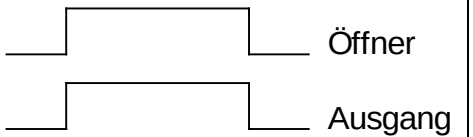
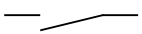
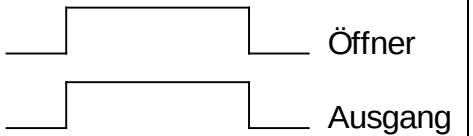
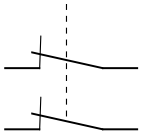
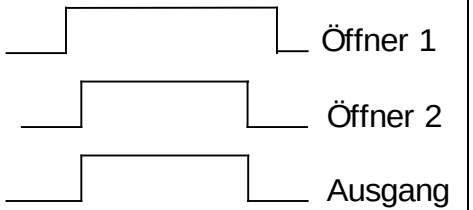
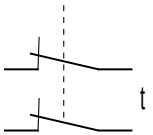
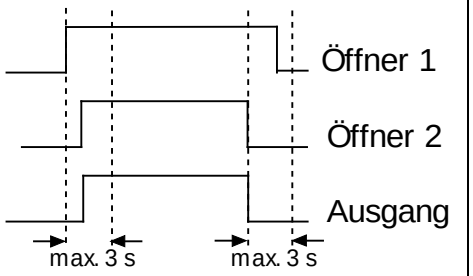
Fatal Error Code	F 9017 / F 9018
Fault message	Internal fault – please contact the manufacturer!

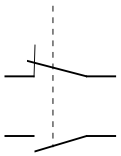
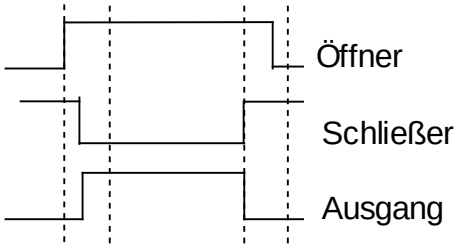
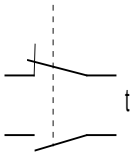
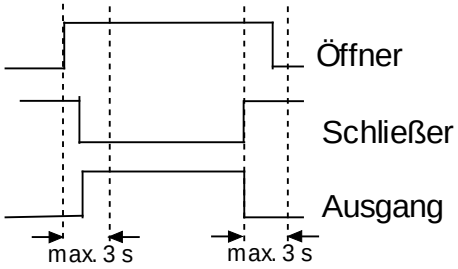
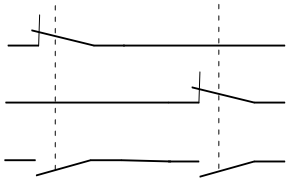
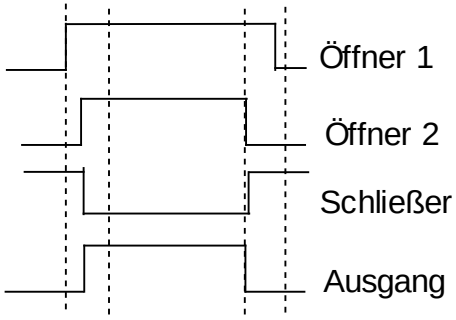
Fatal Error Code	F 9103 / F 9104
Fault message	SDDC network fault
Cause	Checking the received message failed!
Remedy	Check network configuration Consult the manufacturer

Fatal Error Code	F 9105 / F 9106
Fault message	Internal fault – please contact the manufacturer!

Should a fault occur, that is not listed in the list of error codes, please consult the manufacturer!

17 Switch types

Type	Graphic symbols	Truth table	Function block	Function	
1	 eSwitch_1o	Ö | A 0 | 0 1 | 1		Normally open, only shown normally closed	
2	 sSwitch_1s	S | A 0 | 0 1 | 1		Normally open, as type 1	
3	 eSwitch_2o	Ö1 | Ö2 | A 0 | 0 | 0 1 | 0 | 0 0 | 1 | 0 1 | 1 | 1		AND operation of both inputs	
4	 eSwitch_2oT	Ö1 | Ö2 | A 0 | 0 | 0 1 | 0 | 0 0 | 1 | 0 1 | 1 | 1	Time monitoring MET1..MET4	Like 3, but with time monitoring of state changes. In case of signal changes at S or Ö a complementary signal must follow within a period of t=3 s. If not, detect fault and A=0	

<table>
<tr><th>Type</th><th>Graphic symbols</th><th>Truth table</th><th></th><th>Function</th><th></th></tr>
<tr><td>5</td><td> 
eSwitch_1s1o</td><td><table><tr><td>S</td><td>Ö</td><td>A</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>1</td></tr><tr><td>1</td><td>1</td><td>0</td></tr></table></td><td></td><td>Monitoring for S=inactive and Ö=active</td><td>  </td></tr>
<tr><td>6</td><td> 
eSwitch_1s1oT</td><td><table><tr><td>S</td><td>Ö</td><td>A</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>1</td></tr><tr><td>1</td><td>1</td><td>0</td></tr></table></td><td>Time monitoring MET1..MET4</td><td>Like 5, but with time monitoring of state changes.
In case of signal changes at S or Ö a complementary signal must follow within a period of t=3 s. If not, detect fault and A=0</td><td>  </td></tr>
<tr><td>7</td><td> 
eSwitch_2s2o</td><td><table><tr><td>S1</td><td>Ö 1</td><td>S2</td><td>Ö2</td><td>A</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></table></td><td></td><td>Monitoring for S1*S2=inactive and Ö1*Ö2=active</td><td>  </td></tr>
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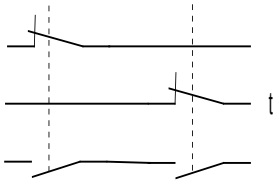
<td> 

eSwitch_2s2oT</td>
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<table>
<tr><th>S1</th><th>Ö 1</th><th>S2</th><th>Ö2</th><th>A</th></tr>
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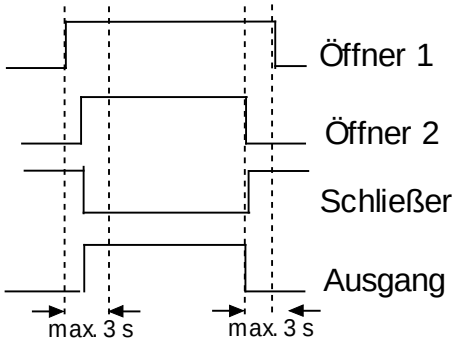
<tr><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td></tr>
</table>
</td>
<td>Time monitoring MET1..MET4</td>
<td>Like 6, but with time monitoring of state changes.
In case of signal changes at S (Attention: Bus line) or Ö a complementary signal must follow within a period of t=3 s. If not, detect fault and A=0</td>
<td> 
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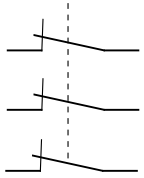
<td> 
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<tr><th>Ö1</th><th>Ö2</th><th>Ö3</th><th>A</th></tr>
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<tr><td>1</td><td>1</td><td>1</td><td>1</td></tr>
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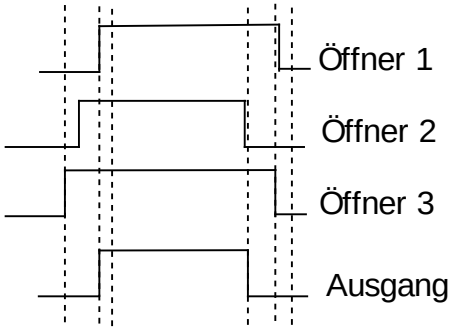
</td>
<td></td>
<td>AND operation of both inputs</td>
<td> 
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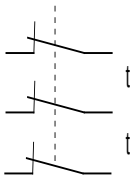
<td> 

eSwitch_3oT</td>
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<tr><th>Ö1</th><th>Ö2</th><th>Ö3</th><th>A</th></tr>
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<tr><td>1</td><td>0</td><td>0</td><td>0</td></tr>
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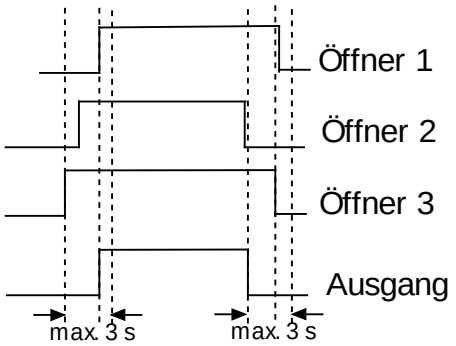
<tr><td>1</td><td>1</td><td>1</td><td>1</td></tr>
</table>
</td>
<td>Time monitoring
MET1..MET4</td>
<td>Like 8, but with time monitoring of state changes.
In case of signal change on one of the Ö-inputs the other inputs must follow within a period of t=3 s. If not, detect fault and A=0</td>
<td> 
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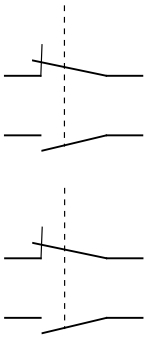
<td> 
eTwoHand_2o</td>
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<table>
<tr><th>Ö1</th><th>S1</th><th>Ö2</th><th>S2</th><th>A</th></tr>
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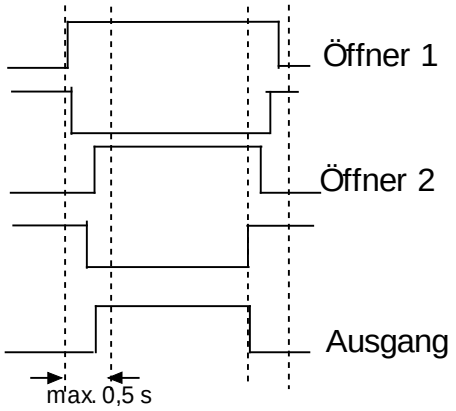
</td>
<td>Two-hand operation
MEZ</td>
<td>Monitoring for S1*S2=inactive and Ö1*Ö2=active + temporal monitoring of this status. This means that in case of a signal change of an S from 1->0 or Ö from 0->1, the other signals (i.e. further S=0 or Ö=1) must follow within a period of 0.5 s. If not, the output = 0.
No interference evaluation! No temporal monitoring when changing to inactive state.</td>
<td> 
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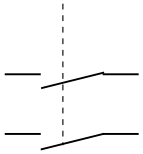
<td> 
eTwoHand_2s</td>
<td>
<table>
<tr><th>S1</th><th>S2</th><th>A</th></tr>
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<tr><td>0</td><td>1</td><td>0</td></tr>
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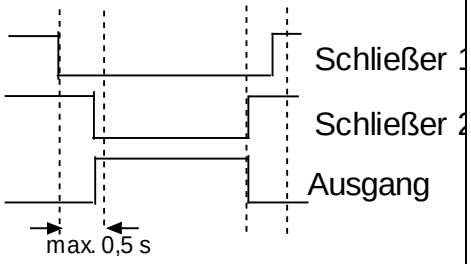
</table>
</td>
<td>Two-hand operation
MEZ</td>
<td>Monitoring for S1*S2=inactive + temporal monitoring of this status. This means that in case of a signal change of one S from 1->0 the other signal (i.e. another S=0) must follow within a period of 0.5 s. If not, the output = 0.
No interference evaluation! No temporal monitoring when changing to inactive state.</td>
<td> 
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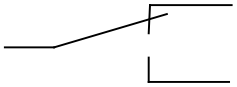
<td> 
eMode_1s1o</td>
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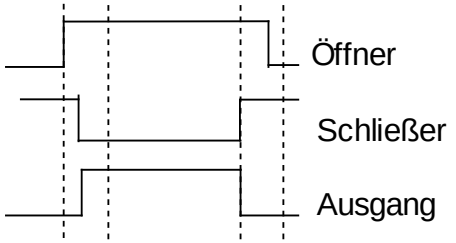
<td>Clear linkage of permissible switch positions</td>
<td> 
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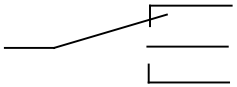
<td> 
eMode_3switch</td>
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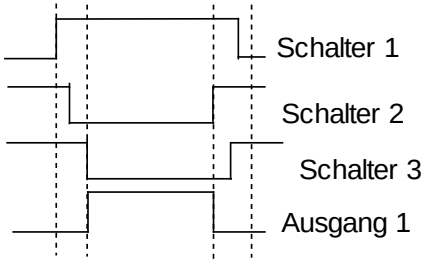
<td> 
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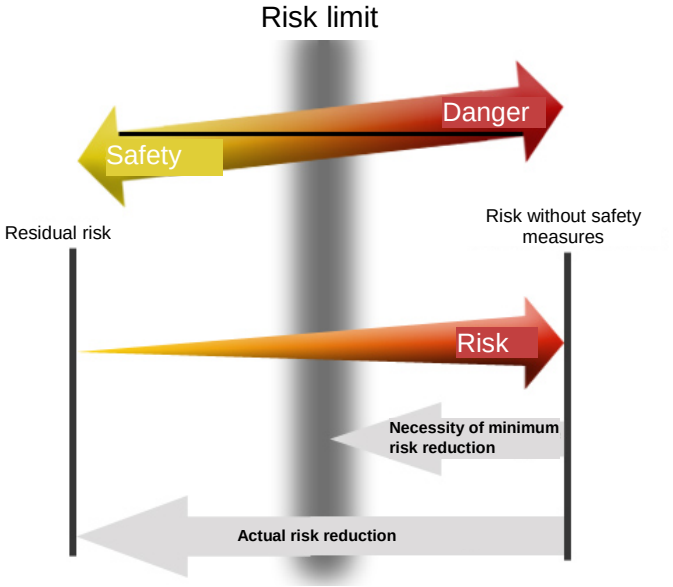
Öffner = Normally closed 2; Ausgang = Output; Schließer = Normally open; Schalter = Switch

18 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.

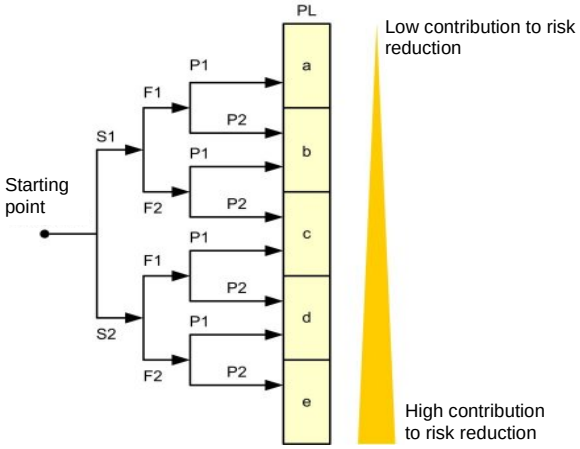
18.1 Risk assessment

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 13849-1:2009 Safety of machines
IEC 61508:2010 Functional safety of safety related e/e/p e systems
.

Risk assessment acc. to EN ISO 13849-1:2009

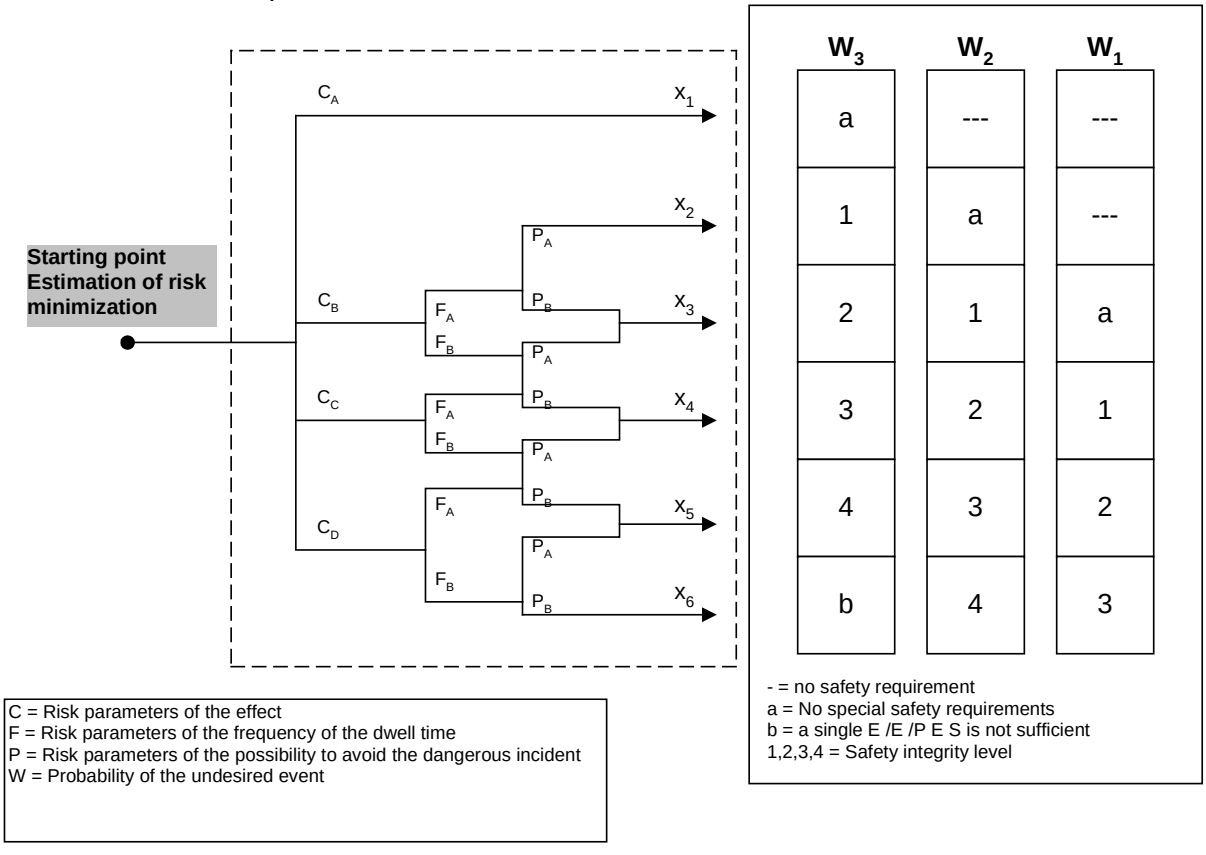


S – Severe physical injury
S1 = minor, reversible injury
S2 = severe, irreversible injury

F – Frequency and/or duration of exposure to danger
F1= rarely, not cyclic
F2 = frequently up to permanent and/or long duration, cyclic operation

P – Possibility to avoid the danger
P1 = possible, slow movement / acceleration
P2 = hardly possible, high acceleration in case of a fault

Risk assessment as per EN ISO 61508:2010



C = Risk parameters of the effect
F = Risk parameters of the frequency of the dwell time
P = Risk parameters of the possibility to avoid the dangerous incident
W = Probability of the undesired event

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 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.

18.2 Required technical documents

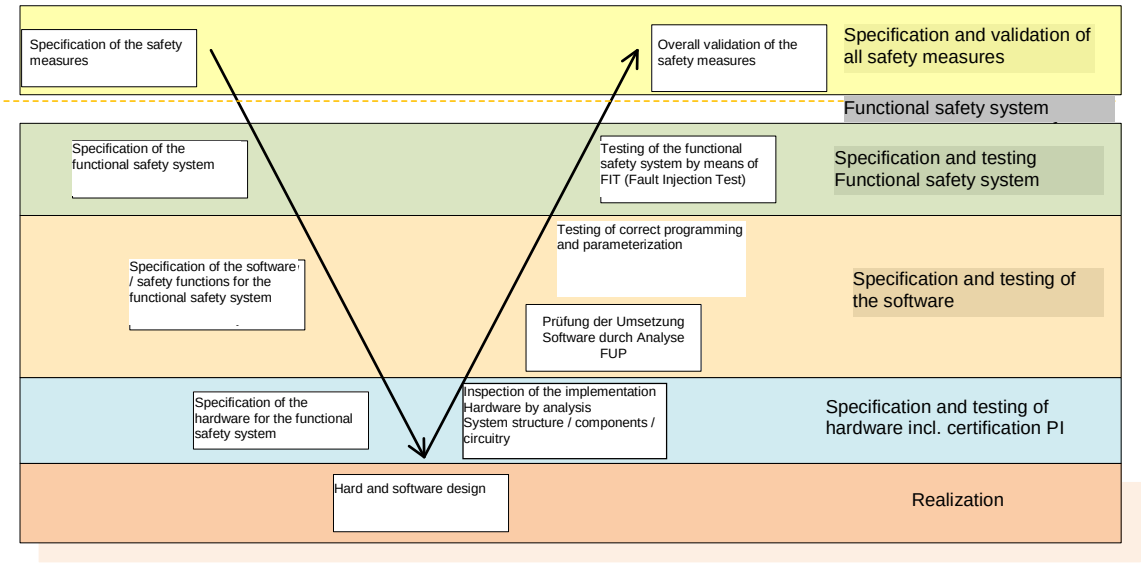
The manufacturer is obliged to supply various technical documents. The minimum extent is also contained in the applicable regulations and standards.
The EU machine directive, for example, requires the delivery of the following documents:

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.

18.3 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 EN ISO 13849-2:2008 or IEC 61508:2010) 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 SDC series offers safety relevant control and monitoring functions to support the system architecture (architecture Cat. 4 acc. to EN ISO 13849-1:2009) 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 SDC series.



Phases of the V-model

Designation	Description Design phase	Validation phase
Specification and validation of all passive and active safety measures	Specification of all 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. Specification of the PL r 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. Definition of parameters for individual safety functions, such as e.g. max. speed, stop ramps and - categories, etc.	Testing of correct implementation of specified functions by analysis FUP programming Validation of application programs and parameters by comparing the validation report with FUP or 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 PL 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. Actual implementation of safety functions by programming in FUP	Nil

18.3.1 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_r)**
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 13849-1:2009

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: In the work area there must be sufficient space for workers so that they can perform all work on the cabin... In the return flow there must be sufficient space for empty suspensions of the automatic machine.
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:

Safety proof for declaration of manufacturer			Machine type Packaging plant Customer	Order-Number 200-402 Created: Michael Duessel Oct. 16. 2005 Page 1 of 4					
Operating status	Endangered by		Result or protection objective	Solution	Start Cl.	St. Cat.	Standards and directives used	Notes/criteria for commissioning and testing	tested
	Short description	Check							on / by
			Linear units						
Automatic and manual mode	Pinching Getting caught Being pulled in		Protection against pinching, getting caught and being pulled in required for: - Linear movement in direction X - Linear movement in direction Y	Protective covering 2 m high, with spot welded grid MW 40 mm Safety door with safety door switch			EN 292-2 sect. 3.2 EN 294 sect. 4.5.1	Protective covering present? Tightly bolted to the machine? ES-function tested -Machine must stop immediately when the door is opened	
			Tensioning cylinder / sword						
Automatic and manual mode	Pinching Punching		Protection against pinching and punching required for: - pneumatic linear movement	Protective covering 2 m high, with spot welded grid MW 40 mm			EN 292-2 sect. 3.2 EN 294 sect. 4.5.1	Protective covering present? Tightly bolted to the machine?	
			Centring with pressing plate						
Automatic and manual mode	Crushing Getting caught Being pulled in		Protection against pinching, getting caught and being pulled in required for: - pneumatic slewing movement	Protective covering 2 m high, with spot welded grid MW 40 mm Safety door with safety door switch			EN 292-2 sect. 3.2 EN 294 sect. 4.5.1	Protective covering present? Tightly bolted to the machine? ES-function tested -Machine must stop immediately when the door is opened	
			Closing rollers						
Automatic and manual mode	Crushing Getting caught Being pulled in		Protection against pinching, getting caught and being pulled in required for: - pneumatic linear movement	Protective covering 2 m high, with spot welded grid MW 40 mm Protective covering made of sheet metal or perforated sheet metal. Gaps and hole size < 8 mm			EN 292-2 sect. 3.2 EN 294 sect. 4.5.1	Protective covering present? Protective covering present? Tightly bolted to the machine?	

18.3.2 Specification of the functional safety system

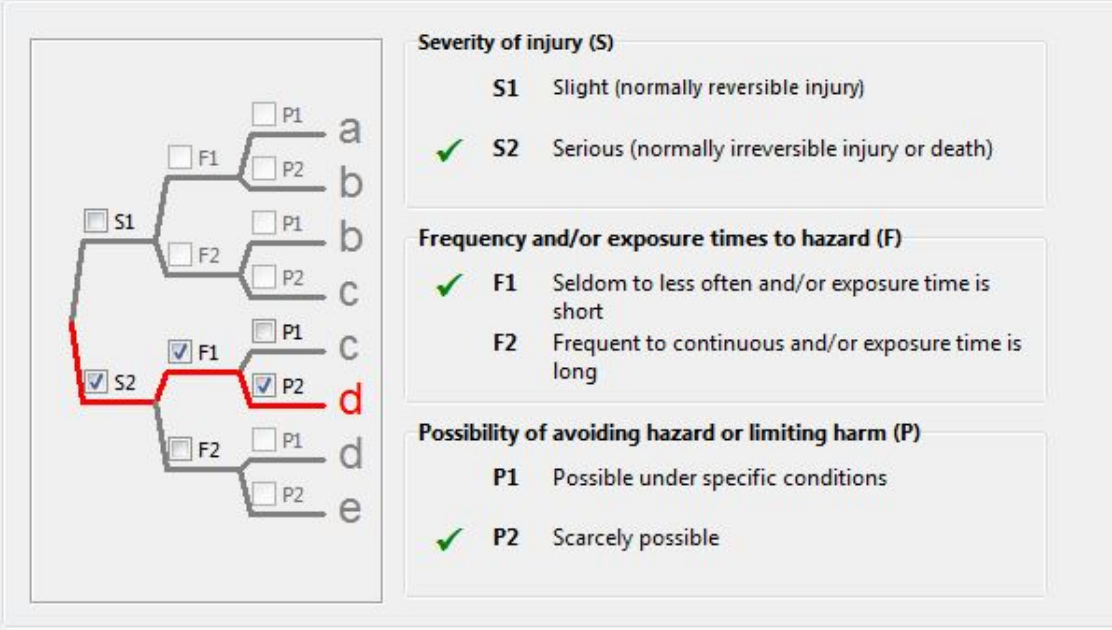
Derived from the general danger and risk analysis for the machine, the active safety functions must be identified and specified.
Active safety functions are, e.g. securely reduced speed under certain system conditions, monitored stop and standstill functions, area monitoring facilities, processing of 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.

18.3.2.1 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 the control units
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.:……

18.3.2.2 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 PF = d (source Sistema)

18.3.2.3 Example – Specification of safety functions in form of a table

Ser.-No.	Safety function	Ref from GFA	PL_r	Measuring value /sensor	Implementation of software	Nominal Parameters	Input/ Activation	Response/ Output
1.1	Limitation of max. travel speed to limitation of the maximum speed	2.3	e	1 x WCS absolute encoder 1 x Incremental encoder on motor / drive wheel	Monitoring by means of tested safety function SLS for fixed limits	550mm/s Fault distance monitoring 200mm	Permanently Reset: Acknowledgement button	Operation stop SF 1.7.1
1.2	Limitation of max. travel speed in working area of workers Monitoring of the maximum speed to < 0.33 m/s	2.4	e	1 x WCS absolute encoder 1 x Incremental encoder on motor / drive wheel	Monitoring by means of tested safety function SLS for fixed limits	60 mm/s Fault distance monitoring 200mm	Identification of worker's work area via position of carriage AND NOT Setup Reset: Acknowledgement button	SF 1.7.1
1.3	Limitation of max. travel speed in setup operation Monitoring of the maximum speed to < 0.07 m/s	3.1	d	1 x WCS absolute encoder 1 x Incremental encoder on motor / drive wheel	Monitoring by means of tested safety function SLS for fixed limits	70mm/s Fault distance monitoring 200mm	Operating mode Setup AND button "Bridge safety" Reset: Acknowledgement button	SF 1.7.1
1.4	Collision protection of carriage 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. 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 Reset: Acknowledgement button	SF 1.7.1
1.6.1	Monitoring of carriage sensor system Muting management of the two carriage sensors	5.1	e	1 x WCS absolute encoder 1 x Incremental encoder on motor / drive wheel	Muting of diagnoses for both carriage sensors by means of tested SCA function 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) Pos 2 (11030-1263) Pos 3 (75134-5338) Pos 4 (145562-145622) Pos 5 (143935-143995) Pos 6 (80000-80060)	SF 1.6.2

18.3.3 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 18.3.2.3).
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.

Example of software specification

Ser.-No.	Safety function	Plr	Measuring value /sensor	Solution new	Input/activation	Response/output
1.4	Monitoring V_Rope to V_Nominal Monitoring of differences between speed of main drive and rope drive for maximum value	d	Digital incremental encoder, 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 Shut-down dual-channel new (see below)	Permanently Reset: Acknowledgement button	Operation stop SF 1.3.1
1.6	Backstop Monitoring for reversing	d	Mechanical limit switch 22S2 Digital incremental encoder	Monitoring by means of tested function direction monitoring SDI	EMERGENCY (auxiliary contact 28K4 – reversing) Reset: Acknowledgement button	Operation stop SF 1.3.1
1.15	Step-by-step shut-down 3 Activation of the safety brake	e	-	Processing of SF in Safe PLC	SF 1.2 SF 1.3.2 SF 1.7 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 OR Set service brake	SF 1.15/ Set safety brake
1.9	direction monitoring	e	Digital incremental encoder	Monitoring by means of tested function direction monitoring SDI	28K1 = FORW. 28K2 = BACK = safe signals from control	Operation stop SF 1.3.1

18.3.4 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.

18.3.4.1 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 = 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 the SRP/CS participating in the safety function must generally be performed in accordance with the schematic Sensor / PES / Actuator.

18.3.4.2 Example for hardware specification

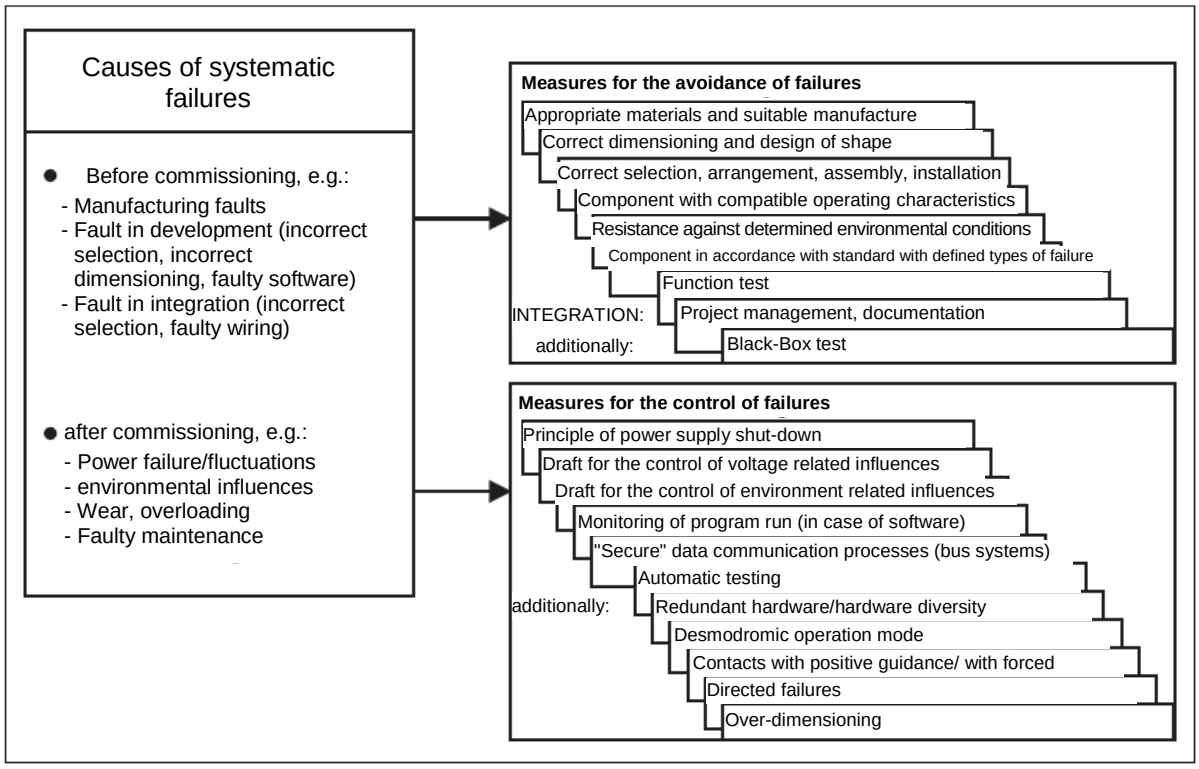
Safety function		Securely reduced speed	SF 2.2	Securely monitored limited speed with door open							
Type	Designation	Function	Design ation	Characteristic data							Note
				Architec ture	MTTFD [Years]	PFH [1/h]	B10d	Source	DC [%]	Source	
Sensor	Sensor 1	Door lock – Monitoring of the access door	A 3.1	4			100000	Data sheet	99	Inst. manual op. SDC	
	Sensor 2.1	Incremental encoder – Motor feedback SIN/COS	G 1.1	4	45			Gen. specificati on	99	Inst. manual op. SDC	Cat. 4 in connection with selection SDC
PES	SDC	Safety module of the Parker servo drive	A 4.1			1.19 E-9		SDC data sheet			
Actuator	STO	Safe Torque Off on Parker servo drive	A 5.1	4	140			Servo drive data sheet	90	Inst. manual op. SDC+ Servo drive	Cat. 4 in connection with SDC

18.3.4.3 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 a 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 13849-9:2008



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 13849-1:2009)
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-circuit in cables and lines, as well as routing of cables in cable ducts – especially for use in elevator technology acc. to EN81.

18.3.5 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

18.3.6 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 13849-1:2009).

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.

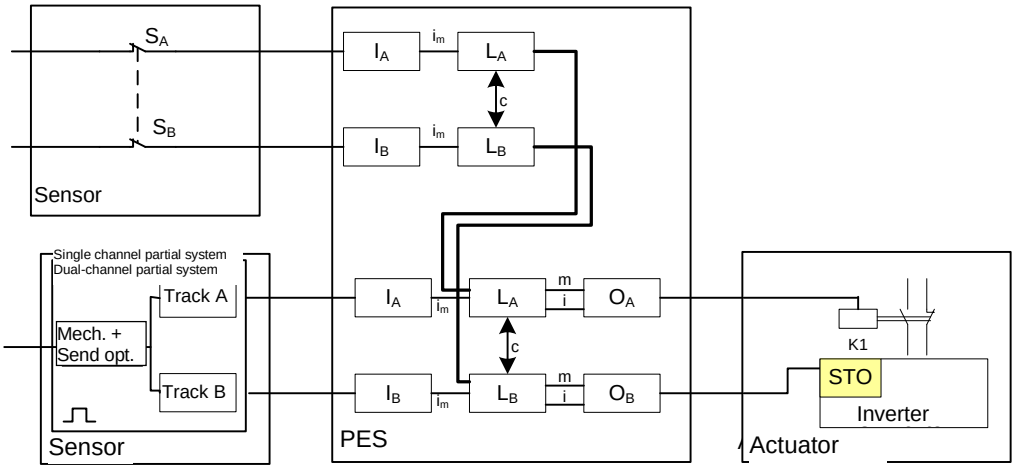
18.3.6.1 Iterative testing of the achieved safety level

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.

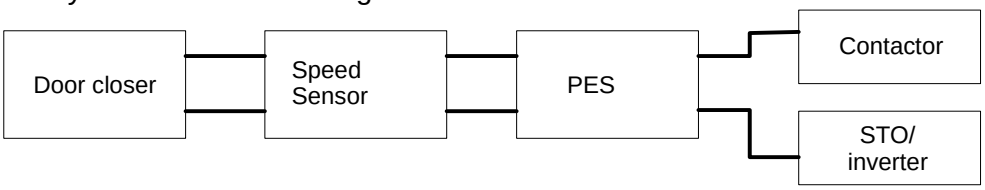
A calculation acc. to EN ISO 13849-1:2009 shall serve as an example:

Safety function:
Securely reduced speed with access door open

Structural diagram:



Safety related structural diagram:



Calculation acc. to EN 13849:2009-1
Channel A – shut-down via STO:

Component	MTTFD [years]	DC
Door closer	B10d = 100000 Nop = 30/AT = 10000/year(309 AT/year)	DCSwitch = 99%
SIN/COS-Encoder	MTTFD_SinCos = 100 years	DCEncoder = 90%
PES	PFH = 1,9 * 10^{-9}	DCPES = 99%
STO	MTTFD_STO = 140 years	DCSTO = 99%

$$\text{MTTFD} = \frac{\text{B10d}}{0{,}1 * \text{Nop}} = 100\ \text{Jahre}$$

$$\text{MTTFD} = \frac{1}{8760 * \text{MTTFD}} = 60 * 10^3\ \text{Jahre}$$

$$\text{MTTFD\_A} = \frac{1}{\frac{1}{\text{MTTFD\_Türz}} + \frac{1}{\text{MTTFD\_SinCos}} + \frac{1}{\text{MTTFD\_PES}} + \frac{1}{\text{MTTFD\_STO}}} = 36\ \text{years}$$

Channel B – shut-down via STO/servo drive:

Component	MTTFD [years]	DC
Door closer	B10d = 100000 Nop = 30/AT = 10000/year(309 AT/year)	DCSwitch = 99%
SIN/COS-Encoder	MTTFD_SinCos = 100 Jahre	DCEncoder = 90%
PES	PFH = 1,9 * 10^{-9}	DCPES = 99%
STO/ Servo-antriebs	MTTFD_STO = 140 years	DCSTO = 99%

$$\text{MTTFD} = \frac{\text{B10d}}{0{,}1 * \text{Nop}} = 100 \text{ years}$$

$$\text{MTTFD} = \frac{1}{8760 * \text{ MTTFD}} = 60 * 10^3 \text{ Jahre}$$

$$\text{MTTFD\_B} = \frac{1}{\frac{1}{\text{MTTFD\_Türz}} + \frac{1}{\text{MTTFD\_SinCos}} + \frac{1}{\text{MTTFD\_PES}} + \frac{1}{\text{MTTFD\_STO}}} = 36 \text{ years}$$

Note:
The values for $MTTF_D$ and DC used in the example above are only exemplary. The actually used data may vary considerably for a specific application and are available from the manufacturer on request ($MTTF_D$) or can be taken from this manual based on the technology and architecture (DC) used.

Resulting PL for both channels:

Symmeterization of both channels:	$$MTTFD = \frac{2}{3}\left[MTTFD\_A + MTTFD\_B - \frac{1}{\frac{1}{MTTFD\_A} + \frac{1}{MTTFD\_B}}\right] = 36{,}8 \text{ years}$$
DC mean value	$$DC = \frac{\frac{DCSwitch}{MTTFD\_Türz} + \frac{DCSinCos}{MTTFD\_SinCos} + \frac{DCPES}{MTTFD\_PES} + \frac{DCSTO}{MTTFD\_STO}}{\frac{1}{MTTFD\_Türz} + \frac{1}{MTTFD\_SinCos} + \frac{1}{MTTFD\_PES} + \frac{1}{MTTFD\_STO}} = 95{,}6\%$$
PL	MTTFD = 36.8 years = average DC avg = 95.6 % = average Category > 3 PL =“d” (from EN ISO 13849-1:2009, tables 5, 6 and 7) In this case the B10d value of the door monitoring feature is decisive for PL. If an even higher safety level is to be reached a second encoder is to be used.

Note:
The PL can also be determined with the program tool "Sistema" from BGIA.

18.3.7 Verification software (program) and parameters

Verification takes place in two steps.

- Checking the FUP with respect to the specified functionality.
- Checking the FUP against the AWL-listing of the validation report, or the default parameters against the one listed in the validation report.

The creation of a report and the performance of a validation is described in detail in chapter 9.3.

18.3.8 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			
	Activate setup operation Travel with maximally allowed speed	- Diagnose of the actual speed versus the SLS limit - Manipulation of the setup speed beyond the permitted reduced speed	
2 Test SSX for Stop-category 2			
	Travel with max. speed Actuate the emergency stop	- Diagnose of the SSX-ramp against the actual deceleration ramp - Setting an impermissible weak deceleration - Moving the axis after standstill is reached by manipulating the drive	
3 Test of the dual-channel door monitoring			
	Select operating mode for setup operation	Diagnose of inactive monitoring with door closed (using diagnostics function FUP) Diagnose of active monitoring with door open (using diagnostics function FUP) Disconnecting one channel and opening the door Generate cross-shorting between both inputs	

Appendix

Appendix A – Classification of switch types

General note:

The achievable Performance Level (acc. to EN ISO 13849-1) or SIL CL (acc. to EN IEC 62061) on machines or SIL (IEC 61508 / IEC 61511) in process technology depends on the use, wiring and type of sensors/controls. In this case the possible faults and fault types of a sensor/control must be examined. This must probably be examined by means of a detailed FMEA in the application. The most suitable wiring must be used in order to be able to create appropriate diagnostic measures. In addition one must, in dual or multi-channel structures, apply measures against the failure caused by an event , which could adversely affect all channels.

Note:
The standards EN ISO 13849-2, EN IEC 62061, IEC 61508 and IEC 61511 contain information about possible faults / fault types, recommended measures for avoidance as well as for the avoidance of common-cause faults and fault exclusions, which may be permissible under certain conditions.

Sensors / controls with 2 contacts can be assigned to the digital inputs SMF11/SMF12 to SMX41/SMF42 always in pairs, whereby they are of category-4 architecture.

Single-channel sensors / controls with safety function can be connected to the inputs DI6 or DI7 or parallel to the inputs SMF11/SMF12 to SMX41/SMF42. This results in a safety structure with max. category-3 architecture (depending on the wiring) for the external sensor /control.

Detailed notes on architecture, wiring and diagnostic measures / diagnostic coverage can be found in chapter 4.2.1 "Safety related characteristic data and wiring of the input elements".

For sensors / controls the following prerequisites must be fulfilled, depending on the safety level to be achieved:

- Measure M1: Use of pulse detection on sensor, examination of sensor failure type+
- Measure M2: Ensuring sufficiently protected cables = fault exclusion cross-shorting / short circuit (see also information in the previously mentioned standards concerning the permission of this fault exclusion
- Measure M3: Cyclic test of sensor / control for function by actuation or similar methods.
  The testing rate of the sensor should be considerably higher than the one demanded for the safety function.
  Recommended magnitude of testing frequency compared with the actual request: 100 to 1.
  You may alternatively use positively opening sensors with exclusion of cross-shorting.
- Measure M4: Measures against failure caused by a (common) cause (CCF)
- Measure 5: FMEA with respect to a possible fault of the specific sensor in the application.

The following sensors (connected sensors) achieve the following safety related classification:
The classification acc. to SIL also refers to a SIL CL acc. to EN IEC 6201´61 or a SIL acc. to IEC 61511.

Enable switch

Switch type	Comment	Classification PL	Classification SIL	Prerequisites/limitations
1 normally closed	Enable switch standard	PL d	SIL 2	M1 or M2, M4, M5
1 normally open	Enable switch standard	PL d	SIL 2	M1 or M2, M4, M5
2 normally closed	Enable switch higher requirements	PL e PL d	SIL 3 SIL 2	M1 or M2, M4 without M1 or M2 only PL d / SIL 2
2 normally closed time monitored	Enable switch monitored	PL e PL d	SIL 3 SIL 2	M1 or M2, M4 without M1 or M2 only PL d / SIL 2

Emergency Stop

Switch type	Comment	Classification PL	Classification SIL	Prerequisites/limitations
1 normally closed	Emergency stop single	PL d [1)]	SIL 2	M1, M5, M3
2 normally closed	Emergency stop higher requirements	PL e PL d	SIL 3 SIL 2	M1 or M2, M4 without M1 or M2 only PL d / SIL 2
2 normally closed time monitored	Emergency stop monitored	PL e PL d	SIL 3 SIL 2	M1 or M2, M4 without M1 or M2 only PL d / SIL 2

[1)] Fault exclusions and boundary conditions acc. to EN 13849-2:2008 must be observed!

Door monitoring

Switch type	Comment	Classification PL	Classification SIL	Prerequisites/limitations
2 normally closed	Door monitoring higher requirements	PL e PL d	SIL 3 SIL 2	M1 or M2, M4 without M1 or M2 only PL d / SIL 2
2 normally closed time monitored	Door monitoring monitored	PL e PL d	SIL 3 SIL 2	M1 or M2, M4 without M1 or M2 only PL d / SIL 2
1 normally open + 1 normally closed	Door monitoring higher requirements	PL e PL d	SIL 3 SIL 2	M1 or M2, M4 without M1 or M2 only PL d / SIL 2
1 normally open + 1 normally closed time monitored	Door monitoring monitored	PL e PL d	SIL 3 SIL 2	M1 or M2, M4 without M1 or M2 only PL d / SIL 2
2 normally open + 2 normally closed	Door monitoring higher requirements	PL e	SIL 3	M1, M4
2 normally open + 2 normally closed time monitored	Door monitoring monitored	PL e	SIL 3	M1, M4
3 normally closed	Door monitoring higher requirements	PL e	SIL 3	M1, M4
3 normally closed time monitored	Door monitoring monitored	PL e	SIL 3	M1, M4

Two-hand button

Switch type	Comment	Classification PL	Classification SIL	Prerequisites/limitations
2 two-way switch	Two-hand button higher requirements	Type III C PL e	SIL3	M1, M4
2 normally open	Two-hand button monitored	Type III A PL e	SIL3	M1, M4

Note: With these inPort elements a fixed pulse assignment takes place, which cannot be influenced by the user!

Light curtain

Switch type	Comment	Classification PL	Classification SIL	Prerequisites/limitations
2 normally closed	Light curtain higher requirements	PL e	SIL 3	M1, M4
2 normally closed time monitored	Light curtain monitored	PL e	SIL 3	M1, M4
1 normally open + 1 normally closed	Light curtain higher requirements	PL e	SIL 3	M1, M4
1 normally open + 1 normally closed time monitored	Light curtain monitored	PL e	SIL 3	M1, M4

Mode selector switch

Switch type	Comment	Classification PL	Classification SIL	Prerequisites/limitations
2 positions	Mode selector switch monitored	PL e	SIL 3	M4, M5
3 positions	Mode selector switch monitored	PL e	SIL 3	M4, M5

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 PL	Classification SIL	Prerequisites/limitations
1 normally closed	Sensor input standard	PL d	SIL 2	M1 or M2, M4, M5, M3
1 normally open	Sensor input standard	PL d	SIL 2	M1 or M2, M4, M5, M3
2 normally closed	Sensor input higher requirements	PL e	SIL 3	M1 or M2, M4
2 normally closed with time monitoring	Sensor input monitored	PL e	SIL 3	M1 or M2, M4
1 normally open + 1 normally closed	Sensor input higher requirements	PL e	SIL 3	M1 or M2, M4
1 normally open + 1 normally closed time monitored	Sensor input monitored	PL e	SIL 3	M1 or M2, M4

Start / reset element

Switch type	Comment	Classification PL	Classification SIL	Prerequisites/limitations
1 normally open	Alarm reset standard (evaluation of edge)	--	--	-
1 normally open	Logic reset standard	PL d	SIL 2	M1 or M2, M4, M5, M3
1 normally open	Start monitoring standard (optional function)	--	--	-

Note: The alarm reset inPort can be operated with 24V continuous voltage and is edge triggered.

19 EG-Konformitätserklärung

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EG KONFORMITÄTSERKLÄRUNG FÜR SICHERHEITSBAUTEILE IM SINNE DER EG-MASCHINENRICHTLINIE 2006/42/EG (ANHANG IV)

EC DECLARATION OF CONFORMITY FOR SAFETY COMPONENTS ACCORDING THE EU MACHINERY DIRECTIVE 2006/42/EG (APPENDIX IV)

Dokumenten Nr. *Declaration N.*	**DoC013-R 1.0**
Firma *Manufacturer*	**Parker Hannifin GmbH & Co.KG**
Anschrift *Address*	**Robert-Bosch-Straße 22** **77656 Offenburg** **Deutschland**
Produkt *Product*	**Frei programmierbare Sicherheitssteuerung zur Überwachung von Antriebssystemen, geeignet für SIL 3 IEC 61508:2010, bzw. PL e nach EN ISO 13849:2009.** ***Free programmable safe plc for monitoring of drives, appropriated for SIL 3 IEC 61508:2010, resp. PL e according EN ISO 13849:2009***
Produktname *Product name*	**SDC, benannt als Sicherheitsoption S3 bei der Compax3 Serie – C3M (Mehrachsfamilie)** ***SDC, called as safety option S3 for Compax3 series – C3M (Multi axis family)***

Für das Sicherheitsbauteil wurde eine **EG-Baumusterprüfung** durch den TÜV durchgeführt.
*For the safety component a **EC Type-Examination** from TÜV was done.*

Anschrift TÜV *Address TÜV*	TÜV Rheinland Industrie Service GmbH, Alboinstr. 56, D-12103 Berlin, Kennnummer Notified Body NB 0035

Das Produkt wurde entwickelt, konstruiert und gefertigt in Übereinstimmung der o.g. Richtlinie.
The product was developed, designed and manufactured in accordance to the directive as named above

Folgende Normen wurden angewendet:
Following standards were applied:

Norm / *Standard*	Titel / *Title*	Ausgabe / *Edition*
EN ISO 13849-1	Sicherheit von Maschinen - Sicherheitsbezogene Teile von Steuerungen - Teil 1: Allgemeine Gestaltungsleitsätze *Safety of machinery – Safety-related parts of control systems - Part 1: General principles for design*	2008 + AC:2009
EN 62061	Sicherheit von Maschinen - Funktionale Sicherheit sicherheitsbezogener elektrischer, elektronischer und programmierbarer elektronischer Steuerungssysteme *Safety of machinery - Functional safety of safety-related electrical, electronic, programmable electronic control systems*	2005
EN 50178	Ausrüstung von Starkstromanlagen mit elektronischen Betriebsmittel *Equipment of power installations with electronic equipment*	1997

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EN 60204-1	Sicherheit von Maschinen – Elektrische Ausrüstung von Maschinen - Teil 1: Allgemeine Anforderungen *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*	2006 +A1:2009 +AC:2010 (auszugsweise/*in extracts*)
EN ISO 13850	Sicherheit von Maschinen, NOT-Halt, Gestaltungsleitsätze *Safety of machinery, Emergency stop, principles for design*	2008
IEC 61508	Teil 1-7: Funktionale Sicherheit sicherheitsbezogener elektrischer/elektronischer/programmierbarer elektronischer Systeme *Part 1-7: Functional safety of electrical/electronic/programmable electronic safety-related systems*	2010
EN 55011 (Klasse A)	Industrielle, wissenschaftliche und medizinische Geräte - Funkstörungen - Grenzwerte und Messverfahren *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*	2007
EN 61800-3	Drehzahlveränderbare elektrische Antriebe - Teil 3: EMV-Anforderungen einschließlich spezieller Prüfverfahren *Adjustable speed electrical power drive systems - Part 3: EMC requirements and specific test methods.*	2005-7
EN 61800-5-1	Elektrische Leistungsantriebssysteme mit einstellbarer Drehzahl - Teil 5-1: Anforderungen an die Sicherheit – Elektrische, thermische und energetische Anforderungen *Adjustable speed electrical power drive systems - Part 5-1: Safety Requirements- Electrical, thermal and energy*	2008-04
EN 61800-5-2	Elektrische Leistungsantriebssysteme mit einstellbarer Drehzahl Teil 5-2: Anforderungen an die Sicherheit – Funktionale Sicherheit *Adjustable speed electrical power drive systems - Part 5-2: Safety requirements - Functional*	2007
EN 61000-6-2	Elektromagnetische Verträglichkeit (EMV) – Teil 6-2: Fachgrundnormen - Störfestigkeit für Industriebereiche *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards - Immunity for industrial environments*	2005

Bemerkungen/*Notes*:
Die Produkte entsprechen den Anforderungen der Niederspannungs-Richtlinie 2006/95/EG und der EMV-Richtlinie 2004/108/EG.
The products are in accordance to the Low Voltage Directive 2006/95/EC and EMC Directive 2004/108/EC.

Den im Produkthandbuch beschriebenen Sicherheits-, Installations- und Bedienungshinweisen muss Folge geleistet werden.
These products must be installed and operated with reference to the instructions in the Product Manual.
All instructions, warnings and safety information of the Product Manual must be adhered to.

Für das Produkthandbuch zeichnet sich Dipl.-Ing. (FH) Jürgen Killius verantwortlich.
For the Product Manual is responsible Dipl.-Ing. (FH) Jürgen Killius.

Offenburg, 14/03/2013
Jürgen Killius, *Operations Manager* ppa.