

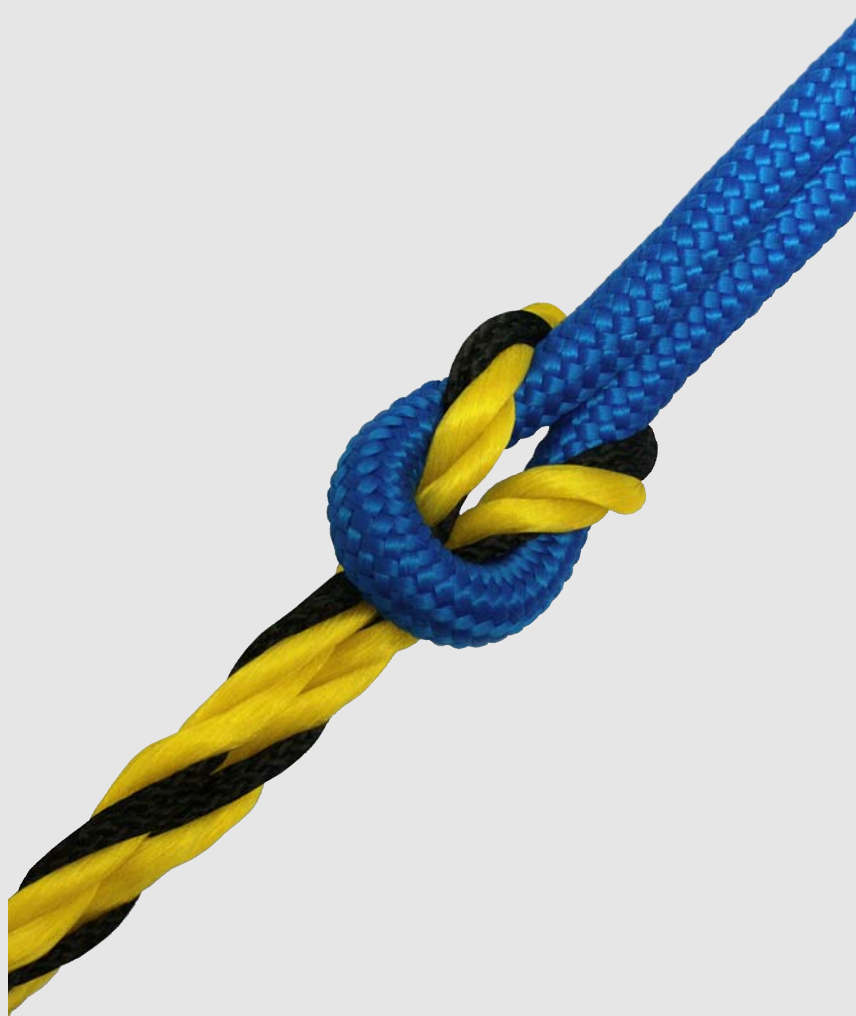
ASP 5001

Operating manual

Data

Concept

Example



V 5.6

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en

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1 Introduction

The *Safe Torque Off* (STO) safety function can be realized with devices from the 5th generation of STÖBER inverters.

There are two switchoff distances available:

The enable function is used for the first switchoff distance. The diagnostics can be performed via the binary output or a fieldbus system.

For the second switchoff distance, the ASP 5001 option is used. If the safety function is required, the controller of the final stage is switched off via the switching elements of a safety relay and the positively-driven signal contact is switched at the external safety circuit (NC contact).

The start-up of the motor is then also prevented when faults in the region of the final stage or the control circuit are present as the required rotary field is no longer generated.

Advantages of the start inhibitor:

- No switching of the supply voltage required.
- Faster restart possible.
- Lower contact wear.
- Simplified wiring.

The following tables shows which inverter the ASP 5001 certified accessory is available for:

Inverter	Size			
	Size 0	Size 1	Size 2	Size 3
MDS 5000A	certified	certified	certified	certified
FDS 5000A	certified	certified	—	—
SDS 5000A	certified	certified	certified	certified

As a result, applications can be realized up to a maximum:

- PL e in category 3 to DIN EN ISO 13948-1:2008-12 or
- SIL 3 to DIN EN 61800-5-2:2008-04.

You can find the certificate at www.stoeber.de.

1.1 Other manuals

The documentation of the MDS 5000 includes the following manuals:

Manual	Contents	ID	Latest version
Commissioning Instructions	Reinstallation, replacement, function test	442296	V 5.6
Projecting manual	Installation and connection	442272	V 5.6
Operating manual	Set up the inverter	442284	V 5.6



The documentation of the FDS 5000 includes the following manuals:

Manual	Contents	ID	Latest version
Commissioning Instructions	Reinstallation, replacement, function test	442292	V 5.6
Projecting manual	Installation and connection	442268	V 5.6
Operating manual	Set up the inverter	442280	V 5.6

The documentation of the SDS 5000 includes the following manuals:

Manual	Contents	ID	Latest version
Commissioning Instructions	Reinstallation, replacement, function test	442300	V 5.6
Projecting manual	Installation and connection	442276	V 5.6
Operating manual	Set up the inverter	442288	V 5.6

You can find information about fieldbus communication in the following manuals:

Manual	ID	Latest version
CANopen operating manual®	441684	V 5.6
PROFINET operating manual®	441685	V 5.6
EtherCAT operating manual®	441895	V 5.6
PROFINET operating manual®	442339	V 5.6
USS operating manual	441706	V 5.6

1.2 Further support

If you have questions about the technology which have not been answered in this document, please contact:

- Telephone: +49 (0) 7231 582-1187
- E-Mail: applications@stoeber.de

If you have questions about the documentation or training programs, please contact:

- E-Mail: electronics@stoeber.de

2 Notes on Safety

WARNING!

The inverter and its accessories pose dangers.

- ▶ Read and observe the safety warnings in this section before you use the ASP 5001 in your application.

The ASP 5001 option does provide galvanic separation of the mains supply network. Dangerous voltages may also be present at the motor terminals for the required safety function! The function is not a protection device against *electric shock* according to DIN EN 60204-1.

- Secure the system during maintenance or repair work by switching to zero-potential and using an appropriate system protection!
- Observe the regulations for emergency stop situations!

The accessory ensures that the rotary field is switched off.

- Secure vertically moving axles against falling!

Note that controlling the *Safe Torque Off* safety function with OSSD signals can lead to unexpected machine behavior. The inverter enable can not evaluate OSSD signals or tolerate them in the presetting.

- Activate the OSSD tolerance of the interface by entering a delay corresponding to the OSSD signal in the *A43 Enable Switchoff Delay* parameter. Note that the OSSD signals are not evaluated but suppressed!

2.1 Component part of the product

The technical documentation is a component part of a product.

- Since the technical documentation contains important information, always keep it handy in the vicinity of the device until the machine is disposed of.
- If the product is sold, disposed of, or rented out, always include the technical documentation with the product.

2.2 Qualified personnel

Since the devices may harbor residual risks, all configuration, transportation, installation and commissioning tasks including operation and disposal may only be performed by trained personnel who are aware of the possible risks.



Personnel must have the qualifications required for the job. The following table lists examples of occupational qualifications for the jobs:

Activity	Possible occupational qualifications
Transportation and storage	Worker skilled in storage logistics or comparable training
Configuration	- Graduate engineer (electro-technology or electrical power technology) - Technician (m/f) (electro-technology)
Installation and connection	Electronics technician (m/f)
Commissioning (of a standard application)	- Technician (m/f) (electro-technology) - Master electro technician (m/f)
Programming	Graduate engineer (electro-technology or electrical power technology)
Operation	- Technician (m/f) (electro-technology) - Master electro technician (m/f)
Disposal	Electronics technician (m/f)

Tab. 2-1: examples of occupational qualifications

In addition, the valid regulations, the legal requirements, the reference books, this technical documentation and, in particular, the safety information contained therein must be carefully

- read
- understood and
- complied with

2.3 Residual dangers

A residual movement of up to 180° /pole pair can arise despite an activated safety function in the event of a short circuit of two power transistors! (Example: 4-pole motor: maximum residual movement $180^\circ/2 = 90^\circ$).

- Consider this residual movement for the risk analysis!

The motor coasts if the safety function is activated for a running motor. Controlled stopping is no longer possible.

- Consider this when configuring your system!

2.4 Presentation of notes on safety

NOTICE

Notice

means that property damage may occur

- ▶ if the stated precautionary measures are not taken.
-

CAUTION!

Caution

with warning triangle means that minor injury may occur

- ▶ if the stated precautionary measures are not taken.
-

WARNING!

Warning

means that there may be a serious danger of death

- ▶ if the stated precautionary measures are not taken.
-

DANGER!

Danger

means that serious danger of death exists

- ▶ if the stated precautionary measures are not taken.
-



Information

indicates important information about the product or a highlighted portion of the documentation which requires special attention.

3 Concept

WARNING!

Improper use poses a danger to life.

- ▶ Safe technical integration of the 5th generation of STÖBER inverters is not permitted without the ASP 5001.

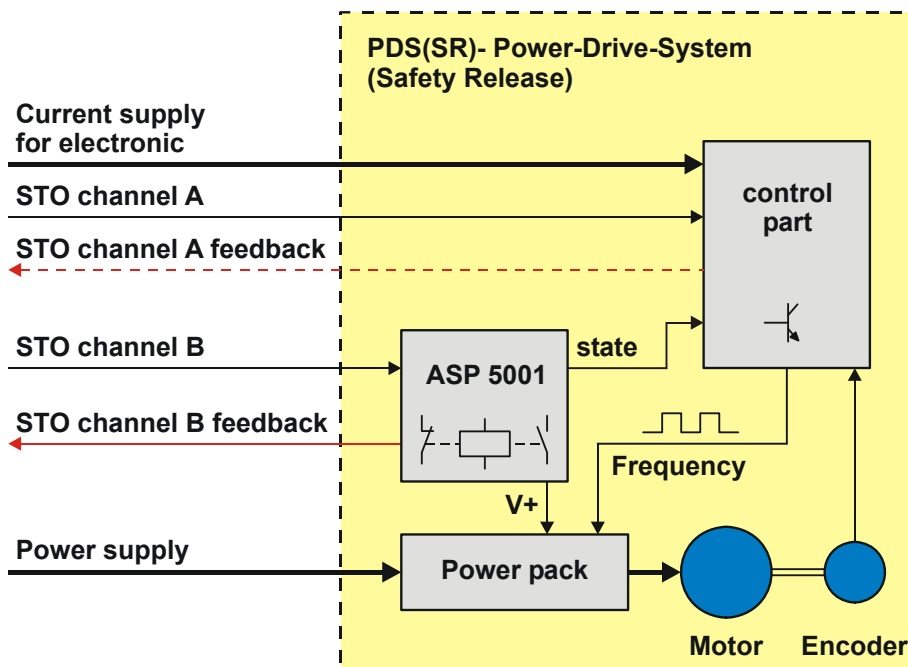
Using the STÖBER safety concept, configurations can be established up to and including

- PL e in category 3 to DIN EN ISO 13948-1:2008-12 or
- SIL 3 in HF1 to DIN EN 61800-5-2:2008-04.

The *Safe Torque Off* (STO) safety function is integrated in the inverter.

For a suitable external configuration, the *Safe Stop 1* (SS1) safety function to DIN EN 61800-5-2:2008-04 or a category 1 stop to DIN EN 60204-1:2007-06 can be realized. In this way, STO constitutes a safe fallback solution.

The devices from the 5th generation of STÖBER inverters meet the requirements for category 3 and HF1 configurations. Accordingly, the device has two switchoff distances that are independent of each other.



3.1 1. Switchoff distance

3.1.1 Controller

The 1st switchoff distance is the enable channel of the control electronics. The control electronics evaluate the two signals: The enable at X1.3 and the additional enable signal. Enable and additional enable have AND logical operations internally in the device, i.e. both signals must be active so that the power output stage is switched on. The enable at X1.3 must always be activated. In the *A60 Additional Enable Source* parameter,

- set which source the signal supplies and
- how the signal evaluates the additional enable.

The following table shows the options available.

Setting in A60 parameter	Control of the enable channel
<i>1:High</i>	Additional enable is continually active. The power output stage is activated via the enable at X1.3.
<i>2:Parameter</i>	For this setting in <i>A60</i> , the status of the <i>A180 bit 0</i> parameter is evaluated. <i>A180</i> is described by the fieldbus.
<i>3:BE1 to 28:BE13-inverse</i>	The signal of the additional enable is evaluated via the set terminal as not inverted or inverted.

If your application differs to the standard applications provided by STÖBER ANTRIEBTECHNIK GmbH & Co. KG, you must conduct tests to ensure that the 1st switchoff distance, – i.e. enable and additional enable,– is always effective.

3.1.2 Acknowledgement

The 1st switchoff distance is acknowledged by the *A900 SysEnableOutput* signal via a binary output or fieldbus. The signal must be dynamically checked by the higher level controller, i.e for a change in state.

For example, the *A900* coordinate is entered in the *F61* parameter for the output on BA1. If the acknowledgement is via a fieldbus system, activate the watchdog function of the bus system. Observe the fieldbus documentation for this (see section 1.1 Other manuals).

Read the *E200 Device Status Byte* parameter from the fieldbus. The acknowledgement is provide from *Bit 0 Enabled*.

3.2 2. Switchoff distance

The 2nd switchoff distance is realized with the ASP 5001. A positively driven safety relay is integrated on the ASP 5001.



Information

Note that the ASP 5001 is optional for sizes 0, 1 and 2. The accessories may only be installed and repaired by STÖBER ANTRIEBSTECHNIK. For this reason, order the inverter with the ASP 5001 installed for these sizes.

For size 3, the ASP 5001 is installed as standard.

In order for the power output stage of the inverter to be controlled by the control part, the STO safety function must be deselected at terminal X12.3.

The switching state of the ASP 5001 is acknowledged via the NC contact at terminals X12.1 and X12.2. If the STO safety function is deselected, the contact is opened. If the ASP 5001 is not controlled, the contact is closed and the safety function is requested.

3.3 Overall functionality

Note that the following parameters can affect the safety function:

- *A39 Tmax Fast Stop*
- *A43 Enable Switchoff Delay*
- *A44 Enable Quick Stop*
- *A55 Manual Function Button*
- *A60 Additional Enable Source*
- The *F61 BA1 Source* to *F70 BA10 Source* parameters

Observe these when configuring, commissioning and modifying your project.

Make sure

- that the setting of the parameters matches your application.
- so that the desired overall functionality is achieved after commissioning and each modification.

4 Data

You can find the data of the enable path and the ASP 5001 in this section.

4.1 1. Switchoff distance

Terminal description X1

Pin	Designation	Function	Data
3	GND	Enable	High level ≥ 12 V High level < 8 V
4	+ input		$I_{E \max} = 16$ mA $U_{E \max} = 30$ V

The configurable binary outputs are provided at different terminals. Also observe the projecting manuals (see section 1.2 Further support). The binary outputs have the following technical data:


- $I_{A \max} = 50$ mA
- $U_{A \max} \leq U_E$
- $T_{A \text{ type}} = 1$ ms

Safety-relevant data of the enable path

Acknowledgement	MTTF _D	DC _{avg}	Mission Time
without feedback system	377 years	60 %	20 years
with feedback system	377 years	90 %	20 years

4.2 ASP 5001

Terminal description X12

Pin		Id.	Function
	1	NC contact (break contact element)	Feedback system; must be integrated in the safety circuit of the controller!
	2		
	3	Relay coil 1 (+)	Controller ^{a)}
	4	Relay coil 2 (-)	

a) For a UL-compliant application, the use of a 4 AT fuse in the 24 V supply line is mandatory. The fuse must be approved according to UL 248.

Coil data

Date	Value
Voltage	20 V _{DC} – 28 V _{DC}
Rated current I _N	70 mA
Safety circuit	Free-wheeling diode

Contact data

Date	Value
Minimum switching voltage	10 V
Maximum switching voltage	30 V
Minimum switching current	10 mA
Maximum switching current	300 mA
Maximum switching frequency	0,1 Hz

**Information**

The feedback contact must be monitored depending on the safety architecture of the higher level safety controller strived for.

Minimum service life of relay

Utilization category	Current	Switching cycles
DC 12	300 mA	450000
DC-13	300 mA	250000

B_{10D} values of the ASP 5001

Utilization category	Current	B _{10D} value
DC-13	1 A	Size 0 – size 2: 10000000 cycles Size 3 7000000 cycles

**Information**

The diagnostic coverage for a positively-driven safety relay is 99 % acc. to DIN EN ISO 13849-1:2008-12.

5 Deselecting and requesting the safety function

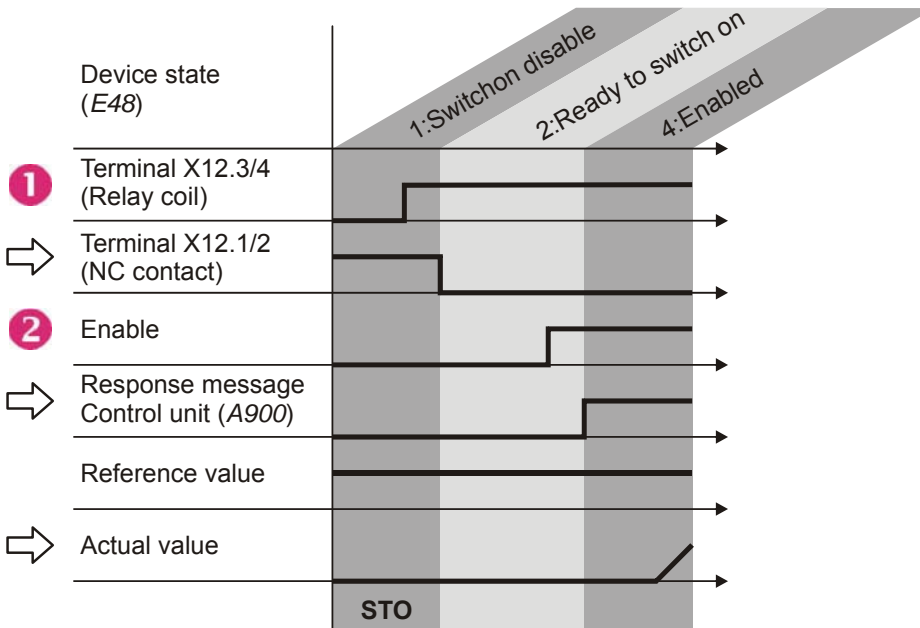
In this section, you will find out how to deselect and request the safety function.

Deselecting a safety function means the safe state is left and regular operation of the drive is allowed. Re-requesting a safety function means that regular operation is left and the inverter is brought to the safe state.

5.1 Deselect STO

Deselect STO

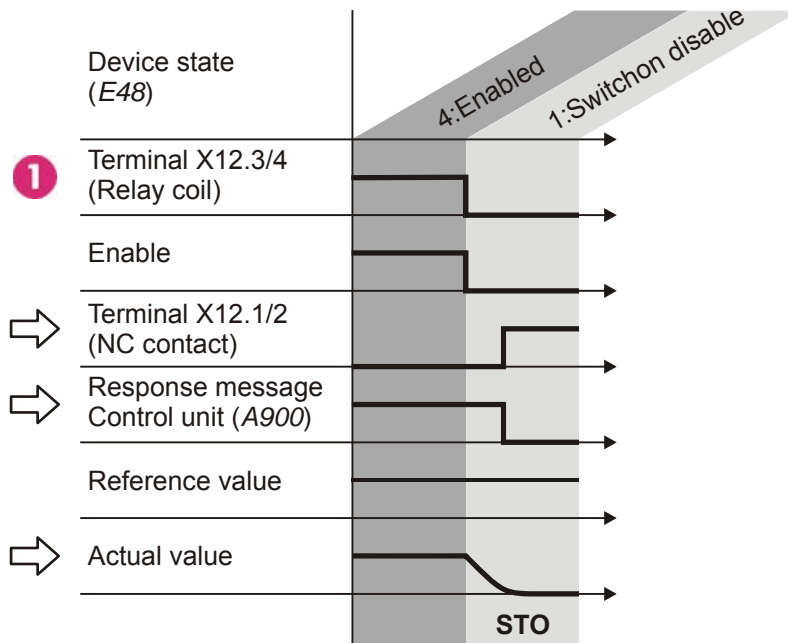
- 1 Switch on the signal at terminal X12.3/4.
 - ⇒ The NC contact at terminal X12.1/2 is opened.
- 2 Switch on the enable.
 - ⇒ The feedback system confirms the enable.
 - ⇒ You have deselected the STO safety function.



5.2 Request STO

Request STO

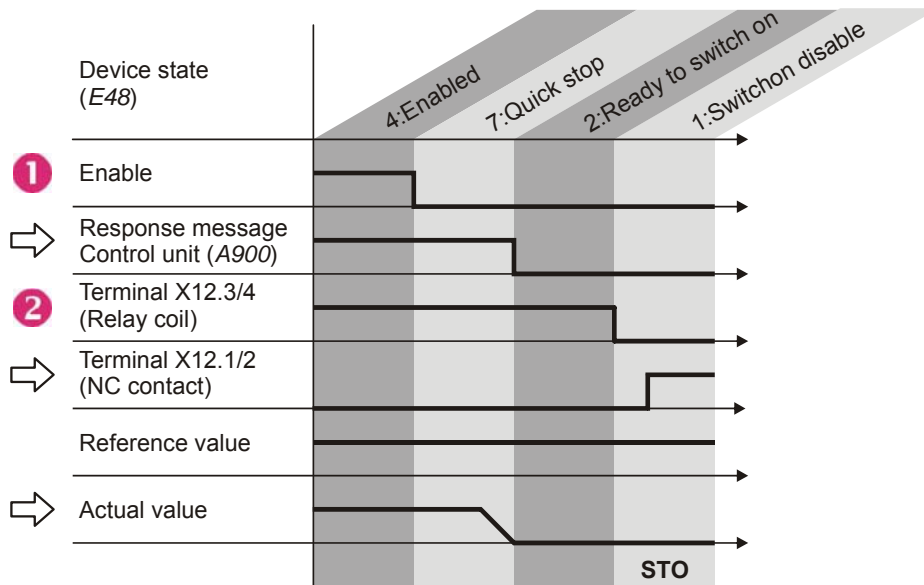
- 1 Switch off the signal at terminal X12.3/4 and the enable.
 - ⇒ The NC contact at terminal X12.1/2 is closed.
 - ⇒ The acknowledgement is switched off.
 - ⇒ You have requested the safety function.



5.3 Request SS1

Request SS1

- 1 Switch off enable.
 - ⇒ A configured quick stop is performed (see A44 parameter). When the quick stop is completed, the feedback system of the control part reports that the power stage is no longer enabled.
 - 2 Switch off the signal at terminal X12.3/4.
 - ⇒ The NC contact at terminal X12.1/2 is closed.
- ⇒ You have requested the safety function.



6 Application example

6.1 Description

This example shows the implementation of the STO safety function when using an inverter from the 5th generation of STÖBER inverters (xDS 5000) in conjunction with a moving and separating safety device and a safety switching device.

The safety function in this example is triggered by opening the safety doors, which is detected via the position switch (B1/B2) of the safety switching device (K1).

Both switchoff paths (T1a, T1b) are controlled in the xDS 5000 via the enable contacts of K1. As well as the STO safety function, the SS1 safety function can also be realized by using a suitable safety switching device (K1) if K1 has corresponding enable contacts with a time delay available.

The switchoff path 1 in the xDS 5000 (T1a) is activated via the enable input. The generation of the pulse pattern is blocked in the microcontroller by switching the signal at this input to low level. This occurs immediately for the STO safety function after requesting the safety function. For the SS1, a stop ramp must be parameterized in the xDS 5000 so that the drive can be initially stopped in a controlled manner before the generation of the pulse pattern is blocked. The microcontroller can respond to the safety switching device (K1) via the binary output and a coupling relay (K2).

The second switchoff channel in the inverter provides a safety relay (T1b) with a NO contact (make contact element) that switches off the controller for the driving stage. This relay is accommodated on the ASP 5001 option. Switchoff occurs immediately after the request for the safety function for the STO and with a corresponding time delay for the SS1. The positively-driven NC contact (break contact element) of the safety relay (T1b) is included in the feedback loop of the safety device (K1) for fault coverage.

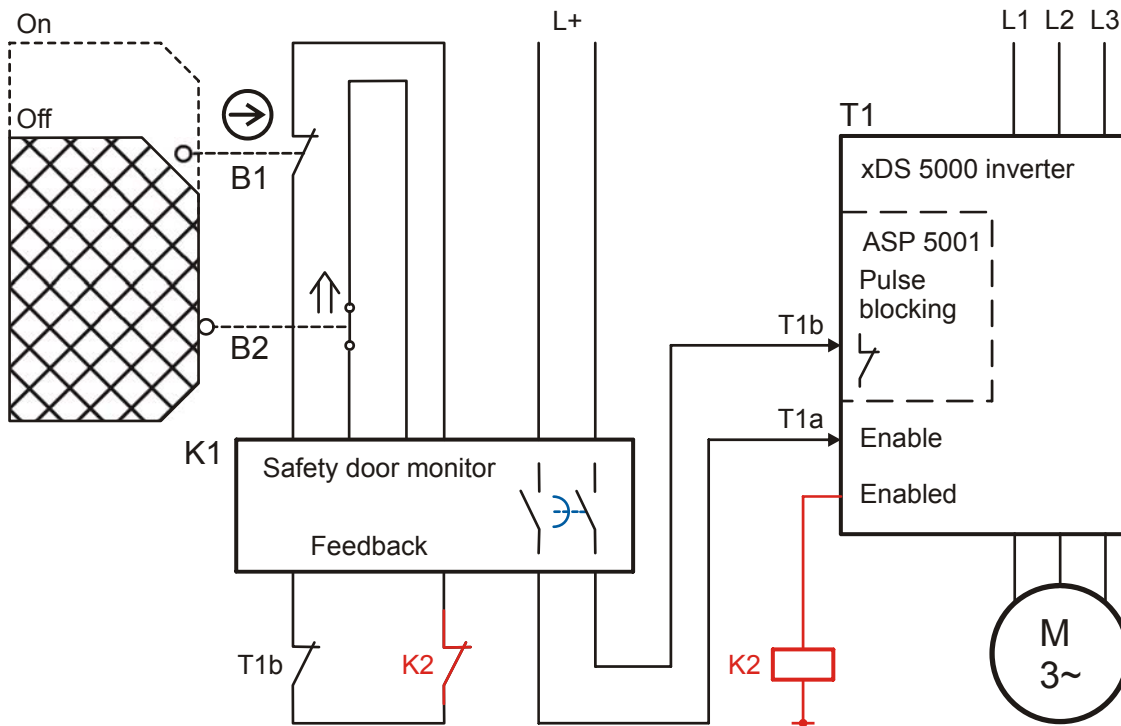


Fig. 6-1: Principal circuit diagram

6.2 Calculations of the failure probability

The calculation for the STO and SS1 safety functions were carried out on the basis of the safety-related block diagrams represented in Fig. 6-2 that were derived from the principal circuit diagram (see section 5.1). Version 1.1.2 of the SISTEMA software assistant was used for a part of the calculations.

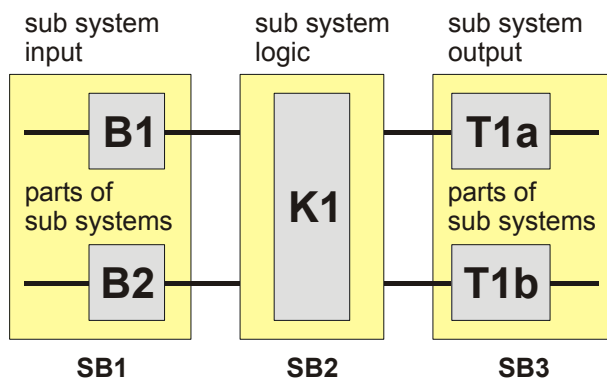


Fig. 6-2: Safety-related block diagram

Switching can be divided into three subsystems. Here, the safety device with the position switches (B1/B2) forms the SB 1 subsystem, the safety switching device (K1) forms the SB 2 subsystem and switchoff paths in xDS 5000 (T1a/T1b) are combined in the SB 3 subsystem.



The K1 safety switching device is a finished product that meets the requirements of category 4 and PL e. The failure probability is specified by the manufacturer as $PFH = 2.31 \times 10^{-9}$ 1/h.

For both other SB 1 and SB 3 subsystems, the failure probability (PFH) is calculated as follows.

In order to determine the failure probability for the overall safety function of the sensor to the actuator, the PFH values of the individual subsystems are added at the end.

MTTF_d

- SB 1: An exclusion of faults for the electrical contact is possible for the B1 position switch with positive opening operation. For the electrical NO contact of B2, a B_{10d} value of 2 000 000 cycles is assumed. This also applies for the mechanical part of B1 and B2. For 365 workdays, 16 work hours and a cycle time of 5 minutes (300 s), $n_{op} = 70\,080$ cycles/year for these components.

MTTF_d for the B1 position switch is 285 years and 143 years for B2.

Both values are reduced to 100 years in SISTEMA (high).

- SB 3:

A MTTF_d value of 100 years can be assumed for the subsystem using the table in section 3.3. for a cycle time of 5 minutes.

DC_{avg}

- SB 1:

DC = 99 % for the B1 and B2 position switches is based on the comparison of both input signals in the K1 safety switching device. This also corresponds to the DC_{avg} for this subsystem (high).

- SB 3:

For the T1a switchoff path, DC = 90 % is estimated when there is acknowledgement of the enable status of the microprocessor via a binary output and a coupling relay at the K1 safety switching device. Without the inclusion of an acknowledgement signal from T1a in the feedback loop K1, DC = 60 % can only be assumed for fault coverage by the process.

DC = 99 % for the T1b safety relay results from the direct monitoring of the positively-driven contact by K1. With feedback from T1a, this results in a DC_{avg} = 91.9 % (average) and 68.2 % (low) without T1a feedback.

CCF

The minimum requirements are met, see section 7.2

Subsystem	Calculation	Failure probability	
		DC 60% for T1a	DC 90% for T1a
SB 1	SISTEMA	PFH = $2.47 \times 10^{-8} \text{ h}^{-1}$	PFH = $2.47 \times 10^{-8} \text{ h}^{-1}$
SB 2	Manufacturer's specifications	PFH = $2,31 \times 10^{-9} \text{ h}^{-1}$	PFH = $2,31 \times 10^{-9} \text{ h}^{-1}$
SB 3	Manufacturer's specifications ^{a)}	PFH = $3,47 \times 10^{-9} \text{ h}^{-1}$	PFH = $2,61 \times 10^{-9} \text{ h}^{-1}$
Total	—	PFH = $3,04 \times 10^{-8} \text{ h}^{-1}$	PFH = $2,96 \times 10^{-8} \text{ h}^{-1}$

a) see table in section 7.1

6.3 Result

6.3.1 DC = 60 % for Ta1

The failure probability for the safety-relevant part of the inverter with DC = 60 % for T1a and PFH = 3.47 was determined to be $3.47 \times 10^{-9} \text{ h}^{-1}$. This corresponds to a SIL 2 according to DIN EN 61800-5-2 considering the structural limitations of the architecture. In this way, 0.35 % of PFH is used by SIL 2.

The relationship between PL and SIL is taken from table 4 of DIN EN ISO 13849-1. SIL 2 in a high/continual operating mode corresponds to a PL d according to this table. The requirements of category 3 with regard to the minimum requirements for DC_{avg} , $MTTF_d$ and CCF are also met.

For the complete STO and SS1 safety function as it is described in the relevant application example, a failure probability of $PFH = 3.04 \times 10^{-8} \text{ h}^{-1}$ is determined. This also corresponds to a PL d or SIL 2.

6.3.2 DC = 90 % for Ta1

The failure probability for the safety-relevant part of the inverter with DC = 90 % for T1a and PFH = 2,61 was determined to be $2,61 \times 10^{-9} \text{ h}^{-1}$. This corresponds to a SIL 3 according to DIN EN 61800-5-2 considering the structural limitations of the architecture. In this way, 2,61 % of PFH is used by SIL 3.

The relationship between PL and SIL is taken from table 4 of DIN EN ISO 13849-1. SIL 3 in a high/continual operating mode corresponds to a PL e according to this table. The requirements of category 3 with regard to the minimum requirements for DC_{avg} , $MTTF_d$ and CCF are also met.

For the complete STO and SS1 safety function as it is described in the relevant application example, a failure probability of $PFH = 2.96 \times 10^{-8} \text{ h}^{-1}$ is determined. This also corresponds to a PL e or SIL 3.



7 xDS 5000 safety figures

7.1 PFH and MTTF

Observe the breakdown according to the sizes and daily operating time in the following tables.

7.1.1 BG 0 to BG 2

16 hours of operation every day

Cycle time	PFH [1/h]		MTTF _d [years]	
	DC = 60 %	DC = 90 %	DC = 60 %	DC = 90 %
1 minute	$1,015 \times 10^{-8}$	$7,164 \times 10^{-9}$	100 ^{a)}	100 ^{a)}
2 minutes	$6,059 \times 10^{-9}$	$4,554 \times 10^{-9}$		
5 minutes	$2,432 \times 10^{-9}$	$1,824 \times 10^{-9}$		
10 minutes	$1,218 \times 10^{-9}$	$9,123 \times 10^{-10}$		
30 minutes	$4,062 \times 10^{-10}$	$3,042 \times 10^{-10}$		
1 hour	$2,032 \times 10^{-10}$	$1,521 \times 10^{-10}$		
2 hours	$1,016 \times 10^{-10}$	$7,605 \times 10^{-11}$		
4 hours	$5,080 \times 10^{-11}$	$3,803 \times 10^{-11}$		
8 hours	$2,540 \times 10^{-11}$	$1,901 \times 10^{-11}$		
16 hours	$1,270 \times 10^{-11}$	$9,506 \times 10^{-12}$		
1 day	$8,467 \times 10^{-12}$	$6,338 \times 10^{-12}$		
2 days	$4,234 \times 10^{-12}$	$3,169 \times 10^{-12}$		
5 days	$1,693 \times 10^{-12}$	$1,268 \times 10^{-12}$		
1 week	$1,210 \times 10^{-12}$	$9,054 \times 10^{-13}$		
2 weeks	$6,048 \times 10^{-13}$	$4,527 \times 10^{-13}$		
1 month	$2,784 \times 10^{-13}$	$2,084 \times 10^{-13}$		
6 months	$4,639 \times 10^{-14}$	$3,473 \times 10^{-14}$		
12 months	$2,320 \times 10^{-14}$	$1,736 \times 10^{-14}$		

a) MTTF_d is reduced to 100 years according to DIN EN ISO 13849-1:2008-12.

24 hours of operation every day

Cycle time	PFH [1/h]		MTTF _d [years]	
	DC = 60 %	DC = 90 %	DC = 60 %	DC = 90 %
1 minute	$1,220 \times 10^{-8}$	$7,721 \times 10^{-9}$	100 ^{a)}	100 ^{a)}
2 minutes	$9,060 \times 10^{-9}$	$6,825 \times 10^{-9}$		
5 minutes	$3,644 \times 10^{-9}$	$2,735 \times 10^{-9}$		
10 minutes	$1,825 \times 10^{-9}$	$1,368 \times 10^{-9}$		
30 minutes	$6,092 \times 10^{-10}$	$4,562 \times 10^{-10}$		
1 hour	$3,047 \times 10^{-10}$	$2,281 \times 10^{-10}$		
2 hours	$1,524 \times 10^{-10}$	$1,141 \times 10^{-10}$		
4 hours	$7,620 \times 10^{-11}$	$5,704 \times 10^{-11}$		
8 hours	$3,810 \times 10^{-11}$	$2,852 \times 10^{-11}$		
16 hours	$1,905 \times 10^{-11}$	$1,426 \times 10^{-11}$		
1 day	$1,270 \times 10^{-11}$	$9,506 \times 10^{-12}$		
2 days	$6,350 \times 10^{-12}$	$4,753 \times 10^{-12}$		
5 days	$2,540 \times 10^{-12}$	$1,901 \times 10^{-12}$		
1 week	$1,814 \times 10^{-12}$	$1,358 \times 10^{-12}$		
2 weeks	$9,072 \times 10^{-13}$	$6,790 \times 10^{-13}$		
1 month	$4,176 \times 10^{-13}$	$3,125 \times 10^{-13}$		
6 months	$6,959 \times 10^{-14}$	$5,209 \times 10^{-14}$		
12 months	$3,480 \times 10^{-14}$	$2,604 \times 10^{-14}$		

a) MTTF_d is reduced to 100 years according to DIN EN ISO 13849-1:2008-12.

7.1.2 BG 3

16 hours of operation every day

Cycle time	PFH [1/h]		MTTF _d [years]	
	DC = 60 %	DC = 90 %	DC = 60 %	DC = 90 %
1 minute	$1,190 \times 10^{-8}$	$7,642 \times 10^{-9}$	100 ^{a)}	100 ^{a)}
2 minutes	$8,632 \times 10^{-9}$	$6,501 \times 10^{-9}$		
5 minutes	$3,471 \times 10^{-9}$	$2,605 \times 10^{-9}$		
10 minutes	$1,739 \times 10^{-9}$	$1,303 \times 10^{-9}$		
30 minutes	$5,803 \times 10^{-10}$	$4,345 \times 10^{-10}$		
1 hour	$2,902 \times 10^{-10}$	$2,173 \times 10^{-10}$		
2 hours	$1,451 \times 10^{-10}$	$1,086 \times 10^{-10}$		
4 hours	$7,257 \times 10^{-11}$	$5,432 \times 10^{-11}$		
8 hours	$3,629 \times 10^{-11}$	$2,716 \times 10^{-11}$		
16 hours	$1,814 \times 10^{-11}$	$1,358 \times 10^{-11}$		
1 day	$1,210 \times 10^{-11}$	$9,054 \times 10^{-12}$		
2 days	$6,048 \times 10^{-12}$	$4,527 \times 10^{-12}$		
5 days	$2,419 \times 10^{-12}$	$1,811 \times 10^{-12}$		
1 week	$1,728 \times 10^{-12}$	$1,293 \times 10^{-12}$		
2 weeks	$8,640 \times 10^{-13}$	$6,467 \times 10^{-13}$		
1 month	$3,977 \times 10^{-13}$	$2,977 \times 10^{-13}$		
6 months	$6,628 \times 10^{-14}$	$4,961 \times 10^{-14}$		
12 months	$3,314 \times 10^{-14}$	$2,480 \times 10^{-14}$		

a) MTTF_d is reduced to 100 years according to DIN EN ISO 13849-1:2008-12.

24 hours of operation every day

Cycle time	PFH [1/h]		MTTF _d [years]	
	DC = 60 %	DC = 90 %	DC = 60 %	DC = 90 %
1 minute	$1,480 \times 10^{-8}$	$8,434 \times 10^{-9}$	100 ^{a)}	100 ^{a)}
2 minutes	$1,044 \times 10^{-8}$	$7,244 \times 10^{-9}$		
5 minutes	$5,198 \times 10^{-9}$	$3,905 \times 10^{-9}$		
10 minutes	$2,606 \times 10^{-9}$	$1,954 \times 10^{-9}$		
30 minutes	$8,701 \times 10^{-10}$	$6,517 \times 10^{-10}$		
1 hour	$4,353 \times 10^{-10}$	$3,259 \times 10^{-10}$		
2 hours	$2,177 \times 10^{-10}$	$1,630 \times 10^{-10}$		
4 hours	$1,088 \times 10^{-10}$	$8,148 \times 10^{-11}$		
8 hours	$5,443 \times 10^{-11}$	$4,074 \times 10^{-11}$		
16 hours	$2,721 \times 10^{-11}$	$2,037 \times 10^{-11}$		
1 day	$1,814 \times 10^{-11}$	$1,358 \times 10^{-11}$		
2 days	$9,072 \times 10^{-12}$	$6,790 \times 10^{-12}$		
5 days	$3,629 \times 10^{-12}$	$2,716 \times 10^{-12}$		
1 week	$2,592 \times 10^{-12}$	$1,940 \times 10^{-12}$		
2 weeks	$1,296 \times 10^{-12}$	$9,700 \times 10^{-13}$		
1 month	$5,965 \times 10^{-13}$	$4,465 \times 10^{-13}$		
6 months	$9,942 \times 10^{-14}$	$7,441 \times 10^{-14}$		
12 months	$4,971 \times 10^{-14}$	$3,721 \times 10^{-14}$		

a) MTTF_d is reduced to 100 years according to DIN EN ISO 13849-1:2008-12.

7.2 CCF

The following measures were taken to prevent failures due to common causes:

- Physical separation between the signal paths (15)
- Diversity (20)
- Protection against overvoltage (15)
- Tests on EMC immunity (25)
- Tests concerning all relevant ambient conditions (10)

An assessment of these measures resulted in a score of 85. As a result, the minimum requirements are met.



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Technische Änderungen vorbehalten
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