STÖBER

ASP 5001

Operating manual

Data

Concept

Example

V 5.6-S or later

10/2017 en

Table of contents

WE KEEP THINGS MOVING

1 Introduction

The *Safe Torque Off* (STO) safety function can be realized with devices from the 5th generation of STOBER inverters.
There are two switchoff distances available:
The enable function of the drive controller is used for the first switch-off 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 power unit 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 power unit or the control circuit are present as the required rotating magnetic 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

With ASP 5001, applications can be realized up to a maximum:

- PL e in category 3 to DIN EN ISO 13849-1:2008-12 or
- SIL 3 to DIN EN 61800-5-2:2008-04.

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

1.1 Further documentation

Manual	Contents	ID
Commissioning Instructions MDS 5000	Reinstallation, replacement, function test	442297
Operating manual MDS 5000	Set up the inverter	442285

You can find the latest document versions at www.stoeber.de.

Manual	Contents	ID
Commissioning Instructions FDS 5000	Reinstallation, replacement, function test	442293
Operating manual FDS 5000	Set up the inverter	442281

You can find the latest document versions at www.stoeber.de.

Manual	Contents	ID
Commissioning Instructions SDS 5000	Reinstallation, replacement, function test	442301
Operating manual SDS 5000	Set up the inverter	442289

You can find the latest document versions at www.stoeber.de.

The devices of the 5th generation of STOBER inverters can be optionally connected with different fieldbus systems. The connection is described in the following manuals:

Manuals	ID
PROFIBUS DP operating manual	441687
CANopen operating manual	441686
EtherCAT operating manual	441896
PROFINET operating manual	442340
USS operating manual	441707

You can find the latest document versions at www.stoeber.de.

1.2 Further support

If you have technical questions that are not answered by this document, please contact:

- Phone: +49 7231 582-3060
- E-mail: applications@stoeber.de

If you have questions about the documentation, please contact:

- E-mail: electronics@stoeber.de

If you have questions about training sessions, please contact:

- E-mail: training@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

As this documentation includes important information for the safe and efficient handling of the product, always keep it in the immediate vicinity of the product until product disposal and ensure it can be accessed by qualified personnel at any time.
Also pass on this documentation if the product is handed over or sold to a third party.

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)

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°/2 = 90°).

- 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
refers to important information about the product or serves to emphasize a section in the documentation to which the reader should pay special attention.

3 Concept

⚠ **WARNING!**

Improper use poses a danger to life.

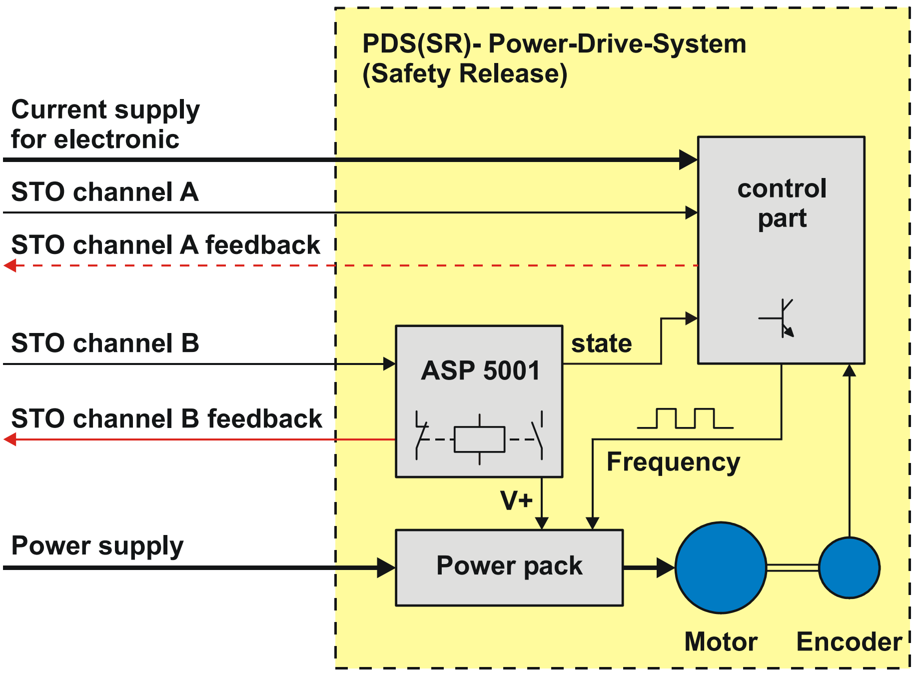
▶ Safe technical integration of the 5th generation of STÖBER inverters is not permitted without the ASP 5001.

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
1:High	Additional enable is continually active. The power output stage is activated via the enable at X1.3.
2:Parameter	For this setting in *A60*, the status of the *A180 bit 0* parameter is evaluated. *A180* is described by the fieldbus.
3:BE1 to *28:BE13-inverse*	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 Control commands and status information

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 Further documentation).

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 $I_{E\ max}$ = 16 mA $U_{E\ max}$ = 30 V
4	+ input		

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:

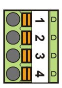
- $I_{A\ max}$ = 50 mA
- $U_{A\ max} \leq U_E$
- $T_{A\ type}$ = 1 ms

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 vdc power supply line is mandatory. The fuse must be approved according to UL 248.

Coil data

Date	Value
Voltage	20 V_{DC} – 28 V_{DC}
Nominal 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 by the higher-level safety controller.

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.

Maximum conductor cross-section

Connection type	Maximum conductor cross-section [mm^2]
Rigid	1.5
Flexible	1.5
Flexible with cable end, without plastic sleeve	1.5
Flexible with cable end, with plastic sleeve	0.5
2 leads with the same cross-section with double cable end	—

5 Deselecting and requesting the safety function

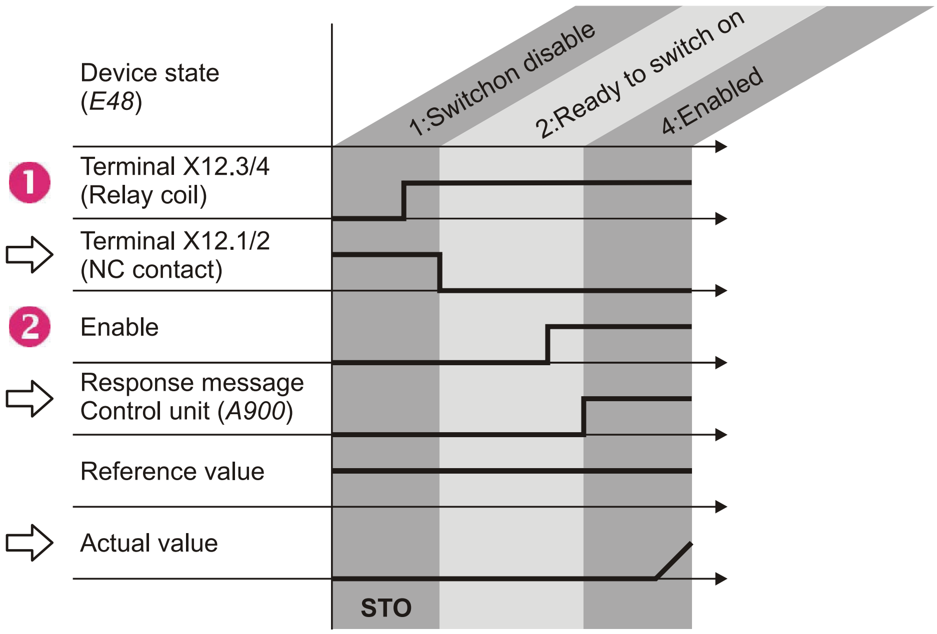
In this section, you will find out how to deselect and request the safety function.
Deselecting a safety function means the safe state is left and regular operation of the drive is allowed.
Requesting a safety function means that regular operation is left and the inverter is brought to the safe state.

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. Turn on the controller enable.
   ⇨ The feedback system confirms the enable.

⇨ You have deselected the STO safety function.



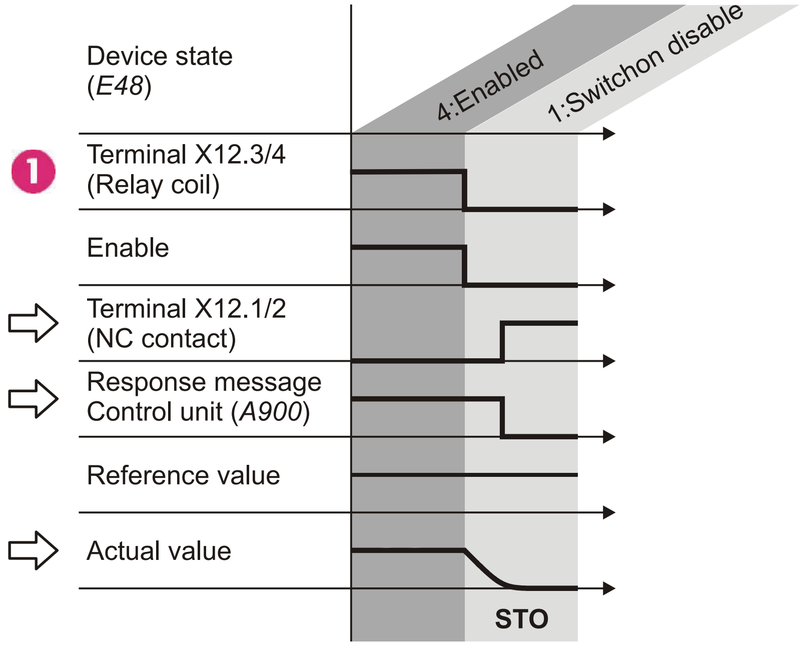
Information
To enable the power output stage, other signals may be required in addition to the controller enable, e.g.

5.2 Request STO

Request STO

1. Switch off the signal at terminal X12.3/4 and the controller enable.
   ⇨ The NC contact at terminal X12.1/2 is closed.
   ⇨ The acknowledgement is switched off.

⇨ You have requested the safety function.

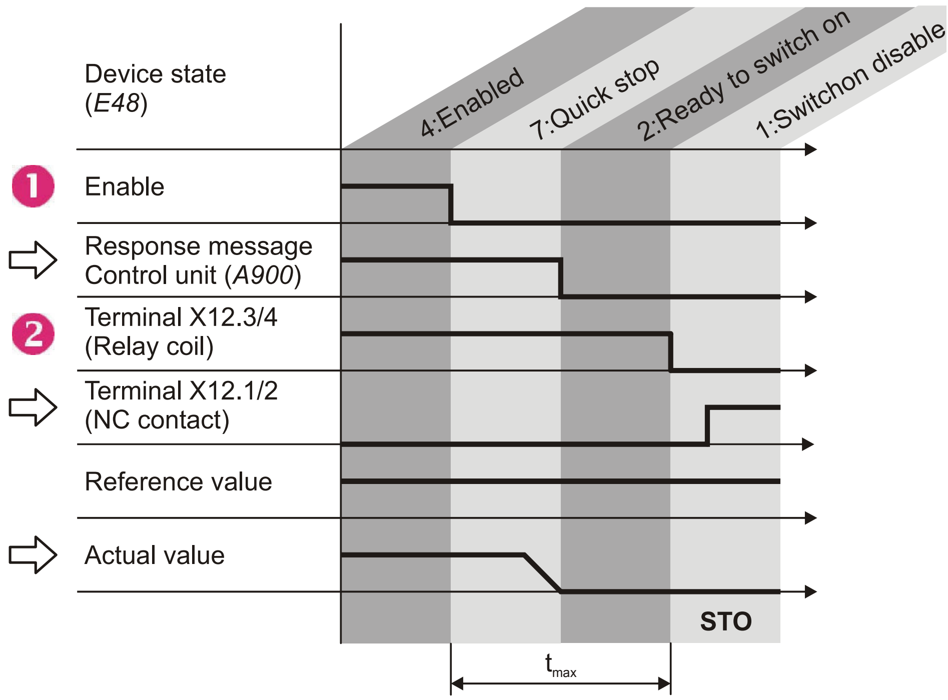


5.3 Request SS1

Request SS1

1. Turn off the controller enable.
   ⇨ A projected quick stop is performed (see *A44* parameter). When the quick stop is completed, the feedback system of the control unit reports that the power unit 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.



t_{max}= application-dependent, maximum permitted delay time after which the relay coil must be shut off.

Information

Note that when SS1 is requested, steps 1 and 2 must occur within a maximum permitted delay time (t_{max}). The maximum permitted delay time an integral part of the SS1 safety function. The duration depends on your application.

6 Sample application

6.1 Description

This example shows the implementation of the STO safety function when using an inverter from the 5th generation of STOBER inverters (xDS 5000) in conjunction with a moving and separating safety device and a safety relay.
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 relay (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 relay (K1) if K1 has corresponding enable contacts with a time delay available.

Switch-off path 1

The switch-off path 1 in the xDS 5000 (T1a) is activated via the controller enable input. The generation of the pulse pattern is blocked in the control unit 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 control unit can respond to the safety relay (K1) via the binary output and a coupling relay (K2).

Switch-off path 2

The second switch-off path 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.

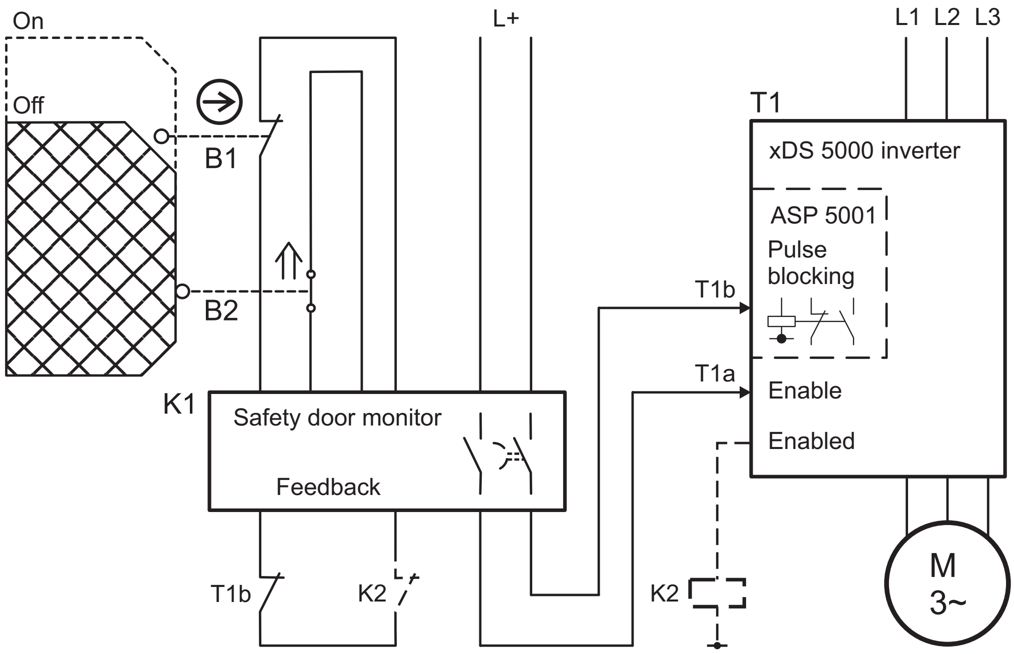


Fig. 6-1Schematic diagram

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 Safety-related block diagram 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.

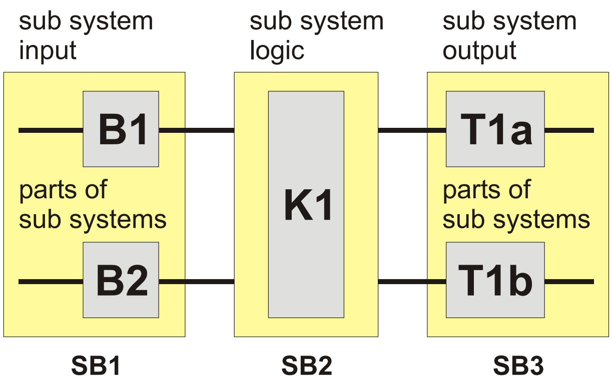


Fig. 6-2Safety-related block diagram

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 = 2.31×10^{-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 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	$PFH_d = 2.47 \times 10^{-8}\ h^{-1}$	$PFH_d = 2.47 \times 10^{-8}\ h^{-1}$
SB 2	Manufacturer's specifications	$PFH_d = 2,31 \times 10^{-9}\ h^{-1}$	$PFH_d = 2,31 \times 10^{-9}\ h^{-1}$
SB 3	Manufacturer's specifications[a)]	$PFH_d = 3,47 \times 10^{-9}\ h^{-1}$	$PFH_d = 2,61 \times 10^{-9}\ h^{-1}$
Total	—	$PFH_d = 3,04 \times 10^{-8}\ h^{-1}$	$PFH_d = 2,96 \times 10^{-8}\ h^{-1}$

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 was determined to be $PFH_d = 3.47 \times 10^{-9}\ h^{-1}$. 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_d 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 $PFH_d = 3.04 \times 10^{-8}\ h^{-1}$ 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 was determined to be $PFH_d = 2{,}61 \times 10^{-9}\ h^{-1}$. 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_d 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 $PFH_d = 2.96 \times 10^{-8}\ h^{-1}$ 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 Size 0 to 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 Size 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.

8 Glossary

B10d
Specifies the mean number of switch cycles when 10 % of the components involved have dangerously failed.

CCF – Common Cause Failures
Failures due to common causes
Influencing factors that affect several systems simultaneously, e.g. failure of different components due to an individual event, whereby these failures are not based on a mutual cause.

DC_{avg} – average Diagnostic Coverage
Specifies the average probability of revealing errors by a test.

MTTF, $MTTF_d$ – Mean Time To (dangerous) Failure
Also mean service life
Statistical parameter that is determined by trial and empirical values. Does not specify a guaranteed service life or guaranteed fault-free time.

PFH, PFH_d – Probability of a (dangerous) Failure per Hour

PL – Performance Level
Characteristic value (according to EN ISO 13849) for the reliability with which a controller fulfills a safety function.

SIL – Safety Integrity Level
Safety Integrity Level according to EN62061 or EN61508.

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