Funktionale Sicherheit

Functional safety

Safety Manual

Safety module Type 3

Firmware - 3.2.0.1

Translation of the original manual

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Imprint

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1 Introduction

The described devices, accessories, hardware and/or software are products of KEB Automation KG. The enclosed documents correspond to conditions valid at printing. Misprint, mistakes and technical changes reserved.

1.1 Markings

1.1.1 Warnings

Certain operations can cause hazards during the installation, operation or thereafter. There is safety information in the documentation in front of these operations.

Warnings contain signal words for the severity of the hazard, the type and/or source of the hazard, the consequence of non-compliance and the measures to avoid or reduce the hazard.

⚠ DANGER

Type and/or source of the hazard.

Leads to death or serious bodily injury if not observed.

a) Measures to avoid the hazard.

b) Can be supplemented by an additional danger sign or pictogram.

⚠ WARNING

Type and/or source of the hazard.

May cause death or serious injury if not observed.

a) Measures to avoid the hazard.

b) Can be supplemented by an additional danger sign or pictogram.

⚠ CAUTION

Type and/or source of the hazard.

May cause bodily injury if not observed.

a) Measures to avoid the hazard.

b) Can be supplemented by an additional danger sign or pictogram.

NOTICE

Type and/or source of the hazard.

Can cause damage to property if not observed.

a) Measures to avoid the hazard.

b) Can be supplemented by an additional danger sign or pictogram.

1.1.2 Information notes

Indicates to the user a special condition, prerequisite, scope or simplification.

This is a reference to further documentation. The barcode is for smartphones, the following link is for online users or for typing.

(🌐► https://www.keb-automation.com/de/search)

Notes on conformity for use in the North American or Canadian market.

1.1.3 Symbols and markers

✓	Condition
a)	Action step
⇨	Result or intermediate result
(≡► Reference [► 9])	Reference to a chapter, table or picture with page reference
ru21	Parameter name or parameter index
(🌐►)	Hyperlink
<Strg>	Control code
COMBIVERT	Lexicon entry

1.2 Laws and guidelines

KEB Automation KG confirms with the CE mark and the EU declaration of conformity that our device complies with the essential safety requirements.

The EU declaration of conformity can be downloaded on demand via our website.

1.3 Warranty and liability

The warranty and liability on design, material or workmanship for the acquired device is given in the general conditions of sale.

Here you will find our general sales conditions.

(🌐► https://www.keb-automation.com/terms-conditions)

Further agreements or specifications require a written confirmation.

1.4 Support

Through multiple applications, not every possible case has been taken into account. If you require further information or if problems occur which are not treated detailed in the documentation, you can request the necessary information via the local KEB Automation KG agency.

The use of our units in the target products is beyond of our control and therefore exclusively the responsibility of the customer**.**

The information contained in the technical documentation, as well as any support provided verbally, written or through testing, is made to the best of our knowledge and information regarding intended use of KEB products. However, due to technical changes, any information provided is considered non-binding and is subject to change. This also applies to any violation of industrial property rights of a third-party.

Selection of KEB units in view of their suitability for the intended use must be done by the user.

Tests can only be carried out within the scope of the intended end use of the product (Application**) by the** Customer**. They must be repeated, even if only parts of hardware, software or the unit adjustment are modified.**

1.5 Copyright

The customer may use the instructions for use as well as further documents or parts from it for internal purposes. Copyrights are with KEB Automation KG and remain valid in its entirety.

Other wordmarks and/or logos are trademarks (™) or registered trademarks (®) of their respective owners.

1.6 Validity of this manual

This safety manual supplements the instructions for use accompanying the unit with the implemented safety functions. The safety manual

- is only valid in conjunction with the instructions for use (control and/or power part).
- supplements the instructions for use with the safety functions.
- contains safety-related supplements and requirements for operation in safety-related applications.
- contains only supplementary safety instructions.
- supplements existing standards. The basic and application standards must still be observed.

1.7 Target group

The safety manual is intended exclusively for qualified electrical personnel with special training or instruction in the field of safety technology. Electrical personnel for the purpose of this instruction manual must have the following qualifications:

- Further training or instruction in the field of safety engineering.
- Knowledge and understanding of the safety instructions.
- Skills for installation and assembly.
- Start-up and operation of the product.
- Understanding of the function in the used machine.
- Detection of hazards and risks of the electrical drive technology.
- Knowledge of IEC 60364.
- Knowledge of national safety regulations (e. g. DGUV Regulation).

2 General Safety Instructions

The products are developed and built according to the state of the art and recognized safety rules. Nevertheless, their use may create dangers to life and limb of the user or third parties or damage to the machine and other material property.

The following safety instructions have been created by the manufacturer for the area of electric drive technology. They can be supplemented by local, country- or application-specific safety instructions. This list is not exhaustive. Non-observance of the safety instructions by the customer, user or other third party leads to the loss of all resulting claims against the manufacturer.

NOTICE

Hazards and risks through ignorance!

a) Read the instructions for use.

b) Observe the safety and warning instructions.

c) Ask if something is unclear.

2.1 Installation

⚠ DANGER

Electrical voltage at terminals and in the device!

Danger to life due to electric shock !

✓ For any work on the device

a) Switch off the supply voltage.

b) Secure it against switching on.

c) Wait until all drives has been stopped in order that no regenerative energy can be generated.

d) Await capacitor discharge time (min. 5 minutes). Measure DC voltage at the terminals.

e) Never bridge upstream protective devices. Also not for test purposes.

⚠ DANGER

Improper installation of safety technology!

Death and serious bodily injuries.

a) Therefore the safety functions may only be installed and put into operation by qualified personnel which are trained in safety technology.

b) Check the safety functions and error responses and generate an acceptance report after installation.

⚠ CAUTION

Movement of the axis due to load

Crushing due to automatic movement with suspended loads or asymmetrical weight distribution.

a) Secure load against mechanical movement (e.g. by brake).

NOTICE

Automatic restart when STO is no longer triggered.

Unpredictable consequences for personnel and machine.

✓ In order to comply with EN 60204-1, observe the following:

a) Ensured by external measures that the drive restarts only after confirmation.

NOTICE

Malfunction due to wrong dimensioning of the current source.

a) Consider all input currents of the used safety functions.

b) If several safety modules are connected, the safety switchgear must supply the required total current.

Additional instructions:

- For the protection against pollution (pollution degree 2) the installation of the units must be provided in environment with increased protection (e. g. control cabinet IP 54).

2.2 Start-up and operation

The start-up (i.e. the starting of normal operation) is prohibited until the machinery has been proved to conform to the provisions Directive 2006/42/EG and Directive 2014/30/EU; EN 60204-1 must be observed.

⚠ DANGER

Continue mains voltage with active STO function!

Electric Shock

a) Always switch off the power supply before working on the device.

b) Await discharge time.

Without mechanical brake the drive leads to coast. Motor is free-wheeling. Additional protective devices must be installed (e.g.locking systems) if damage to persons or property can occur.

⚠ DANGER

Motor coast in the event of a fault

Danger to persons

✓ If there is a danger to persons after the motor control has been switched off by STO:

a) Block access to the hazardous area.

b) Wait until the drive stops.

The start-up can be prevented with interruption of the STO signals. STO may not be released in case of danger according to EN 60204-1. Also note the instructions to the external safety switch devices.

2.3 Maintenance

⚠ WARNING

Failure of safety functions

No protection

✓ To ensure the safety permanently:

a) The safety functions must be checked in regular intervals.

b) The intervals result from the risk analysis.

c) The useful life is limited to 20 years. After this time the unit must be replaced.

3 Product description

3.1 Validity

This manual describes the safety module type 3.

Material number:	03H6x10-00xx
Hardware:	Safety module type 3
Firmware version:	See table
used in drive controllers	xxS6A3x-xxxx xxF6A3x-xxxx

The software version of the safety module can be read out using parameter de42 (safety software version).

The software date of the safety module can be read out using parameter de43 (safety software date).

Firmware	Date code (Firmware)	Manual (Version)	Date of issue (Manual)	Comment
3.2.0.1	20171026	06	21.02.2018	Changes see appendix
3.3.0.2	20250710	08	12.09.2025	Changes see appendix

Tab. 1: Validity firmware date/manual version

Firmware	Date code	Modification notes
3.2.0.1	20171026	Released firmware with full range of safety functions.
3.3.0.2	20250710	

Tab. 2: Firmware modification notes

NOTICE

FS

The certification of drive controllers with safety technology is only valid under the following conditions:

a) The material number corresponds with the numerical code below.

b) The FS logo is printed on the type plate.

3.2 Function

With electronic protection devices there are safety functions integrated in the drive control in order to minimize or eliminate danger by malfunctions in machines. The integrated safety functions replace the complex installation of external safety components. The safety functions can be requested or released by an error.

3.3 Classification of the safety functions

The following general information is taken into account for the classification:

- Service life 20 years
- Specifications according to IEC 61508 / IEC 62061 / IEC 61800-5-2 (see table "Specifications 1")
- Specifications according to ISO 13849-1 (see table "Specifications 2")

Function	Description	Data 1	Data 2
STO	**Safe torque off** The drive is switched off by the two-channel switching off of commutation of the power semiconductors. After triggering of the function the drive coasts down. The drive reaches the stop position depending on the speed and the active torque.	SIL 3	PL e
		PFH $6.6 \cdot 10^{-11}$ 1/h	Category 3
		PFD $5.7 \cdot 10^{-6}$	DC value medium
		HFT 1	MTTF(D) > 1500 a
		SFF > 99 %	
		PTI = 20 a	
SBC	**Safe brake control** The function ensures safe brake engage on demand.	SIL 3	PL e
		PFH $6.6 \cdot 10^{-11}$ 1/h	Category 3
		PFD $5.7 \cdot 10^{-6}$	DC value medium
		HFT 1	MTTF(D) > 1500 a
		SFF > 99 %	
		PTI = 20 a	
SS1	**Safe stop 1** The drive is decelerated due to the effect of the drive control, while the brake ramp is monitored. After reaching the idle position or after expiration of a deceleration time, state STO is set.	SIL 3	PL e
		PFH $6.6 \cdot 10^{-11}$ 1/h	Category 3
		PFD $5.7 \cdot 10^{-6}$	DC value medium
		HFT 1	MTTF(D) > 1500 a
		SFF > 99 %	
		PTI = 20 a	
SS2	**Safe stop 2** The drive is decelerated due to the effect of the drive control, while the deceleration is time-monitored. After reaching the idle position, state SOS is set.	SIL 3	PL e
		PFH $6.6 \cdot 10^{-11}$ 1/h	Category 3
		PFD $5.7 \cdot 10^{-6}$	DC value medium
		HFT 1	MTTF(D) > 1500 a
		SFF > 99 %	
		PTI = 20 a	
SOS	**Safe operation stop** within this safe function the drive has stopped. The motor control remains active and can resist external forces.	SIL 3	PL e
		PFH $6.6 \cdot 10^{-11}$ 1/h	Category 3
		PFD $5.7 \cdot 10^{-6}$	DC value medium
		HFT 1	MTTF(D) > 1500 a
		SFF > 99 %	
		PTI = 20 a	
SLS	**Safely-limited speed** Exceeding of a speed limit value is prevented by this function.	SIL 3	PL e
		PFH $6.6 \cdot 10^{-11}$ 1/h	Category 3
		PFD $5.7 \cdot 10^{-6}$	DC value medium
		HFT 1	MTTF(D) > 1500 a
		SFF > 99 %	
		PTI = 20 a	
SLP	**Safely-limited position** This function prevents exceeding of a position limit value.	SIL 3	PL e
		PFH $6.6 \cdot 10^{-11}$ 1/h	Category 3
		PFD $5.7 \cdot 10^{-6}$	DC value medium
		HFT 1	MTTF(D) > 1500 a
		SFF > 99 %	
		PTI = 20 a	
SLI	**Safely-limited increment** a limited increment is monitored with this safety function.	SIL 3	PL e
		PFH $6.6 \cdot 10^{-11}$ 1/h	Category 3
		PFD $5.7 \cdot 10^{-6}$	DC value medium

		HFT 1	MTTF(D) > 1500 a
		SFF > 99 %	
		PTI = 20 a	
SDI	**Safe direction** The safety function monitores the direction of rotation of a drive.	SIL 3	PL e
		PFH 6.6 • 10^{-11} 1/h	Category 3
		PFD 5.7 • 10^{-6}	DC value medium
		HFT 1	MTTF(D) > 1500 a
		SFF > 99 %	
		PTI = 20 a	
SMS	**Safe maximum speed** Exceeding of a speed limit value is prevented by this function.	SIL 3	PL e
		PFH 6.6 • 10^{-11} 1/h	Category 3
		PFD 5.7 • 10^{-6}	DC value medium
		HFT 1	MTTF(D) > 1500 a
		SFF > 99 %	
		PTI = 20 a	
SSM	**Safe speed monitor** The safety function provides a safe digital output signal below a specified speed value of a drive.	SIL 3	PL e
		PFH 6.6 • 10^{-11} 1/h	Category 3
		PFD 5.7 • 10^{-6}	DC value medium
		HFT 1	MTTF(D) > 1500 a
		SFF > 99 %	
		PTI = 20 a	
SLA	**Safe load acceleration** The safety function prevents exceeding or falling below the acceleration limit value.	SIL 3	PL e
		PFH 6.6 • 10^{-11} 1/h	Category 3
		PFD 5.7 • 10^{-6}	DC value medium
		HFT 1	MTTF(D) > 1500 a
		SFF > 99 %	
		PTI = 20 a	

Tab. 3: Overview of safety functions with achievable SIL/PL level

SAR corresponds to SLA with an upper and a lower limit with the same sign.

SSR corresponds to SLS with an upper and a lower limit with the same sign.

For the SIL classification or the classification within a performance level in connection with the applications, the failure rates of the external switching devices must also be taken into account for the final assessment.

3.4 Safe condition

In case of failure, the module changes into the safe state. The safe state is defined with the following status:

- Modulation off (STO)
- Brake closed (SBC)
- All outputs (Clock/Ripple/Out1/Out2) switched off

4 Description of the I/Os

4.1 Terminal X2B

PIN (x/x intern gebrückt)	Name	Function
1/2	STO.1	STO inputs
3/4	STO.2	
5/6	SBC.1	SBC inputs
7/8	SBC.2	
9/10	FUNC1.1	Funktion1 inputs
11/12	FUNC1.2	
13/14	FUNC1.1	Funktion2 inputs
15/16	FUNC2.2	
17/18	Ripple.1	Ripple- inputs
19/20	Ripple.2	
21/22	Clock.1	Clock-outputs
23/24	Clock.2	
25/26	Out1	Output 1
27/28	Out2	Output 2
29/30	Ripple Out.1	Ripple outputs
31/32	Ripple Out.2	

Tab. 4: Terminal X2B

The voltages of all inputs and outputs refer to the 0V of the COMBIVERT control board. The pin assignment of the control terminals is described in the respective manual of the COMBIVERT.

4.1.1 Assembly of the wires

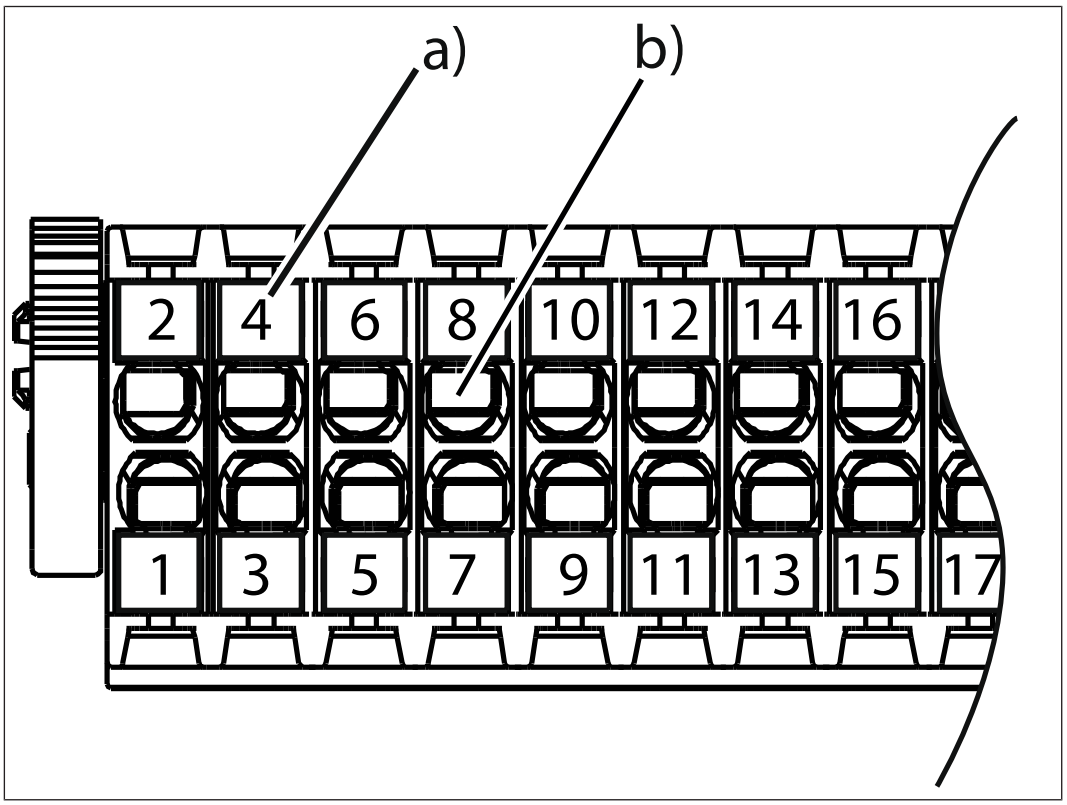

Fig. 1: Assembly of the terminal X2B

a Pusher b Connecting wire hole

- Press pusher by hand. Insert connecting wires into the respective hole, that no single wires can be seen from the outside or bend outward. A first resistance must be overcome when inserting. Release the pusher.
- Check that the connecting wire is fixed and can not be pulled-out. It is important to ensure that the connecting wire and not the insulation is clamped. The connecting wire can also be inserted without pressing the pusher in case of cross-sections upto 1.00 mm².

4.1.2 Assembly of connecting wires with wire-end ferrules according to DIN46228/4

Cross-section / AWG	Metal sleeve length	Stripping length
0.50 mm² / 21	10 mm	12 mm
0.75 mm² / 19	12 mm	14 mm
1.00 mm² / 18	12 mm	15 mm

4.1.3 Assembly of connecting wires without wire-end ferrules

Cross-section / AWG	Stripping length
0.14…1.5 mm² / 25…16	10…12 mm
Stranded wire (rigidly and flexibly)	

Note

- KEB generally recommends the use of wire-end ferrules in industrial environments.
- A safe clamping can not be guaranteed when using shorter wire-end ferrules.

4.1.4 Specification of the inputs

The inputs are specified as follows according to IEC61131-2 type 3:

Inputs	Status 0		Status 1	
	UL [V]	IL [mA]	UH [V]	IH [mA]
max.	5	15	30	15
min.	-3	not defined	11	2

The maximum short-term starting current of the input is limited to 30 mA.

4.1.5 Specification of the outputs

The short-circuit proof, digital outputs are specified in accordance with IEC 61131-2, (Type 0.1).The rated output current is 100 mA.

Only ohmic loads are permissible; there is no internal free-wheeling path.

4.2 Terminal brake

The position of the terminals and specification of the brake output is described in the respective manual of the COMBIVERT. The free-wheeling path to control the brake is integrated in the COMBIVERT.

4.3 Terminal encoder interface

The description of the encoder interface is described in the respective manual of the COMBIVERT .

4.4 Status LEDs

Arrangement of the LEDs is defined in the respective manual of the COMBIVERT.

The LED display of the safety mode indicates the following status:

LED	Status
off	No voltage supply of the safety module
green	Safety module in operation
orange	Safety module in reset or new configuration will be saved
red	Safety module in error
green orange flashing	Flashes for 60 seconds when a new user has logged in.
green orange double flashing	Flashes orange briefly twice every 1.6 seconds. Signals that the state of the bus communication is not the data state. The safety module is in a safe condition.

Tab. 5: LED displays of the safety module

5 Parameterisation and user management

The parameterisation is done with the PC program KEB COMBIVIS. A KEB safety module can be added in an existing project by right-clicking on the project and then select the entry KEB safety module under "add object".

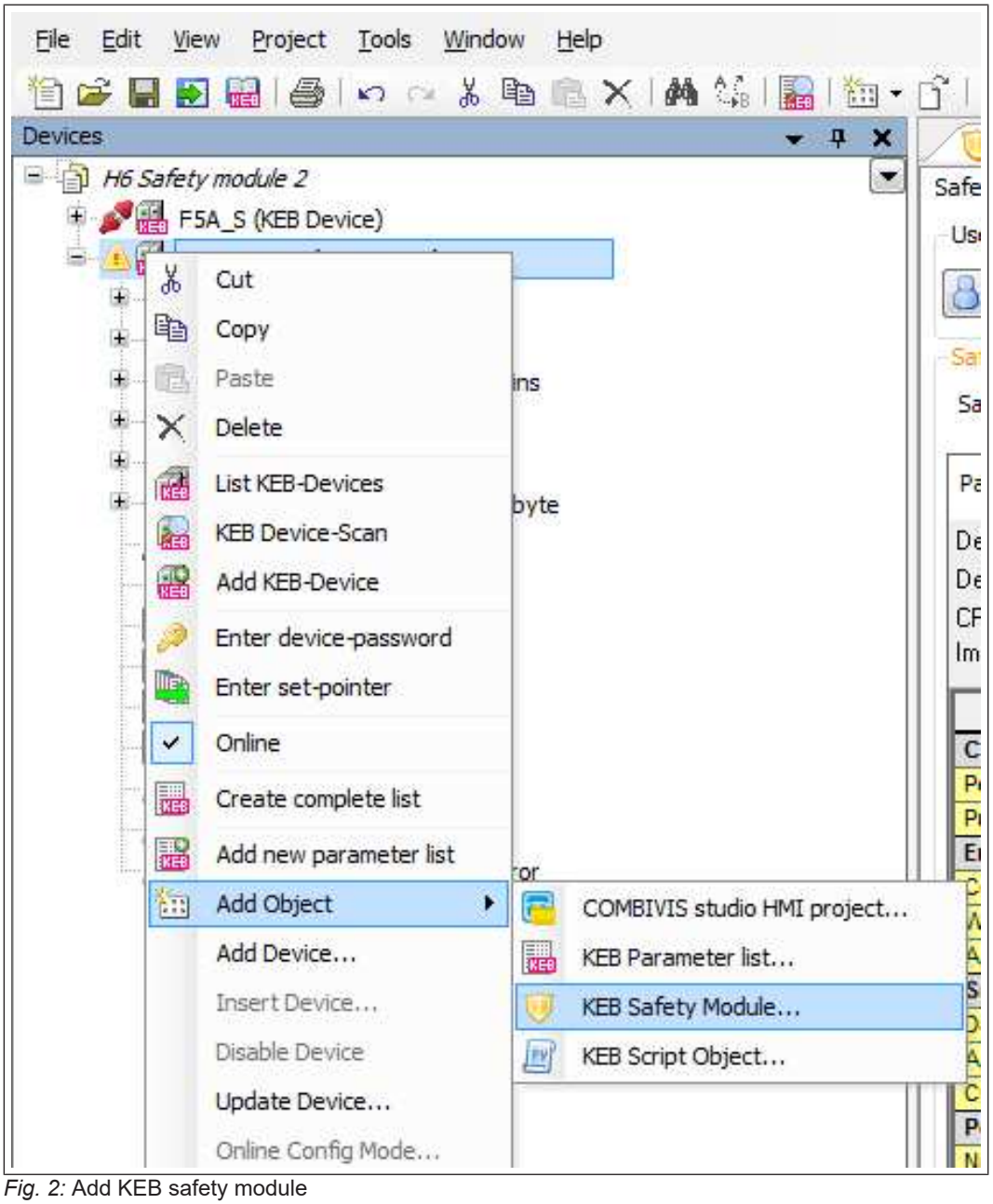

Fig. 2: Add KEB safety module

5.1 General settings

5.1.1 Settings in the safety module editor

(See also instruction manual KEB COMBIVIS)

5.1.2 User management and login

The tab "Settings" in the KEB Safety Editor contains the user administration as first button "(≡► Open user administration [▸ 20])“(≡► [▸ 19]).

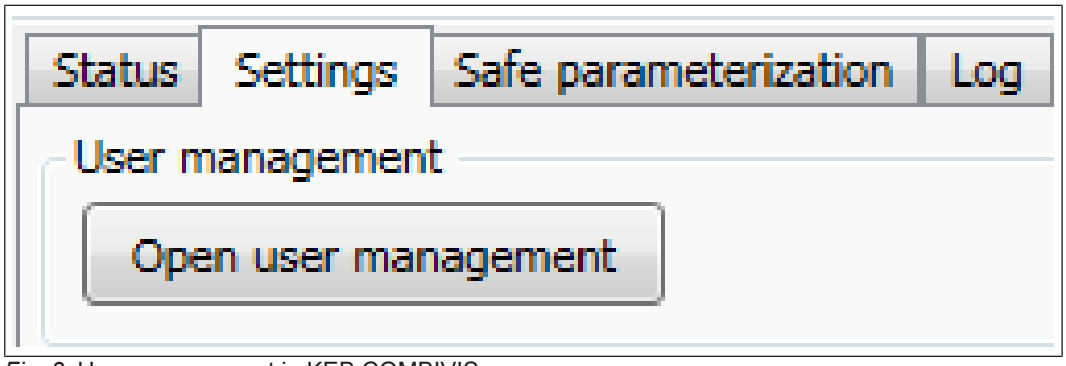

Fig. 3: User management in KEB COMBIVIS

When the "Open user administration" button is pressed, the (≡► Login window in COMBIVIS [▸ 20]) is displayed.

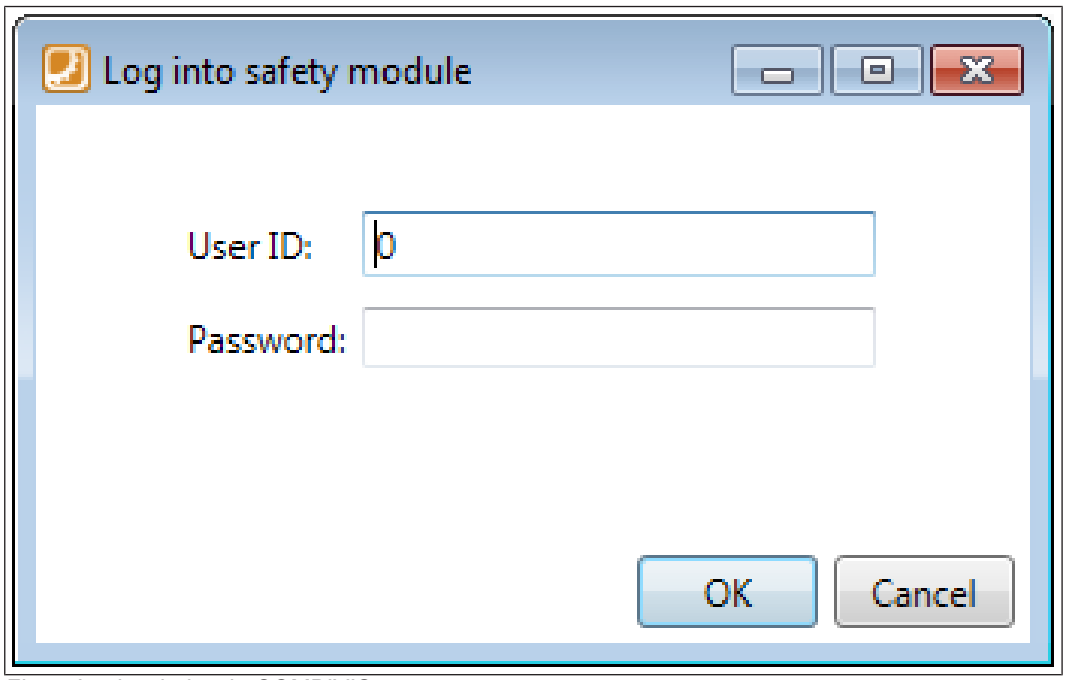

Fig. 4: Login window in COMBIVIS

For the first login there is a standard user, the login is done by input of

- User-ID = 1 and password = default
- The safety module flashes for approx. 1 minute after login. With the default user it is only possible to create new users, is not possible to download safety parameters onto the safety module or to read an existing configuration.
- Users can be created and provided with different rights. The user management is accessible via the button "User settings", see (≡► User management and login [▸ 21]). An user-ID and password can be assigned for each user. The user-ID 0 is not possible. Multiple creating of an user with the same user-ID is not possible and an error message is displayed.
- As soon as a user has been created who is allowed to manage users, logging in with user-ID 1 and password "default" is no longer possible.

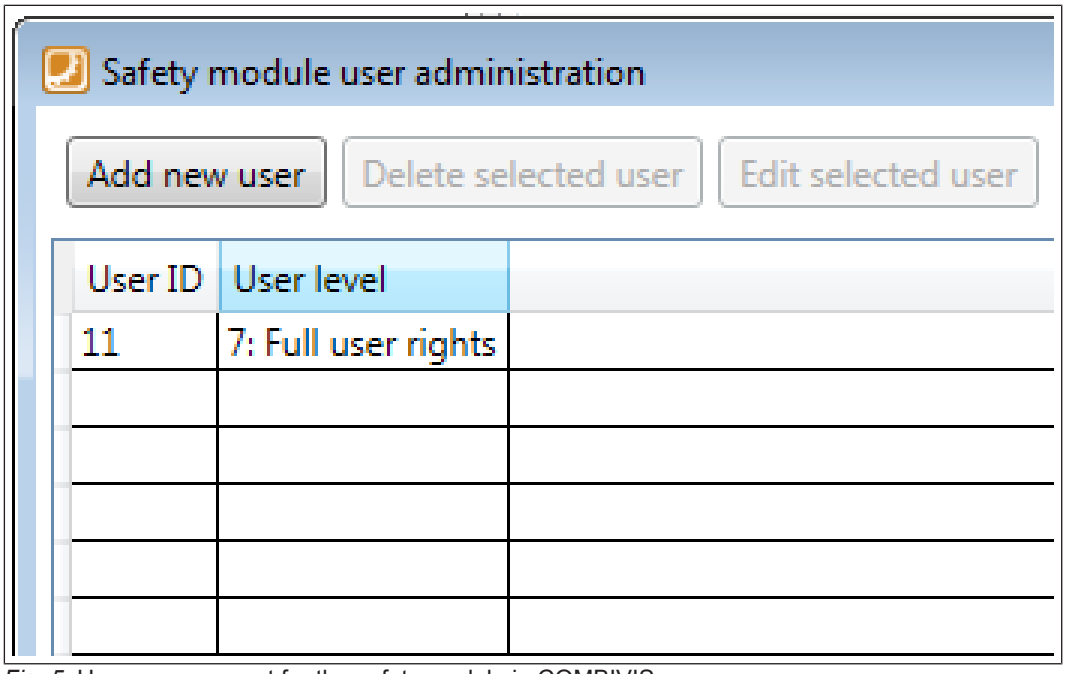

Fig. 5: User management for the safety module in COMBIVIS

5.1.2.1 Overview of user rights and user levels

There are 6 different user rights. When a new user was created the login with the default user is no longer possible.

User level	Login possible	Can change his own password	Can change existing user or add new user	Can download new configuration data	Can read an existing configuration
0: No user rights	x	x			
1: Add and change users	x	x	x		
2: Write new configuration data	x	x		x	
4: Read out configuration information	x	x			x
6: Read out and write configuration information	x	x		x	x
7: Full user rights	x	x	x	x	x

Tab. 6: Overview of the user rights to user level

5.2 Safe configuration of parameters of the safety module

The parameters of the safety module are configured in the tab "Safe parameterization" (≡► Safe configuration of parameters of the safety module [▷ 22])(≡► [▷ 21]). The parameters are classified into different groups, which can be filtered by the "parameter group" selection field. If the mouse pointer is left over a parameter for a longer time, then a tool tip is displayed, which contains further useful information about the parameter (≡► Safe configuration of parameters of the safety module [▷ 23])(≡► [▷ 21]).

Status | Settings | Safe parameterization | Log

Parameter group: - Display all groups - | Download | Upload | Im/Export

Device Type: **Safety Module Type 3**
Description: **Parameterversion: 3.2.0.1.**
Device CRC: **0x2CE18DDA**
Import file: -

Parameter	Value	Unit
Filter time of the safety inputs		
Filter time of the STO-Inputs	0.010000	s
Filter time of the SBC-Inputs	0.010000	s
Filter time of the Function1-Inputs	0.010000	s
Filter time of the Function2-Inputs	0.010000	s
Filter time of the Ripple-Inputs	0.010000	s
Test signal input configuration		
Test signal period	10.000000	s
Test signal pulse length	0.001000	s
Check of the test-signal for the STO-Inputs	off	
Check of the test-signal for the SBC-Inputs	off	
Check of the test-signal for the Function1-Inputs	off	
Check of the test-signal for the Function2-Inputs	off	
STO Hardware input configuration		
Configuration of the STO-Inputs	STO Safe torque off	
Tolerance time of the STO-Inputs	0.010000	s
Status of the STO-Inputs	equivalent	
SBC Hardware input configuration		
Configuration of the SBC-Inputs	SBC Safe brake control	
Tolerance time of the SBC-Inputs	0.010000	s
Status of the SBC-Inputs	equivalent	

Fig. 6: Safe configuration of the parameters of the safety module

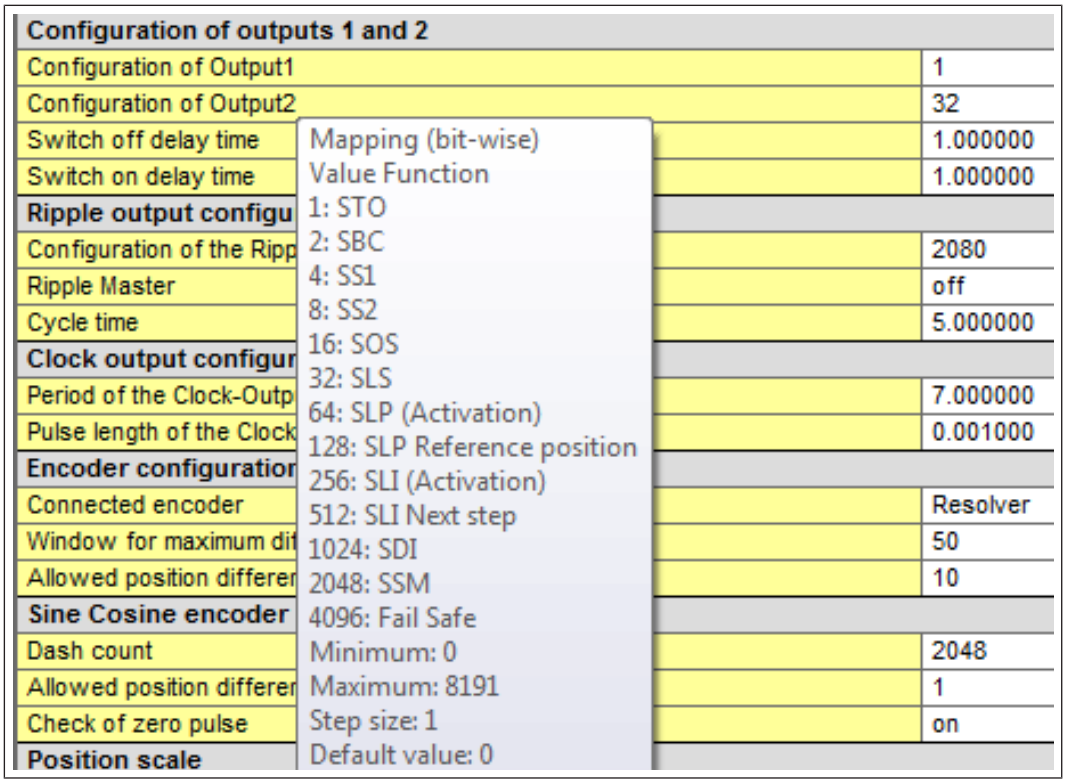

Fig. 7: Tooltip for the parameter Configuration of the ripple output

5.2.1 Download of new configuration data

The new parameterisation can be transferred to the safety module via the "download" button, if the logged-in user has sufficient rights. With the download the safety module checks again if the parameters are correctly configured. If an error is detected during the transfer of the configuration data, the data are not accepted and the safety module changes into error state. Then the errors can be read out from the range protocol (≡▶ Read out of errors [▶ 27]) and remedied.

5.2.2 Read out of existing configuration information from the safety module

If the logged-in user has sufficient rights, then configuration information can be read out from the safety module. It is sufficient to click the button "upload". After the completion of the readout process, the existing configuration is displayed in the configuration editor.

5.2.3 Import and export of configuration information

Configuration information can be imported or exported. Click the button "import/export“ and select an option.

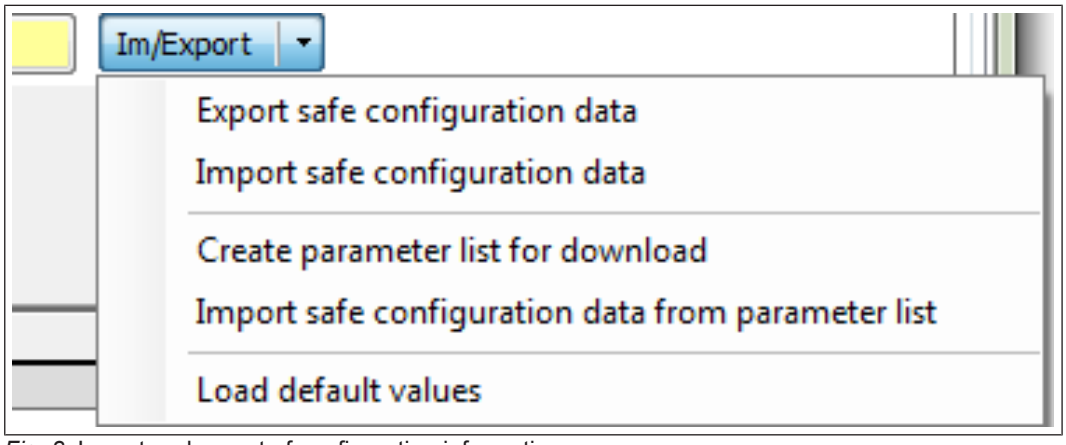

Fig. 8: Import and export of configuration information

5.2.3.1 Export of safe parameter data

The adjusted configuration data can be exported into a file via this menu item. These data can be imported again into another project. A change of the data in the file is not possible, since otherwise the import of data can not be executed.

5.2.3.2 Import of safe parameter data

Configuration data from a previously exported file can be imported again via this menu item. The data are displayed in the configuration editor after the import. The editor for the configuration data is write protected after the import. The write protection can be removed by a right-click in the editor and the option "unlock".

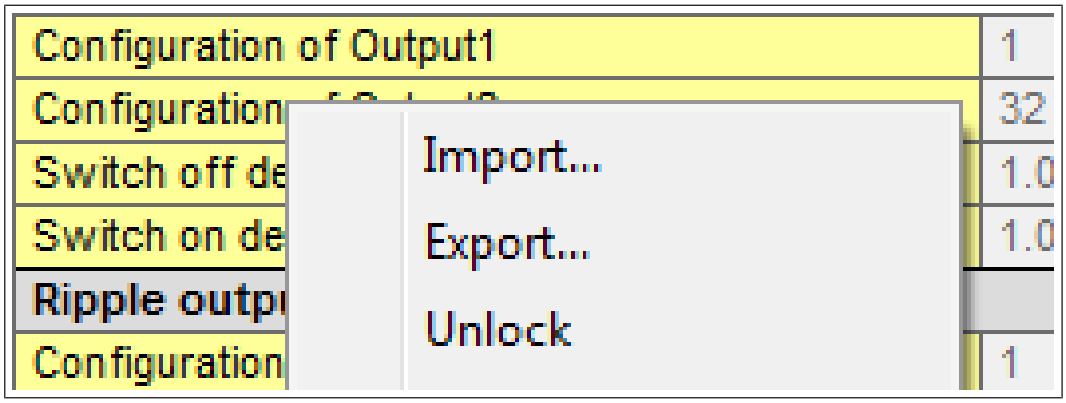

Fig. 9: "Unlock“ after the import of configuration information

Ein Import ist nur bei gleicher Firmwareversion möglich (Beispiel Firmwareversion 3.2.0.1 oder 5.5.0.8).

5.2.3.3 Generate parameter list for download

A download list is generated here, which can be transferred without the configuration editor COMBIVIS into the safety module. The download list can not be edited without the configuration editor, otherwise the download of the configuration data is rejected by the safety module. The download list is not human-readable.

5.2.3.4 Import safe parameter data from parameter list

Hereby a previously created download list is imported back into the configuration editor. The data are displayed in the configuration editor after the import.

Ein Import ist nur bei gleicher Firmwareversion möglich (Beispiel Firmwareversion 3.2.0.1 oder 5.5.0.8).

5.2.3.5 Load default values

This loads the default values for all safety-oriented parameters. This is useful to restart the safety-oriented parameterization from a defined state in case of an unknown state of the configuration.

By loading the default values, the default values are not automatically transferred in the safety module. The acceptance of the values always requires an explicit download.

5.3 Status of the safety module

The status of the safety module can be displayed in the "Status" tab (≡▶ Status of the safety module [▶ 25]). If the safety module is in error state is displayed in the status of the control of COMBIVERT with parameter ru01 = "55“ (error safety module).

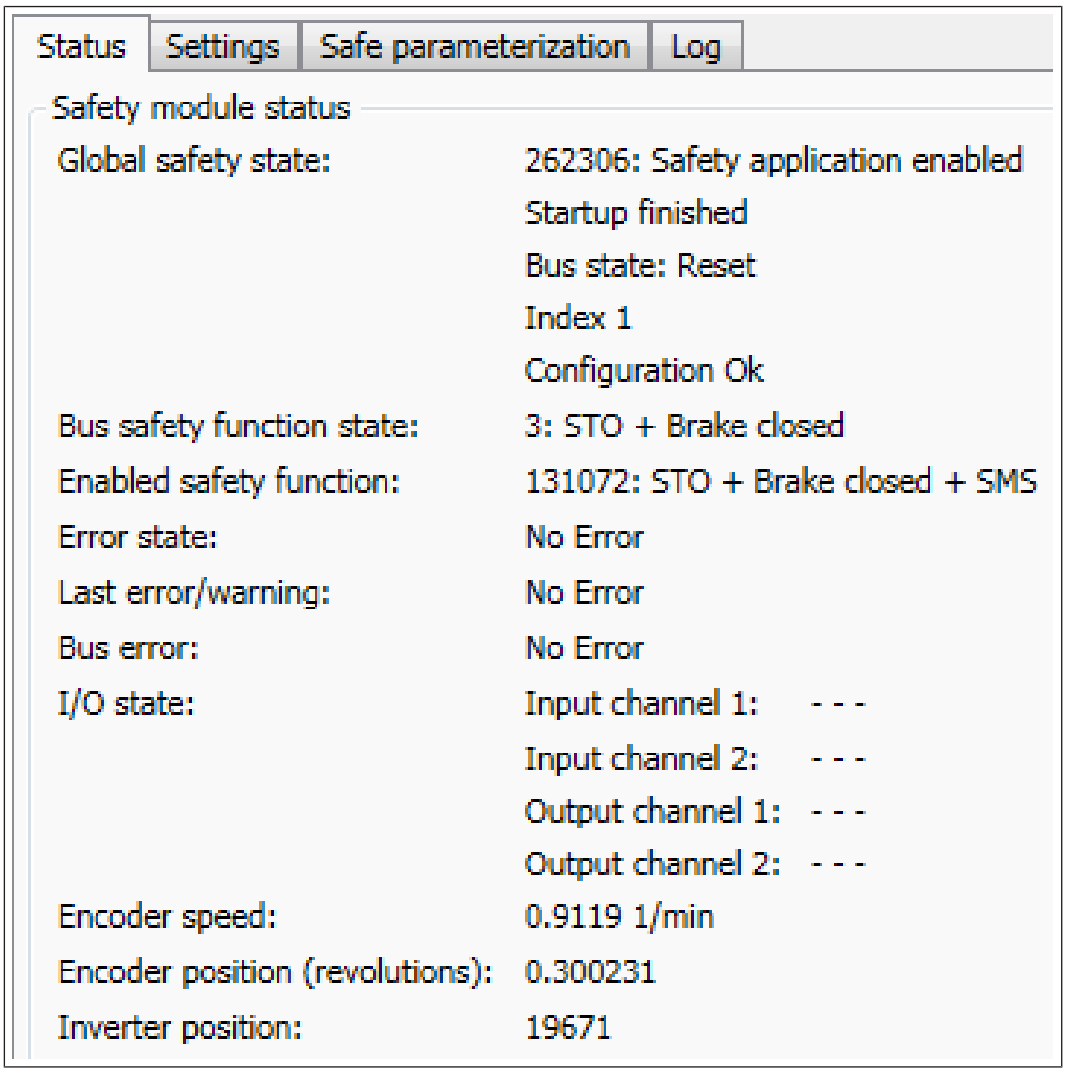

Fig. 10: Status tab in the KEB safety editor

General safety state:

Provides information if the safety module works properly and whether the configuration has any faulty entries. Details (≡► Configuration state and configuration transfer [▷ 40]).

Bus safety function state:

Provides information which safety function was requested by the safe bus system.

Activated safety functions

List of safety functions currently activated as summarized result of the state of the digital inputs and FSoE data.

Error state:

The error status provides information whether there is an error. The error cause can be detected by the displayed error text (≡► Status of the safety module [▷ 26])(≡► [▷ 25]) (≡► [▷ 25]).

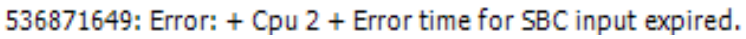

Fig. 11: Error state with error description in COMBIVIS

Last error / warning notice:

The last detected error is displayed here, and all errors are also recorded in the error log.

Bus error:

The last bus error which has been detected during the communication with the safe master is displayed here.

I/O state:

The input and output state is displayed here. The input state is the state of the inputs to the safety module.

The outputs on the safety card are designed as two-channel systems. The output state consists of the input state at the terminals of the safety module, the configuration for the outputs and partly from the input state of the control board. In order that the brake can be switched off (switching the brake output), the SBC input of the safety module must be switched on and co00 bit 15 must be set to 1 in the device parameters of the COMBIVERT. Only then the brake output will be switched.

Encoder speed:

The speed of the drive is displayed here. The speed was determined by the safety module.

Encoder position (in revolutions):

The position of the drive is displayed here. If a reference position was already approached and is confirmed with the button, then the position is output depending on the reference position.

Inverter position (in bits per revolution):

The position is indicated here as scaled position value. The position value is displayed with the configured „Position scale“. If a reference position was already approached and is confirmed with the button, then the position is output depending on the reference position.

5.4 Read out of the log data

Read out of the log data can be done via the tab "Log". There are different types of log data which can be read out. The readout process is started by selecting one or more buttons and then clicking the "Update" button.

The last 20 entries in each category are stored non-volatile.

The log data are based on the clock on the safety module. If this clock is not set correctly, the log data may contain the wrong time and the wrong date. The real-time clock has a power reserve of approx. 2 days.

5.4.1 Read out of errors

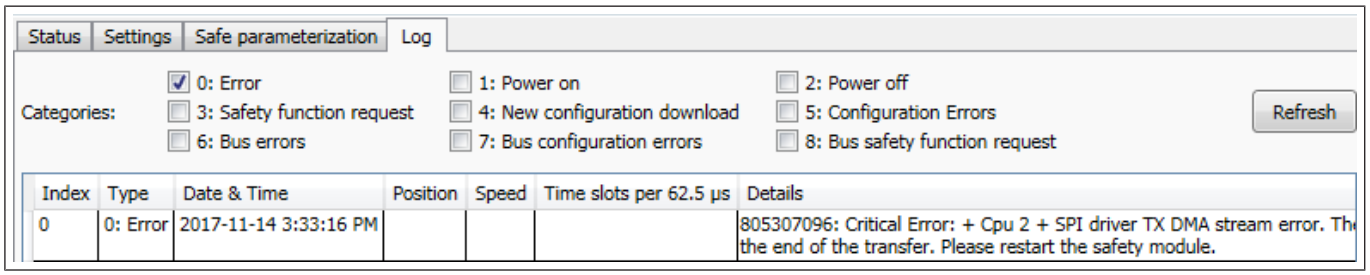

Fig. 12: Error time, error number and description

To read out errors, the respective category must be marked in the "Potocol" tab. Then the error log is read out and displayed by the safety module by clicking on "update".

5.4.2 Read out of switch-on sequences

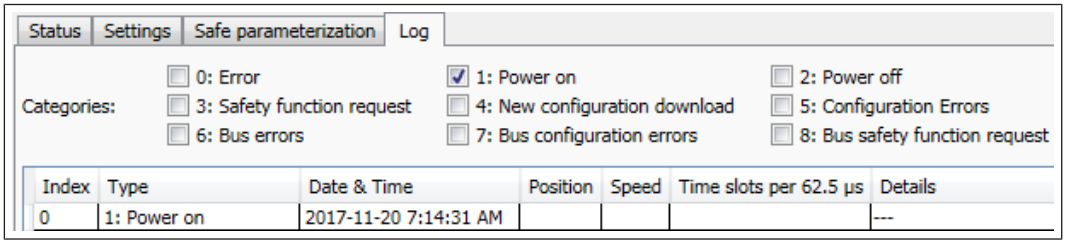

Fig. 13: Switch-on sequences with date and time in log

To read out switch-on times, the button "Switch on" must be set in the "Protocol" tab. Then the protocol of the safety module is read out and displayed by click on "update".

5.4.3 Read out of switch-off sequences

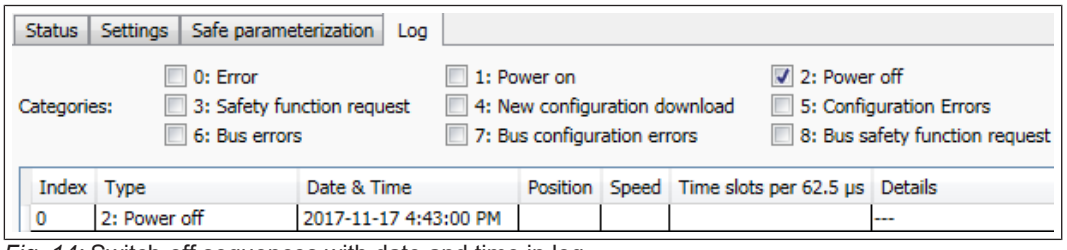

Fig. 14: Switch-off sequences with date and time in log

For read out of the switch-off sequences, press the button "switch-off" in the "Protocol" tab. Then the protocol of the safety module is read out and displayed by click on "update". The switch-off time is to 5 minutes precisely.

5.4.4 Read out of requirements for safety functions

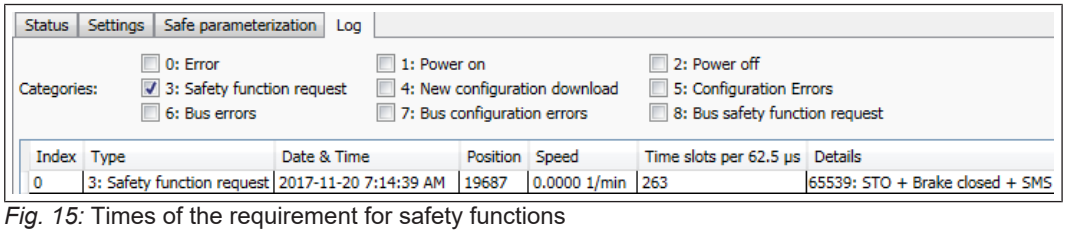

Fig. 15: Times of the requirement for safety functions

To read out requests of safety functions, the "Safety function execution time" switch must be set in the Log tab. Then the protocol of the safety module is read out and displayed by click on "update".

5.4.5 Read out of the time to assume new configuration data

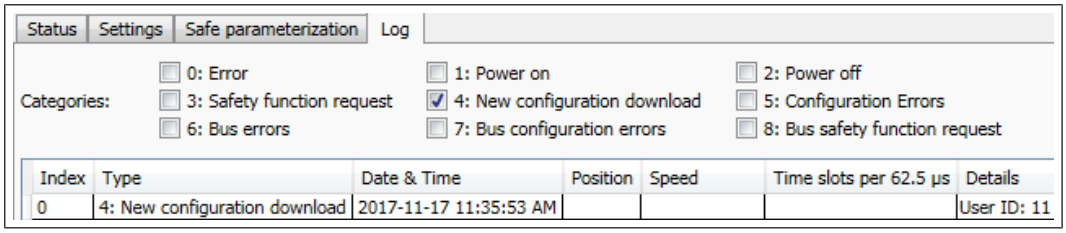

Fig. 16: Transfer time of new configuration data

For read out of transfer times of new configuration data, press the button "transfer time of the new configuration“ in the "Protocol" tab Then the protocol of the safety module is read out and displayed by click on "update". The transfer time and the user-ID is displayed in the protocol.

5.4.6 Read out of configuration errors

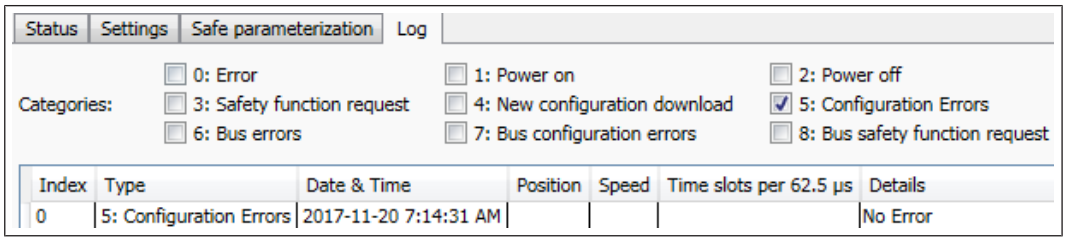

Fig. 17: Time, error number and description of configuration errors

To read out configuration errors, the "Configuration errors" button must be activated in the "Protocol" tab. Then the protocol of the safety module is read out and displayed by click on "update".

The configuration errors are deleted at a restart of the safety module and the old functional configuration without configuration errors is restored.

5.4.7 Read out of bus errors

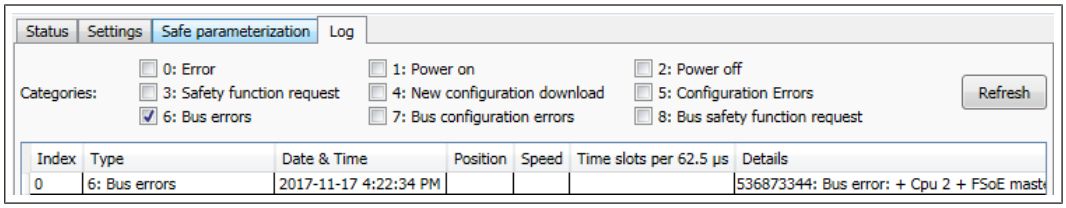

Fig. 18: Bus error with date and time in log

To read out bus errors, the "Bus error" switch must be activated in the "Protocol" tab. Then the protocol of the safety module is read out and displayed by click on "update".

5.4.8 Read out of bus configuration errors

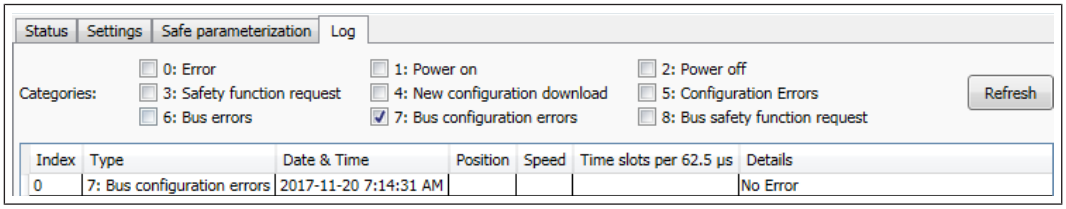

Fig. 19: Bus configuration errors with date and time in log

For read out of bus configuration errors, "Bus configuration error" switch must be set in the "Protocol" tab Then the protocol of the safety module is read out and displayed by click on "update".

5.4.9 Bus request of safety functions

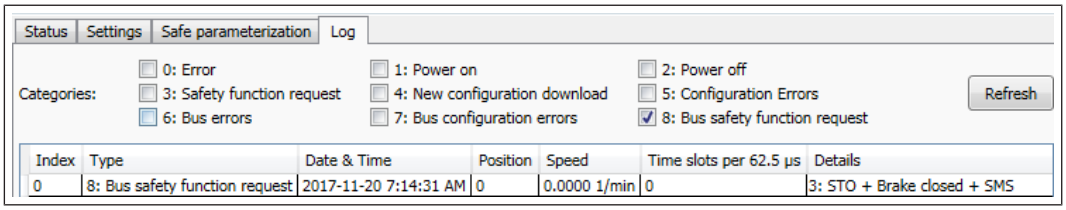

Fig. 20: Bus request of safety functions in log

To read out the requests for safety functions via the safe bus system, the "Bus request for safety functions" switch must be activated in the "Protocol" tab. Then the protocol of the safety module is read out and displayed by click on "update".

5.5 Parameter List

Name	Note	Unit	min	Max	Default
(≡▶ Filter times of the safety and diagnostic inputs [▶ 42])					
Filter time of the STO inputs	Filter time for debouncing of STO safety function input signals	s	0	0,1	0,01
Filter time of the SBC inputs	Filter time for debouncing the input signals of the safety function SBC	s	0	0,1	0,01
Filter time of function1 inputs	Filter time for debouncing the input signals of safety function 1	s	0	0,1	0,01
Filter time of function2 inputs	Filter time for debouncing the input signals of safety function 2	s	0	0,1	0,01
Filter time of the ripple inputs	Filter time for debouncing the input signals of the ripple function	s	0	0,1	0,01
Clock signal input configuration					
Test signal period	Period of the test-signals (clock-output) to check the connection. The setting is valid for all inputs	s	0,01	10,0	10,0
Test signal pulse length	Period of the test-signals (clock-output) to check the connection. The setting is valid for all inputs	s	0,0005	0,001	0,001
Check of the test-signal for the STO-Inputs	Check of the STO-Inputs on, if they are connected with a test signal		off	on	off
Check of the test-signal for the SBC-Inputs	Check of SBC inputs on, if they are connected with a test signal		off	on	off
Check of the test-signal for the Function1-Inputs	Evaluation of the function 1 inputs if they are assigned a test signal.		off	on	off

Evaluation of the test signal for the function2 inputs	Evaluation of the function 2 inputs if they are assigned a test signal.		off	on	off
STO hardware input configuration					
Assignment of STO inputs	Selection of the safety function which can be activated by the STO inputs		0	18	STO
Tolerance time of the STO-Inputs	The status between the two STO-Inputs can be different during the tolerance time	s	0	0,1	0,01
Status of the STO-Inputs	The status of both STO-Inputs is equivalence or non-equivalence		antivalent	equivalence	equivalence
SBC hardware input configuration					
Assignment of the SBC inputs	Selection of the safety function which can be activated by the SBC inputs		0	18	SBC
Tolerance time of the SBC-Inputs	The status between the two STO-Inputs can be different during the tolerance time	s	0	0,1	0,01
Status of the SBC-Inputs	The status of both SBC-Inputs is equivalence or non-equivalence		antivalent	equivalence	equivalence
Function 1 Hardware input configuration					
Assignment of the function1 inputs	Selection of the safety function which can be activated by the Function1-Inputs		0	18	0
Tolerance time of the Function1-Inputs	The status between the two Function1-Inputs can be different during the tolerance time	s	0	0.1	0.01
Status of the Funktion1-Inputs	The status of the two function 1 inputs is equivalent or antivalent.		antivalent	equivalence	equivalence
Function 2 Hardware input configuration					
Assignment of the function2 inputs	Selection of the safety function which can be activated by the Funktion2-Inputs		0	18	0
Tolerance time of the Funktion2-Inputs	The status between the two Funktion2-Inputs can be different during the tolerance time	s	0	0.1	0.01
Status of the Funktion2-Inputs	The status of the two function 2 inputs is equivalent or antivalent.		antivalent	equivalence	equivalence
Ripple hardware input configuration					
Assignment of the ripple inputs	Selection of the safety function which can be activated by the Ripple-Inputs		0	18	0
Tolerance time of the Ripple-Inputs	During the tolerance time, the status between the two ripple inputs may deviate.	s	0	0.1	0.01
Configuration of the outputs 1 and 2					
Output1 configuration	Assignment (bitwise)		0	131071	0
Configuration of Ausgang2	Assignment (bitwise)		0	131071	0

Switch on delay time	Outputs 1 and 2 are switched on with a delay to the switching condition	s	0	1	0.0
Configuration of the Ripple-Output					
Configuration of the Ripple-Output	Mapping (bitwise)		0	8191	0
Ripple Master	With "on", this security module is the master of the ripple chain from				off
Cycle time	Required time to send the ripple signal through a closed chain	s	0	60	0.0
Clock output configuration					
Period of the Clock-Output	Period of the test-signals to check the connection	s	0.01	10	10.0
Pulse length of the Clock-Output	Pulse-time of the test-signals (clock-output) to check the connection.	s	0.0005	0.001	0.001
Encoder configuration					
Connected encoder	Selection of the encoder type: - No encoder - Sin/Cos encoder - Resolver				no encoder
Window for maximum difference	The deviation of the sine and cosine signals is monitored by sin ² x + cos ² x = 1 ± window	%	0	95	50
Allowed position difference between the input channels	If the difference of the position determination of the two CPUs is higher than the adjusted value, the module changes into the safe state	°	1	90	10
Sine cosine encoder configuration					
Increments per revolution	Number of sine-/ cosine-periods per revolution		128	16000	2048
Allowed position difference	If the difference between the position in increments and the number of sine or cosine channel pulses is bigger as this parameter, than the safety module is going to the safety state. The maximum value is (dash count * 4) / 2 - 1.		1	Line count/2-1	1
Check of zero pulse	The check of the zero pulse can be switched off				on
Scaling settings for the position					
Number of bits per revolution (Ps)	The resolution of the position is configured by this parameter (Unit Ps). The 32 bit position values are divided into the parameter value for the bit per revolution and the remaining bits are used for the full turns	Bit	2	30	16
Settings for speed measurement					
Speed scan time	Parameter specifies the time over which the engine speed average is calculated.		2	7	4
Speed PT1 time	Parameter specifies the time of the PT1 filter for the speed calculation.	ms	0	256	2.0
SBC: Safe brake control					

Coupling of SBC with STO	If on, the SBC function is activated when the STO function is executed.				off
Measurement of the brake current	The measurement of the brake current can be enabled (on). If the current is bigger than 3.3 A, the module is transferred to a safe state				on
SS1: Safe stop 1					
Selection of the type of the function	Possible types of functions: Type r and t Type r Type t				Type r and t
Deceleration	Specification of the monitoring ramp. Speed change in the time period of delta t.	1/s²	0.01	60000	0.01
Negative tolerance	The allowed negative tolerance to the ramp	rpm	0	120000	0.0
Positive tolerance	The allowed positive tolerance to the ramp	rpm	0	120000	0.0
Time window of speed deviation	If the deviation of the velocity is greater than the tolerance and longer than the specified time window existed, the STO function is executed	s	0	600	0.0
Type t time	Time period till the STO function is activated	s	0	600	0.0
Higher deceleration allowed	The speed must not be higher than the deceleration + positive tolerance. However, the lower speed limit is 0 - negative tolerance. Thus the drive can also decelerate faster.				off
SS2: Safe stop 2					
Selection of the type of the function	Possible types of functions: Type r and t Type r Type t				Type r and t
Deceleration	Specification of the monitoring ramp. Speed change in the time period of delta t.	1/s²	0.01	60000	0.01
Negative tolerance	The allowed negative tolerance to the ramp	rpm	0	120000	0.0
Positive tolerance	The allowed positive tolerance to the ramp	rpm	0	120000	0.0
Time window of speed deviation	If the deviation of the velocity is greater than the tolerance and longer than the specified time window existed, the STO function is executed	s	0	600	0.0
Type t time	Time period till the STO function is activated	s	0	600	0.0

Higher deceleration allowed	The speed must not be higher than the deceleration + positive tolerance. However, the lower speed limit is 0 - negative tolerance. Thus the drive can also decelerate faster.				off
SLS: Safely-limited speed					
Upper speed limit	If the speed exceeds the upper speed limit, then the error function will be activated. This is the limit value for the positive direction of rotation.	rpm	-60000.000000	60000.000000	60000.000000
Lower speed limit	If the speed falls below the lower speed limit, then the error function will be activated. This is the limit value for the negative direction of rotation.	rpm	-60000.000000	60000.000000	-60000.000000
Tolerance time	Within this time an exceeding of the speed limits is ignored.	s	0	60	0.000000
Error function	Selection of the function that is executed when the limit is passed.		STO	SS1	STO
SSM: Safe speed monitor					
Upper speed limit	If the speed exceeds the upper speed limit, then the error function will be activated. This is the limit value for the positive direction of rotation.	rpm	-60000.000000	60000.000000	60000.000000
Lower speed limit	If the speed falls below the lower speed limit, then the error function will be activated. This is the limit value for the negative direction of rotation.	rpm	-60000.000000	60000.000000	-60000.000000
Hysterese	If the speed exceeds the speed level + hysteresis, then the output condition of the function is activated. At underrun of speed level - hysteresis, the output is disabled.	rpm	0.000000	60000.000000	0.000000
Monitoring always active	At "off" the speed monitoring has to be activated via an input. At "on" it is always active and an input configured for the same safety function is ignored.				off
SMS: Safe maximum speed					
Upper speed limit	If the speed exceeds the upper speed limit, then the error function will be activated. This is the limit value for the positive direction of rotation.	rpm	-60000.000000	60000.000000	60000.000000
Lower speed limit	If the speed falls below the lower speed limit, then the error function will be activated. This is the limit value for the negative direction of rotation.	rpm	-60000.000000	60000.000000	-60000.000000
Tolerance time	Within this time an exceeding of the speed limits is ignored.	s	0.000000	60.000000	0.000000

Error function	Selection of the function that is executed when the limit is passed.		STO	SS1	STO
SLA: Safely limited acceleration					
Upper acceleration limit	The upper acceleration limit of the safely limited acceleration in the forward direction (clockwise rotation).	1/s²	$-1 \cdot 10^{-6}$	$1 \cdot 10^{-6}$	0.000000
Lower acceleration limit	The lower acceleration limit of the safely-limited acceleration in reverse direction (counter-clockwise rotation).	1/s²	$-1 \cdot 10^{-6}$	$1 \cdot 10^{-6}$	0.000000
Error function	Selection of the function that is executed when the limit is passed.		STO	SS1	STO
SOS. Safe operation stop					
Position window	Tolerance window of the standstill position	Ps	$-2.147 \cdot 10^{9}$	$2.147 \cdot 10^{9}$	0
Time window for position deviations	If the position difference to the standstill position is greater than the position window and is present for longer than the set time window, the STO function is executed	s	0.000000	60.000000	0.000000
SLI: Safely-limited increment					
Limited increment	Configuration of the position difference that the drive may execute when an increment is triggered via the input.	Ps	0	4294967295	0
Minimum stay in the position window	Configuration of the minimum time that the drive must be in the SOS function before a new increment is accepted.	s	0.000000	1.000000	0.000000
Error function	Selection of the function that is executed out at a breach of the limited increment (STO or SS1)		STO	SSI	STO
Position window	Tolerance window of the position	Ps	0	4294967295	0
Time window for position deviations	If the position difference is greater than the position window and this is existed longer than the time window, the selected error function is activated	s	0.000000	1.000000	0.000000
SLP: Reference position					
Absolute reference position	Configuration of the position at the reference point.	Ps	$-2.147 \cdot 10^{9}$	$2.147 \cdot 10^{9}$	0
SLP: Safely-limited position					
Maximum drive position	If the position is greater than the set value, the drive executes the selected error function.	Ps	$-2.147 \cdot 10^{9}$	$2.147 \cdot 10^{9}$	0
Minimum drive position	If the position is smaller than the set value, the drive executes the selected error function.	Ps	$-2.147 \cdot 10^{9}$	$2.147 \cdot 10^{9}$	0
Error function	Selection of the function that is executed when leaving the position range (STO or SS1).		STO	SS1	STO

SEL: Difference position	The safety function SEL is activated as soon as the difference position to the max. or min. position has been reached.	Ps	0	$2.147 \cdot 10^9$	0
SEL: Limit for the speed	If the safety function SEL is activated, the speed of the drive must not be increased beyond the limit. This is a ramp up to SLP maximum drive position.	rpm	0	60000	0
Bus settings					
Bus type	This is the selection of the safe bus type. The selection parameters are "No bus" or "FSoE".		0	1	No bus
Safety address	Safety address of the safety module in the safety field bus		0	65535	0
Safe bus data length	If a safe bus system has been selected, the length of the safe data must be adjusted.		5	19	11
Safe bus data telegram selection			0x000h	0x098Ah	0x000h
Bus units					
Scaling of the position of the bus data			0	16	0
Scaling of the speed via safe bus data			0	13	0

Tab. 7: Parameter list safety module type 3

6 Operating condition of the safety module

The operating and error state can be checked in COMBIVIS via the KEB safety editor Status of the safety module.

6.1 Global operating condition

The operating condition of the safety module is divided into different stages. The global status of the safety module (≡► [▷ 36])(≡► [▷ 36])displays the different states for the safety module.

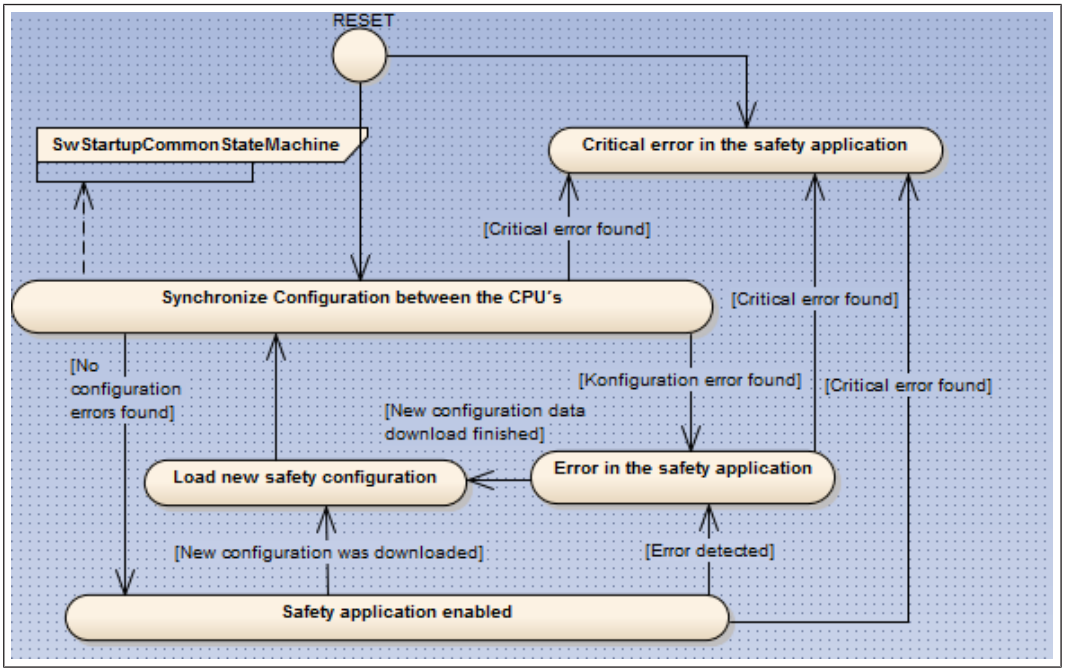

Fig. 21: The global status of the safety module

Reset:

This is the status when the safety module is switched on. The safety module performs the safety function STO.

Synchronize configuration between the CPUs:

The safety module has two independent CPUs. After the configuration has been loaded, it must be transferred to the two CPUs and checked. In this status, the safety module executes the safety function STO and the outputs remain switched off.

Safety operation released:

The safety module is ready to carry out safety operations.

Critical error in the safety module:

A critical error has been detected in the safety module. The detected error can be checked in status safety module. The safety module performs the safety function STO and the outputs are switched off. This status is permanent and can be left only by a power on reset.

Error in the safety module:

A non-critical error has been detected in the safety module, e.g. a configuration error. The state can be left by downloading a new configuration or by power on reset.

Loading of new safety configuration:

New configuration data were transferred to the safety module. Now the new configuration data are complete and in the next step the safety module tries to validate the configuration data.

6.2 Start of the safety module and transfer of new configuration data

Starting the safety module and the appropriate software is divided into different states. (≡► Start of the safety module and transfer of new configuration data [▸ 38]) displays the different states of the safety module when starting.

Software is initialised:

This status indicates that the software has been initialised. The configuration data is read from the memory.

CPU communication is started:

The safety module has two CPUs. The data communication between the two CPUs must be functional in order to exchange configuration data.

Synchronize time slot:

The two CPUs of the safety module must run synchronously. Therefor the time slot must be synchronised.

Start the synchronisation of the configuration:

Now the configuration is provided for the synchronisation from one to the other CPU of the safety module.

Complete the synchronisation of the configuration:

Now the configuration is transferred to the other CPU.

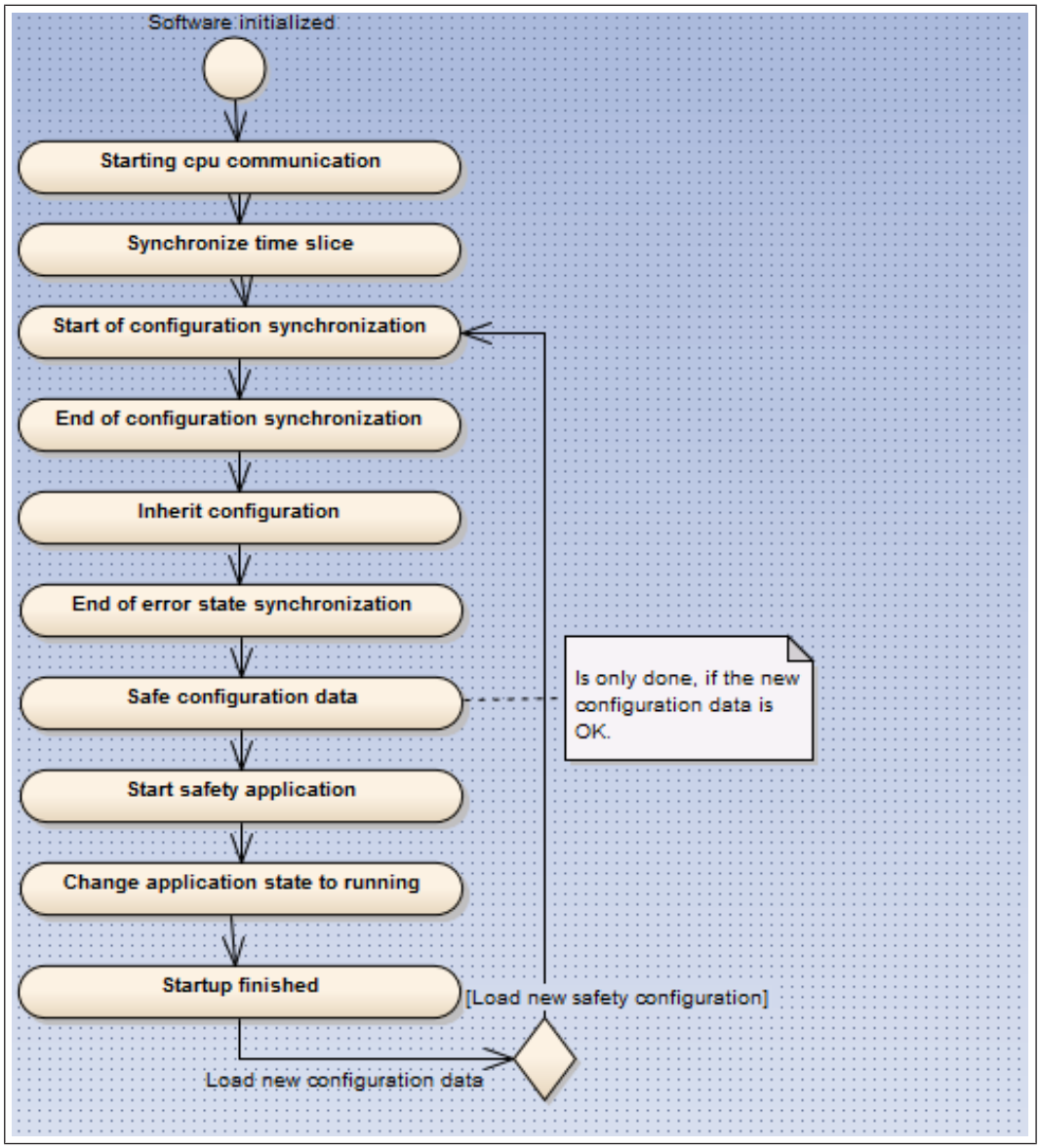

Fig. 22: Booting the safety module

Configuration data transfer:

The configuration transfer is complete. The configuration data are now checked for plausibility.

Complete the synchronisation of the error status:

Configuration errors have been provided after configuration data transfer and are now exchanged between the two CPUs.

Safe the configuration data:

These data are now saved if the configuration data have no error.

Start the safety software:

The safety software can be started now, the configuration data are available.

Change the application status to safety operation released:

The general operating mode is changed now to safety operation released. The general operating mode is changed to error in the safety module if an error was detected in the configuration.

Booting the safety module completed:

The safety module is now able to carry out safety operations.

6.3 Error reset

Errors can be reset as follows

- Restart (Power-On-Reset)
- Loading a configuration
- Digital input (fail safe bit); Reset by switching off the voltage
- Resetting the fail safe reset bit

7 Configuration state and configuration transfer

7.1 Configuration state

The configuration status displays whether new configuration data are error-free. Configuration status of the safety module shows the various statuses of the safety module.

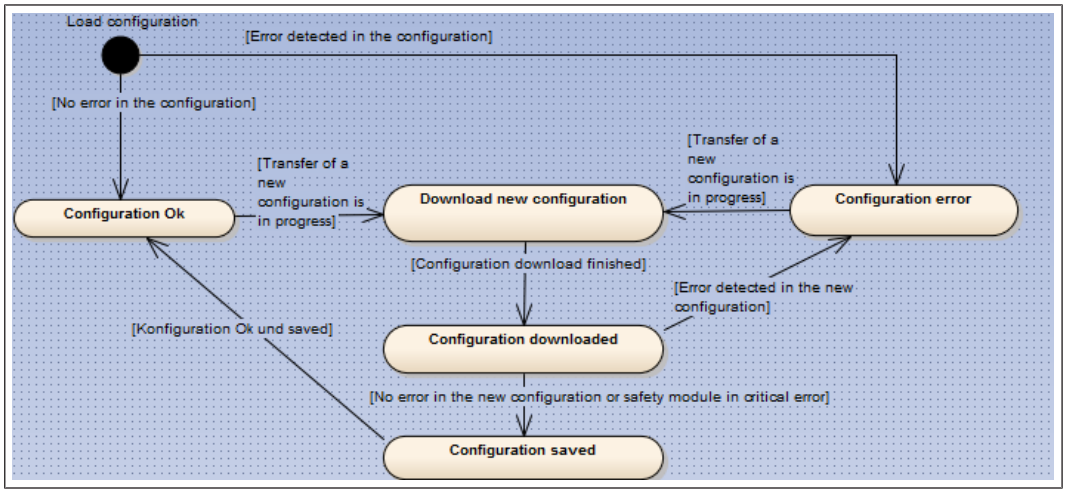

Fig. 23: Configuration state of the safety module

Load configuration:

The configuration data are loaded from the non-volatile memory.

Download of the new configuration:

Just download new configuration data.

Configuration stored:

Configuration data were downloaded, are error-free and were stored in non-volatile memory. Or the safety module is in state "Critical error in the safety module“. Then, the new configuration is stored without checking the correctness. This is done with the next start of the safety module.

Configuration is incorrect:

The configuration is incorrect and is not stored. The configuration error can be read in the configuration log.

Configuration OK:

The configuration has been downloaded, checked and is error-free. The configuration has been stored.

7.2 Create configuration data for different machines

Configuration data for different machines can be equipped with a safety module address. An address between 0 and 65535 can be configured individually for each safety module. If a configuration is downloaded to the safety module, the new configuration is accepted only if the addresses are conform.

The safety module address is displayed in the configuration data in (≡► Create configuration data for different machines [▶ 41])(≡► [▶ 40])(≡► [▶ 40]).

Setting the security module address Identification (safety module address).Identification (safety module address)

Fieldbus parameter		
Safety address	0	

Fig. 24: Safety module address in the configuration data

8 Input configuration and input parameter

The safety module has 2 configurable inputs, 2 fixed assigned inputs and a ripple input.

- The fixed assigned inputs can be used for safety function STO and SBC.
- Configurable inputs can be used for triggering of safety functions.
- The ripple input is used to network the safety module with other safety modules.

8.1 Filter time for safety and diagnosis inputs

A filter time can be configured for each safety input and the diagnostic inputs. The filter time suppresses interference at the input. The change of input status is delayed by the filter time.

Filter time of the STO inputs

A change of signal at the input is only recognised by the safety module after the set time has elapsed (debounce).

ID	Name	Value	Unit	Min. value	Max. value
01.01	Filter time of the STO inputs	0.010000	s	0.000000	0.100000

Filter time of the SBC inputs

A change of signal at the input is only recognised by the safety module after the set time has elapsed (debounce).

ID	Name	Value	Unit	Min. value	Max. value
01.02	Filter time of the STO inputs	0.010000	s	0.000000	0.100000

Filter time of function1 inputs

A change of signal at the input is only recognised by the safety module after the set time has elapsed (debounce).

ID	Name	Value	Unit	Min. value	Max. value
01.03	Filter time of function1 inputs	0.010000	s	0.000000	0.100000

Filter time of function2 inputs

A change of signal at the input is only recognised by the safety module after the set time has elapsed (debounce).

ID	Name	Value	Unit	Min. value	Max. value
01.04	Filter time of function2 inputs	0.010000	s	0.000000	0.100000

Filter time of the ripple inputs

A change of signal at the input is only recognised by the safety module after the set time has elapsed (debounce).

ID	Name	Value	Unit	Min. value	Max. value
01.05	Filter time of the ripple inputs	0.010000	s	0.000000	0.100000

8.2 Clock signal input configuration

Each input of the safety module, except the ripple input, can be connected to a signal on which test signals are performed. The logic of the signal is cyclically inverted for one clock signal. The clock input analysis detects cross-faults between the input channels. To detect dangerous line short circuits between two related inputs, contact pairs are supplied via phase-shifted clock outputs. Here, e.g., the clock outputs of the safety module are connected to the clock inputs via switch.

The clock input configuration must agree with the clock output configuration of the connected outputs.

8.2.1 Test signal period

This parameter affects the evaluation of the test signal of all safety inputs. The period is the time from a test signal to the next. The period duration must match the period duration setting for the clock outputs that are connected to the respective inputs.

ID	Name	Value	Unit	Min. value	Max. value
02.01	Test signal period	10.000000	s	0.010000	10.000000

Test signal pulse length

This parameter affects the evaluation of the clock signal of all safety inputs. The pulse length must agree with the setting of the pulse length for the clock outputs, which are connected to the respective inputs.

ID	Name	Value	Unit	Min. value	Max. value
02.02	Test signal pulse length	0.001000	s	0.000500	0.001000

8.2.2 Evaluation of the test signal for the STO inputs

Switches the evaluation on/off.

ID	Name	Value	Unit	Min. value	Max. value
02.03	Check of the test-signal for the STO-Inputs	off	-	off	on

8.2.3 Evaluation of the test signal for the SBC inputs

Switches the evaluation on/off.

ID	Name	Value	Unit	Min. value	Max. value
02.04	Check of the test-signal for the SBC-Inputs	off	-	off	on

8.2.4 Evaluation of the test signal for the function1 inputs

If "on" is selected here, then it is continuously checked, whether a clock signal with the configured period and pulse length is detected at the input. Furthermore, it is checked that the clock signal is not available simultaneously at channel 1 and channel 2. If no clock signal has been detected 5 times successively, the safety module changes into the safe state.

ID	Name	Value	Unit	Min. value	Max. value
02.05	Check of the test-signal for the Function1-Inputs	off	-	off	on

8.2.5 Evaluation of the test signal for the function2 inputs

If "on" is selected here, then it is continuously checked, whether a clock signal with the configured period and pulse length is detected at the input. Furthermore, it is checked that the clock signal is not available simultaneously at channel 1 and channel 2. If no clock signal has been detected 5 times successively, the safety module changes into the safe state.

ID	Name	Value	Unit	Min. value	Max. value
02.06	Evaluation of the test signal for the function2 inputs	off	-	off	on

8.3 STO hardware input configuration

The STO input normally is used to trigger the safety function STO. However, the input can also be configured differently.

8.3.1 Assignment of STO inputs

ID	Name	Value (default)
03.01	Assignment of STO inputs	STO (Safe Torque off)

Value list
Hardware input deactivated: The safety input is not assigned with a safety function.
STO Safe torque off
SBC Safe brake control
SS1 Safe stop 1
SS1 Safe stop 2
SOS Safe operating stop
SLS Safely limited speed
SLP Safely limited position
SLP Set reference point. The safety function "Set safely limited position of the reference position" is executed.
SLI Safely limited pacing When the input is active, the SLI function is not active. If the function is not selected or the input is not active, the safety function "Safely Limited Increment" is executed in addition to other selected safety functions.
SLI Next step Sets the "SLI Next Step" input for the "Safely limited increment" safety function.
SDI Safe direction of movement forwards (clockwise)
SDI Safe direction of movement backwards (anti-clockwise)
SSM Safe speed monitoring
SLA Safely limited acceleration
Reset fail safe If a safety function detects an error, e.g. because limits have been exceeded, then the fail safe bit is set in the status. This error can be reset by means of a configured input. The reset is carried out when the voltage at the input is switched off.
Record number Bit 0 Many safety functions have an index and can therefore be configured multiple times. At runtime, a changeover can then be made via a configured input or via FSoE. Index selection bit 0 controls the first bit ("LSB").
Record number Bit 1 Many safety functions have an index and can therefore be configured multiple times. At runtime, a changeover can then be made via a configured input or via FSoE. Index selection bit 1 controls the second bit.

Value list				
Record number bit 2 Many safety functions have an index and can therefore be configured multiple times. At runtime, a changeover can then be made via a configured input or via FSoE. Index selection bit 2 controls the third bit ("MSB").				
Index selection via configurable inputs 1-3				
Index	**Value**	**Input 3 (Bit 2)**	**Input 2 (Bit 1)**	**Input 1 (Bit 0)**
1	**0**	**0**	**0**	**0**
2	**1**	**0**	**0**	**1**
3	**2**	**0**	**1**	**0**
4	**3**	**0**	**1**	**1**
5	**4**	**1**	**0**	**0**
6	**5**	**1**	**0**	**1**
7	**6**	**1**	**1**	**0**
8	**7**	**1**	**1**	**1**

8.3.2 Tolerance time of the STO-Inputs

The inputs are designed with two channels. This can cause that a channel is switched earlier or later than the second channel. Enter a tolerance time here to ensure that this does not immediately result in an error.

ID	Name	Value	Unit	Min. value	Max. value
03.02	Tolerance time of the STO-Inputs	0.010000	s	0.000000	1.000000

8.3.3 Status of the STO inputs

ID	Name	Value (default)
03.03	Status of the STO inputs	equivalence

Value list
At "equivalent" the two safety inputs must always be switched the same. It is not allowed to supply a channel with 24V input voltage and the other channel with 0V. The safety function is carried out if the input voltage is 0V.
Both channels are controlled with opposite logic at "antivalent". The following applies: The safety function is not carried out if STO.1 is supplied with an input voltage of 24V. The safety function is executed if STO.2 is supplied with an input voltage of 0 V.

Deviations of the set tolerance time from the set Equivalent or Antivalent state lead to a safe state.

8.4 SBC hardware input configuration

The SBC input is normally used to trigger the SBC safety function. However, the input can also be configured differently.

8.4.1 Assignment of the SBC inputs

ID	Name	Value (default)
04.01	Assignment of the function1 inputs	SBC Safe brake control

Value list
Hardware input deactivated: The safety input is not assigned with a safety function.
STO Safe torque off
SBC Safe brake control
SS1 Safe stop 1
SS1 Safe stop 2
SOS Safe operating stop
SLS Safely limited speed
SLP Safely limited position
SLP Set reference point. The safety function "Set safely limited position of the reference position" is executed.
SLI Safely limited pacing When the input is active, the SLI function is not active. If the function is not selected or the input is not active, the safety function "Safely Limited Increment" is executed in addition to other selected safety functions.
SLI Next step Sets the "SLI Next Step" input for the "Safely limited increment" safety function.
SDI Safe direction of movement forwards (clockwise)
SDI Safe direction of movement backwards (anti-clockwise)
SSM Safe speed monitoring
SLA Safely limited acceleration
Reset fail safe If a safety function detects an error, e.g. because limits have been exceeded, then the fail safe bit is set in the status. This error can be reset by means of a configured input. The reset is carried out when the voltage at the input is switched off.
Record number Bit 0 Many safety functions have an index and can therefore be configured multiple times. At runtime, a changeover can then be made via a configured input or via FSoE. Index selection bit 0 controls the first bit ("LSB").
Record number Bit 1 Many safety functions have an index and can therefore be configured multiple times. At runtime, a changeover can then be made via a configured input or via FSoE. Index selection bit 1 controls the second bit.
Record number bit 2 Many safety functions have an index and can therefore be configured multiple times. At runtime, a changeover can then be made via a configured input or via FSoE. Index selection bit 2 controls the third bit ("MSB").

Index selection via configurable inputs 1-3				
Index	**Value**	**Input 3 (Bit 2)**	**Input 2 (Bit 1)**	**Input 1 (Bit 0)**
1	**0**	**0**	**0**	**0**
2	**1**	**0**	**0**	**1**
3	**2**	**0**	**1**	**0**
4	**3**	**0**	**1**	**1**
5	**4**	**1**	**0**	**0**
6	**5**	**1**	**0**	**1**
7	**6**	**1**	**1**	**0**
8	**7**	**1**	**1**	**1**

8.4.2 Tolerance time of the SBC-Inputs

The inputs are designed with two channels. This can cause that a channel is switched earlier or later than the second channel. Enter a tolerance time here to ensure that this does not immediately result in an error.

ID	Name	Value	Unit	Min. value	Max. value
04.02	Tolerance time of the SBC-Inputs	0.010000	s	0.000000	1.000000

8.4.3 Status of the SBC-Inputs

ID	Name	Value (default)
04.03	Status of the SBC-Inputs	equivalence

Value list
At "equivalent" the two safety inputs must always be switched the same. It is not allowed to supply a channel with 24V input voltage and the other channel with 0V. The safety function is carried out if the input voltage is 0V.
Both channels are controlled with opposite logic at "antivalent". The following applies: The safety function is not executed if SBC.1 is supplied with an input voltage of 24 V. The safety function is executed if SBC.2 is supplied with an input voltage of 0 V.

Deviations of the set tolerance time from the set Equivalent or Antivalent state lead to a safe state.

8.5 Function 1 Hardware input configuration

The function1 input of the safety module can be used for different safety functions. The safety function to be performed can be parameterized.

8.5.1 Assignment of the function1 inputs

ID	Name	Value (default)
05.01	Assignment of the function1 inputs	Hardware input deactivated:

Value list
Hardware input deactivated: The safety input is not assigned with a safety function.
STO Safe torque off
SBC Safe brake control
SS1 Safe stop 1
SS1 Safe stop 2
SOS Safe operating stop
SLS Safely limited speed
SLP Safely limited position
SLP Set reference point. The safety function "Set safely limited position of the reference position" is executed.
SLI Safely limited pacing

Value list
When the input is active, the SLI function is not active. If the function is not selected or the input is not active, the safety function "Safely Limited Increment" is executed in addition to other selected safety functions.
SLI Next step Sets the "SLI Next Step" input for the "Safely limited increment" safety function.
SDI Safe direction of movement forwards (clockwise)
SDI Safe direction of movement backwards (anti-clockwise)
SSM Safe speed monitoring
SLA Safely limited acceleration
Reset fail safe If a safety function detects an error, e.g. because limits have been exceeded, then the fail safe bit is set in the status. This error can be reset by means of a configured input. The reset is carried out when the voltage at the input is switched off.
Record number Bit 0 Many safety functions have an index and can therefore be configured multiple times. At runtime, a changeover can then be made via a configured input or via FSoE. Index selection bit 0 controls the first bit ("LSB").
Record number Bit 1 Many safety functions have an index and can therefore be configured multiple times. At runtime, a changeover can then be made via a configured input or via FSoE. Index selection bit 1 controls the second bit.
Record number bit 2 Many safety functions have an index and can therefore be configured multiple times. At runtime, a changeover can then be made via a configured input or via FSoE. Index selection bit 2 controls the third bit ("MSB").

Index selection via configurable inputs 1-3				
Index	**Value**	**Input 3 (Bit 2)**	**Input 2 (Bit 1)**	**Input 1 (Bit 0)**
1	**0**	**0**	**0**	**0**
2	**1**	**0**	**0**	**1**
3	**2**	**0**	**1**	**0**
4	**3**	**0**	**1**	**1**
5	**4**	**1**	**0**	**0**
6	**5**	**1**	**0**	**1**
7	**6**	**1**	**1**	**0**
8	**7**	**1**	**1**	**1**

8.5.2 Tolerance time of the Function1-Inputs

The inputs are designed with two channels. This can cause that a channel is switched earlier or later than the second channel. Enter a tolerance time here to ensure that this does not immediately result in an error.

ID	Name	Value	Unit	Min. value	Max. value
05.02	Tolerance time of the Function1-Inputs	0,010000	s	0.000000	1.000000

8.5.3 Status of the Funktion1-Inputs

ID	Name	Value (default)
05.03	Status of the Funktion1-Inputs	equivalence

Value list
At "equivalent" the two safety inputs must always be switched the same. It is not allowed to supply a channel with 24V input voltage and the other channel with 0V. The safety function is carried out if the input voltage is 0V.
Both channels are controlled with opposite logic at "antivalent". The following applies: If FUNC1.1 is supplied with an input voltage of 24V, the safety function is not executed. If FUNC1.2 is supplied with an input voltage of 0V, the safety function is executed.

Deviations of the set tolerance time from the set Equivalent or Antivalent state lead to a safe state.

8.6 Function 2 Hardware input configuration

The function1 input of the safety module can be used for different safety functions. The safety function to be performed can be parameterized.

8.6.1 Assignment of the function2 inputs

ID	Name	Value (default)
06.01	Assignment of the function1 inputs	Hardware input deactivated:

Value list
Hardware input deactivated: The safety input is not assigned with a safety function.
STO Safe torque off
SBC Safe brake control
SS1 Safe stop 1
SS1 Safe stop 2
SOS Safe operating stop
SLS Safely limited speed
SLP Safely limited position
SLP Set reference point. The safety function "Set safely limited position of the reference position" is executed.
SLI Safely limited pacing When the input is active, the SLI function is not active. If the function is not selected or the input is not active, the safety function "Safely Limited Increment" is executed in addition to other selected safety functions.
SLI Next step Sets the "SLI Next Step" input for the "Safely limited increment" safety function.
SDI Safe direction of movement forwards (clockwise)
SDI Safe direction of movement backwards (anti-clockwise)
SSM Safe speed monitoring
SLA Safely limited acceleration
Reset fail safe If a safety function detects an error, e.g. because limits have been exceeded, then the fail safe bit is set in the status. This error can be reset by means of a configured input. The reset is carried out when the voltage at the input is switched off.

Value list				
Record number Bit 0 Many safety functions have an index and can therefore be configured multiple times. At runtime, a changeover can then be made via a configured input or via FSoE. Index selection bit 0 controls the first bit ("LSB").				
Record number Bit 1 Many safety functions have an index and can therefore be configured multiple times. At runtime, a changeover can then be made via a configured input or via FSoE. Index selection bit 1 controls the second bit.				
Record number bit 2 Many safety functions have an index and can therefore be configured multiple times. At runtime, a changeover can then be made via a configured input or via FSoE. Index selection bit 2 controls the third bit ("MSB").				
Index selection via configurable inputs 1-3				
Index	**Value**	**Input 3 (Bit 2)**	**Input 2 (Bit 1)**	**Input 1 (Bit 0)**
1	**0**	**0**	**0**	**0**
2	**1**	**0**	**0**	**1**
3	**2**	**0**	**1**	**0**
4	**3**	**0**	**1**	**1**
5	**4**	**1**	**0**	**0**
6	**5**	**1**	**0**	**1**
7	**6**	**1**	**1**	**0**
8	**7**	**1**	**1**	**1**

8.6.2 Tolerance time of the Funktion2-Inputs

The inputs are designed with two channels. This can cause that a channel is switched earlier or later than the second channel. Enter a tolerance time here to ensure that this does not immediately result in an error.

ID	Name	Value	Unit	Min. value	Max. value
06.02	Tolerance time of the function2 inputs	0.010000	s	0.000000	1.000000

8.6.3 State of the function2 inputs

ID	Name	Value (default)
06.03	State of the function2 inputs	equivalence

Value list
At "equivalent" the two safety inputs must always be switched the same. It is not allowed to supply a channel with 24V input voltage and the other channel with 0V. The safety function is carried out if the input voltage is 0V.
Both channels are controlled with opposite logic at "antivalent". The following applies: If FUNC2.1 is supplied with an input voltage of 24V, the safety function is not executed. If FUNC2.2 is supplied with an input voltage of 0V, the safety function is executed.

Deviations of the set tolerance time from the set Equivalent or Antivalent state lead to a safe state.

8.7 Ripple hardware input configuration

The ripple inputs are intended for the connection with the ripple outputs of another safety module. However, these can also be used as normal inputs if the parameter "The safety module is the ripple master" is set to "on" in the ripple output configuration.

8.7.1 Assignment of the ripple inputs

ID	Name	Value (default)
07.01	Assignment of the ripple inputs	Hardware input deactivated:

Value list
Hardware input deactivated: The safety input is not assigned with a safety function.
STO Safe torque off
SBC Safe brake control
SS1 Safe stop 1
SS1 Safe stop 2
SOS Safe operating stop
SLS Safely limited speed
SLP Safely limited position
SLP Set reference point. The safety function "Set safely limited position of the reference position" is executed.
SLI Safely limited pacing When the input is active, the SLI function is not active. If the function is not selected or the input is not active, the safety function "Safely Limited Increment" is executed in addition to other selected safety functions.
SLI Next step Sets the "SLI Next Step" input for the "Safely limited increment" safety function.
SDI Safe direction of movement forwards (clockwise)
SDI Safe direction of movement backwards (anti-clockwise)
SSM Safe speed monitoring
SLA Safely limited acceleration
Reset fail safe If a safety function detects an error, e.g. because limits have been exceeded, then the fail safe bit is set in the status. This error can be reset by means of a configured input. The reset is carried out when the voltage at the input is switched off.
Record number Bit 0 Many safety functions have an index and can therefore be configured multiple times. At runtime, a changeover can then be made via a configured input or via FSoE. Index selection bit 0 controls the first bit ("LSB").
Record number Bit 1 Many safety functions have an index and can therefore be configured multiple times. At runtime, a changeover can then be made via a configured input or via FSoE. Index selection bit 1 controls the second bit.
Record number bit 2 Many safety functions have an index and can therefore be configured multiple times. At runtime, a changeover can then be made via a configured input or via FSoE. Index selection bit 2 controls the third bit ("MSB").
Index selection via configurable inputs 1-3

Value list				
Index	**Value**	**Input 3 (Bit 2)**	**Input 2 (Bit 1)**	**Input 1 (Bit 0)**
1	**0**	**0**	**0**	**0**
2	**1**	**0**	**0**	**1**
3	**2**	**0**	**1**	**0**
4	**3**	**0**	**1**	**1**
5	**4**	**1**	**0**	**0**
6	**5**	**1**	**0**	**1**
7	**6**	**1**	**1**	**0**
8	**7**	**1**	**1**	**1**

8.7.2 Tolerance time of the Ripple-Inputs

The inputs are designed with two channels. This can cause that a channel is switched earlier or later than the second channel. Enter a tolerance time here to ensure that this does not immediately result in an error.

ID	Name	Value	Unit	Min. value	Max. value
07.02	Tolerance time of the Ripple-Inputs	0.010000	s	0.000000	1.000000

9 Outputs

The safety module has 2 configurable outputs, a clock output and a ripple output for networking the safety module with other safety modules.

9.1 Configuration of the outputs 1 and 2

The safety module has 2 configurable outputs.

The switch-on delay affects output 1 and output 2.

NOTICE

Interruption of the OSSD signals by function test!

a) In order to check the switch-off capability of the output channel, an interruption of up to 2 ms takes place twice approx. every 30 min.

b) If no voltage drop is detected at the output after 2 ms, the module changes into the safe state.

9.1.1 Output1 configuration

The output can be switched on upon execution of safety functions. The values can be combined as required and set as the initial configuration. The output configuration is "OR connected".

ID	Name	Value	Unit	Min. value	Max. value
08.01	Output1 configuration	0	-	0	131071

Example of an "OR link" of SS1 or SS2.

Enter "12" (sum of SS1="4" and SS2="8").

The output is set when one of the two safety functions is executed.

Value	Function	Description
0	No function	The output is not used.
1	STO	The output is switched on if the safety function STO is executed.
2	SBC	The output is switched on if the safety function SBC is executed.
4	SS1	The output is switched on if the safety function SS1 is executed.
8	SS2	The output is switched on if the safety function SS1 is executed.
16	SOS	The output is switched on if the safety function SOS is executed.
32	SDIR	The output is switched on when the safety function SDI forward is executed.
64	SDIL	The output is switched on if the safety function SDI backwards is executed.
128	Error safety function	If an error occurred during the execution of a safety function, then the output is switched on.
256	SLS	The output is switched on if the safety function SLS is executed.
512	SLA	The output is switched on if the safety function SLA is executed.
1024	SPL (activation)	The output is switched on if the safety function SLP is executed.

Value	Function	Description
2048	SLP Reference position	The output is switched on if the safety function SLP reference position is executed.
4096	SEL	The output is switched on if the safety function SEL is executed.
8192	SLI activation	The output is switched on if the safety function SEL is executed.
16384	SLI Next step	The output is switched on if the safety function SLI Next step is executed.
32768	SSM	The safe output is switched off if the value of the parameterized speed plus hysteresis is exceeded. The safe output is only set when the speed falls below the parameterised speed plus the hysteresis.
65535	SMS	The output is switched on if the safety function SMS is executed.

Tab. 8: Output configuration

9.1.2 Output2 Configuration

The output can be switched on upon execution of safety functions. The values can be combined as required and set as the initial configuration. The output configuration is "OR connected".

ID	Name	Value	Unit	Min. value	Max. value
08.02	Output2 Configuration	0	-	0	131071

Example of an "OR link" of SS1 or SS2.

Enter "12" (sum of SS1="4" and SS2="8").

The output is set when one of the two safety functions is executed.

Value	Function	Description
0	No function	The output is not used.
1	STO	The output is switched on if the safety function STO is executed.
2	SBC	The output is switched on if the safety function SBC is executed.
4	SS1	The output is switched on if the safety function SS1 is executed.
8	SS2	The output is switched on if the safety function SS1 is executed.
16	SOS	The output is switched on if the safety function SOS is executed.
32	SDIR	The output is switched on when the safety function SDI forward is executed.
64	SDIL	The output is switched on if the safety function SDI backwards is executed.
128	Error safety function	If an error occurred during the execution of a safety function, then the output is switched on.
256	SLS	The output is switched on if the safety function SLS is executed.
512	SLA	The output is switched on if the safety function SLA is executed.

Value	Function	Description
1024	SPL (activation)	The output is switched on if the safety function SLP is executed.
2048	SLP Reference position	The output is switched on if the safety function SLP reference position is executed.
4096	SEL	The output is switched on if the safety function SEL is executed.
8192	SLI activation	The output is switched on if the safety function SEL is executed.
16384	SLI Next step	The output is switched on if the safety function SLI Next step is executed.
32768	SSM	The safe output is switched off if the value of the parameterized speed plus hysteresis is exceeded. The safe output is only set when the speed falls below the parameterised speed plus the hysteresis.
65535	SMS	The output is switched on if the safety function SMS is executed.

Tab. 9: Output configuration

9.1.3 Switch on delay time

Switching on the output is delayed by the set time after the safety function is activated.

ID	Name	Value	Unit	Min. value	Max. value
08.03	Switch on delay time	0,000000	s	0.000000	1.000000

9.2 Ripple output configuration

The safety module has a ripple output which can be connected with the ripple inputs of another safety module. The ripple output is designed as two-channel system. The ripple output can be used as normal output if parameter "ripple master" is set to on. However, observe that the behavior of the ripple outputs is reverse to the normal outputs. This means, if the safety function is active then the ripple outputs are switched 0, and if the safety function is not active then the ripple outputs are switched to 1.

9.2.1 Ripple output configuration

The output is switched off during the execution of the configured safety functions. You can configure any safety functions simultaneously. The values correspond to those of the safe outputs.

ID	Name	Value	Unit	Min. value	Max. value
09.01	Configuration of the Ripple-Output	0	-	0	131071

Example of an "OR link" of SS1 or SS2.

Enter "12" (sum of SS1="4" and SS2="8").

The output is set when one of the two safety functions is executed.

Value	Function	Description
0	No function	The output is not used.
1	STO	The output is switched on if the safety function STO is executed.

Value	Function	Description
2	SBC	The output is switched on if the safety function SBC is executed.
4	SS1	The output is switched on if the safety function SS1 is executed.
8	SS2	The output is switched on if the safety function SS1 is executed.
16	SOS	The output is switched on if the safety function SOS is executed.
32	SDIR	The output is switched on when the safety function SDI forward is executed.
64	SDIL	The output is switched on if the safety function SDI backwards is executed.
128	Error safety function	If an error occurred during the execution of a safety function, then the output is switched on.
256	SLS	The output is switched on if the safety function SLS is executed.
512	SLA	The output is switched on if the safety function SLA is executed.
1024	SPL (activation)	The output is switched on if the safety function SLP is executed.
2048	SLP Reference position	The output is switched on if the safety function SLP reference position is executed.
4096	SEL	The output is switched on if the safety function SEL is executed.
8192	SLI activation	The output is switched on if the safety function SEL is executed.
16384	SLI Next step	The output is switched on if the safety function SLI Next step is executed.
32768	SSM	The safe output is switched off if the value of the parameterized speed plus hysteresis is exceeded. The safe output is only set when the speed falls below the parameterised speed plus the hysteresis.
65535	SMS	The output is switched on if the safety function SMS is executed.

Tab. 10: Output configuration

9.2.2 Ripple master

If this safety module is not integrated in a closed ripple chain, this setting must be set to "on". The ripple output can be used as additional output with this adjustment. The output is switched off, if the configured safety function is executed.

ID	Name	Value	Unit	Min. value	Max. value
09.02	Configuration of the Ripple-Output	off	-	off	on

9.2.3 Cycle time

The ripple cycle time is the max. time which is required by the signal to run from this safety module once through the ripple chain and back to the inputs. The ripple cycle time results from:

- maximum switch-on delay ripple inputs: 2ms

- + maximum switch-on delay ripple outputs: 448us
- + maximum delay time for the ripple outputs: 750us = **3.2ms**

The ripple cycle time must be multiplied with the number of users, furthermore the filter time for the ripple inputs must be added.

ID	Name	Value	Unit	Min. value	Max. value
09.03	Cycle time	0.000000	s	0.000000	60.000000

9.3 Clock output configuration

In order to detect dangerous external line short circuits between two related inputs and/or to voltage supply potentials, mechanical contact pairs are supplied via phase-shifted clock outputs. The cyclic clock signals are evaluated by the safe inputs of the control module. Control internal cross circuits are detected by the sequential test of the input circuits.

With cyclic switching operations the cycle duration should always be shorter than the cyclic switching operation. If the demand for a safety function occurs every 10s, then the cycle duration must be shorter than 10 s, otherwise it is possible that the clock pulse is never be examined by the safety module, if this occurs exactly simultaneously with the cyclic switching. Or the cyclic switching is held for the clock pulse and thus the safety module changes into the error state.

9.3.1 Cycle duration of the clock outputs

The period duration for the clock outputs is the time interval between two test pulses.

ID	Name	Value	Unit	Min. value	Max. value
10.01	Period of the Clock-Output	10,000000	s	0.010000	10.000000

9.3.1.1 Recommended adjustments for the cycle duration of the clock outputs

With cyclic switching operations the cycle duration should always be shorter than the cyclic switching operation. If the demand for a safety function occurs every 10s, then the cycle duration must be shorter than 10 s, otherwise it is possible that the clock pulse is never be examined by the safety module, if this occurs exactly simultaneously with the cyclic switching. Or the cyclic switching is held for the clock pulse and thus the safety module changes into the error state.

9.3.2 Pulse length of the clock outputs

The pulse length is the duration of a test pulse.

ID	Name	Value	Unit	Min. value	Max. value
10.02	Pulse length of the Clock-Output	0.001000	s	0.000500	0.0001000

10 Encoder

10.1 Encoder configuration

Two types of encoder can be connected.

Sine/cosine encoder and resolver.

NOTICE

Loose the encoder from the motor housing!

a) In order to be able to apply the fault exclusion against loosening of the encoder housing from the motor housing or the encoder shaft from the motor shaft, the permissible load of the sensor must be known or limited to the specifications in the data sheet. A distinction is made between form-fitting and frictional connections.

10.1.1 Connected encoder

Selection of the connected encoder.

ID	Name	Value (default)
11.01	Connected encoder	no encoder

Value list
no encoder
Sine/cosine encoder
Resolver

10.1.2 Window for maximum difference

The sine and cosine signal of the encoder, is checked via a $\sin^2x+\cos^2x = 1$ evaluation for errors. Since no encoder is ideal, there may be differences. The following formula is valid for deviations: $\sin^2x + \cos^2x = (1 +-$ window for max. deviation (%)).

ID	Name	Value	Unit	Min. value	Max. value
11.02	Window for maximum difference	50	%	0	95

Example: A tolerance range of 50% is recommended in the manual for a SICK SKM36S-HFA0-K02 encoder.

10.1.3 Allowed position difference between the input channels

The safety module has two independent input channels for the evaluation of the position data. This can cause minor deviations between the two channels. This value can be adjusted if there are problems during operation with a suitable encoder. A value of 10° is entered here as standard.

ID	Name	Value	Unit	Min. value	Max. value
11.03	Allowed position difference between the input channels	10	%	1	90

10.2 Sine cosine encoder configuration

NOTICE

Use only SIL-certified sine/cosine encoders

a) Use only SIL-certified sine/cosine encoders. The installation and mounting instructions for the encoder must be observed. The encoder must have an amplitude of 1 Vss and an offset of 2.5 V. The increments per revolution may not be higher than 16000 increments.

Recommendation: **SICK SKM36S-HFA0-K02**

This encoder has 128 increments and no zero track. The maximum input frequency of the encoder evaluation is 200kHz.

10.2.1 Increments per revolution

Input the number of increments per revolution of the sine/cosine encoder according to data sheet.

ID	Name	Value	Unit	Min. value	Max. value
12.01	Increments per revolution	2048	%	128	16000

10.2.2 Allowed position difference

The safety module checks internally whether there are wrong increments during the run-time of the safety module. Furthermore, it is checked whether a position deviation to the zero pulse track was detected. If wrong increments or a position deviation to zero pulse track has been detected which is higher than the permitted position deviation, then the safety module changes into the safe state.
The input of this parameter is done in full increments.

ID	Name	Value	Unit	Min. value	Max. value
12.02	Allowed position difference	1	-	1	15999

10.2.3 Check of zero pulse

Only if the encoder has a zero pulse track, this can be evaluated.

The evaluation of the zero pulse track should be adjusted only if a sine/cosine encoder with zero pulse track is used. It is checked whether the counted increments agrees with the zero pulse and the adjusted increments.

Since a possible position error can be varied via parameter position deviation, the resolution of the safe position should not be lower than the parameter.

$$maximum\ possible\ position\ deviation\ [^\circ] = \frac{permitted\ position\ deviation}{increments} \bullet 360^\circ$$

Fig. 25: Formula: maximum possible error position

ID	Name	Value	Unit	Min. value	Max. value
12.03	Check of zero pulse	off	-	off	on

10.3 Use of resolvers

NOTICE

Use resolver with permanent fixing!

a) The proof of endurance strength of mechanical fixing is required for the resolver.

b) This condition is fulfilled for KEB DL3 motors.

10.3.1 Maximum permissible speed

The maximum permissible speed is limited by the software to 25000 rpm.

10.3.2 Phase shifting of the signals

Furthermore, the resolver may not exceed the indicated phase shiftings:

1. The phase shifting between sine and cosine channel of the resolver may be maximally -54 degrees and +72 degrees. Also the phase shifting between the reference signal of the stator winding to the sine and cosine channel must not be lower than -54 degrees and higher than 72 degrees.
2. An error in the resolver is detected at a phase shifting higher than 72 and lower than 126 degrees. The safety module is changed into the safe state.
3. No error is detected at a phase shifting higher than 126 degrees and lower than 252 degrees, but the detected direction of rotation is inverted.
4. An error is detected in the resolver at phase shifting higher than 252 degrees and lower than 306 degrees. The safety module is changed into the safe state.

10.3.3 Position error

The position error which can be available from checking of the function $\sin^2 x + \cos^2 x = (1 +-$ window for max. deviation (%)/100%) is:

$$maximum\ possible\ error\ position\ = arctan(\sqrt{\frac{window\ for\ max.\ deviation\ (\%)}{100\%}})$$

Fig. 26: Formula : maximal possible error position

The safe position resolution should be higher than the maximum possible error position.

10.4 Scaling settings for the position

Encoder settings for the input channels

Number of bits per revolution

Position limits can be specified for the safety functions SDI, SOS, SLI, SLP reference position and SLP safe limited position. These are always in the format "bits per revolution". 16-bit are entered here as standard, that means, a value of 2^{16} corresponds to 1 revolution or 360 degrees. By increasing the value positions can be entered more precisely. By reducing the value, larger but less precise positions can be entered.

ID	Name	Value	Unit	Min. value	Max. value
13.01	Selection of bits per revolution (Ps)	16	Bit	2	30

10.5 Settings for speed measurement

NOTICE

Response time of the safety functions!

a) The response time of the safety functions SS1, SS2, SLS and SSM is directly related to the encoder adjustments for speed detection.

b) Higher scan times provide a smooth speed, but also a slower response time of the safety functions.

The drive restarts if function STO is no longer released. In order to comply with EN 60204-1, it must be ensured by external measures that the drive restarts only after confirmation.

10.5.1 Speed scan time + speed PT1-time

The behaviour of the speed sampling time with the speed PT1 time is shown in the figure "Speed sampling time and speed PT1 time taken together". The speed jump is decelerated first by the speed scan time. The speed PT1 time is used to this filtered speed change. A step of PT1_KEB is 250 µs.

$$y = y_{t-1} + \frac{t}{T}\left(\left(\frac{\Delta encoder\ \ position}{speed\ \ scan\ \ time}\right) - y_{t-1}\right)$$

Fig. 27: Formula: speed scan time and speed PT1 time

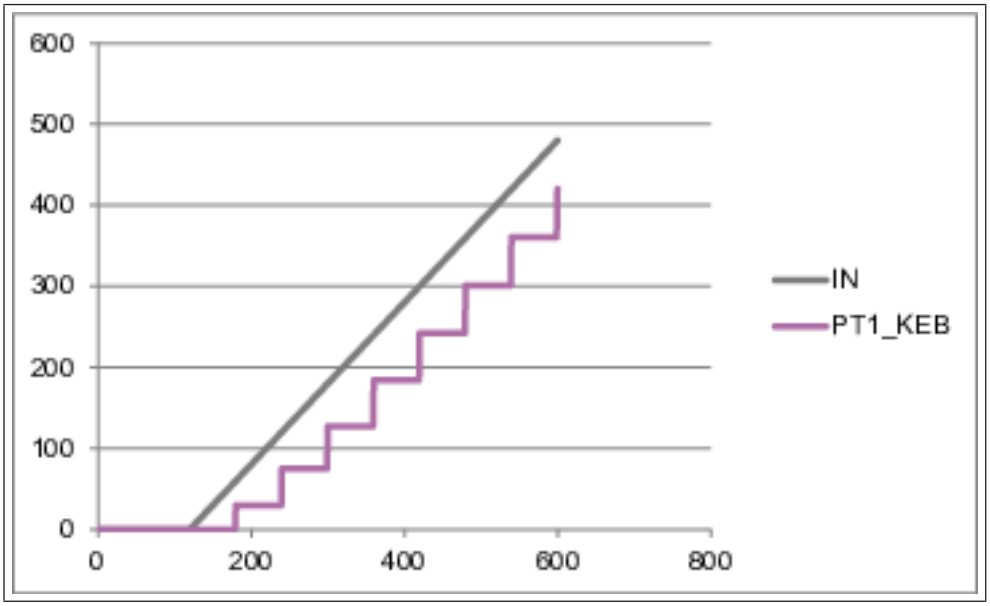

Fig. 28: Speed scan time and speed PT1 time together

Speed scan time

The speed is determined by the following formula:

Position - position (speed sampling time) / speed sampling time.

Position errors are filtered at higher speed scan time, but the response time is slower.

The speed scan time provides a delay of the speed change. Thereby at a speed jump the actual speed is reached only after the speed scan time.

y = Δencoder position / speed sampling time

y = determined speed safety module.

Δencoder position = Encoder position of the actual position compared to the position before speed scan time.

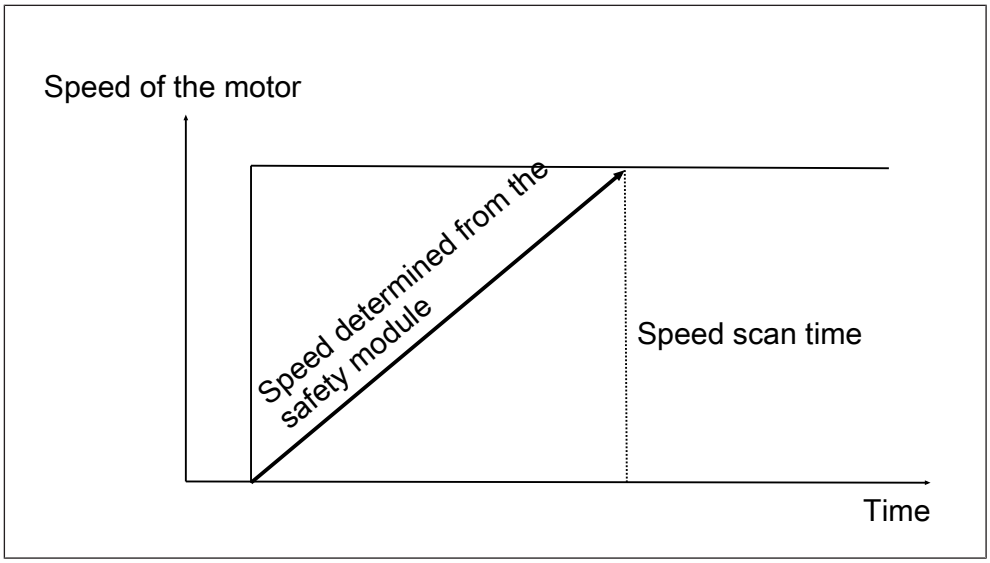

Fig. 29: Speed scan time related to the speed

ID	Name	Value	Unit	Min. value	Max. value
14.01	Speed scan time	1	ms	0.25	8

Speed PT1 time

The speed can be filtered by a PT1 filter. The adjustment of 0 means no PT1 filter is used. The setting of 256 ms means (maximum value), a PT1 filter of 256 ms is used.

The speed PT1- time provides a delay of the speed change. Thereby at a speed jump the actual speed is reached only after the speed PT1-time is reached.

$$y = y_{t-1} + \frac{t}{T}\left(\left(\frac{\Delta encoder\ \ position}{speed\ \ scan\ \ time}\right) - y_{t-1}\right)$$

Fig. 30: Formula: Speed PT1 time

y = determined speed safety module.

x(encoder) = speed from speed scan time detection.

y (t-1) = determined speed from the safety module for the last time

T = speed PT1- time

t = time of calculation (the speed of the safety module is calculated in steps of 250 µs).

The following figure shows the behaviour specified in the formula. PT1_KEB is the behavior of the algorithm in time discrete case. A step of PT1_KEB is 250 µs.

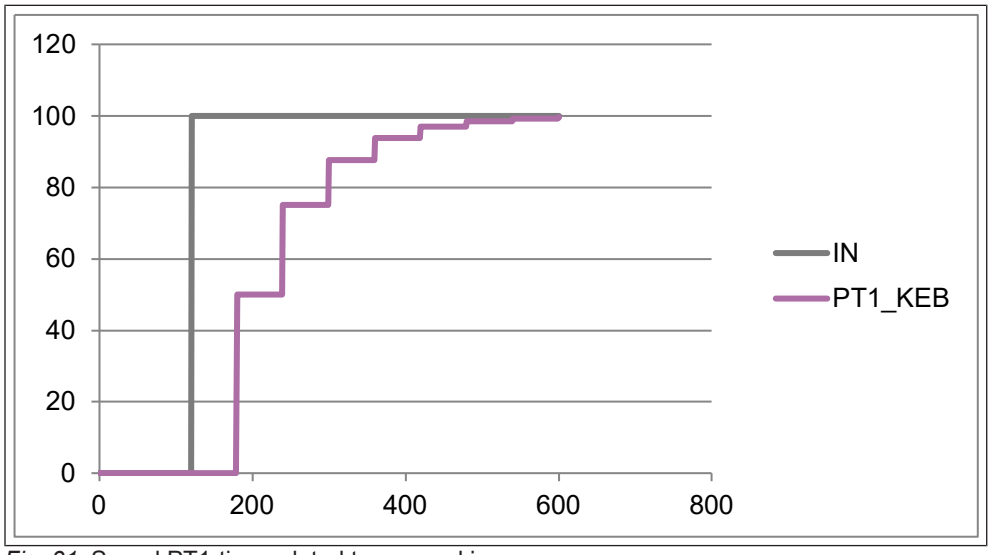

Fig. 31: Speed PT1-time related to a speed jump

ID	Name	Value	Unit	Min. value	Max. value
14.02	Speed PT1 time	2.000000	ms	0.000000	256.000000

11 Functional description of the safety functions

The type 3 safety module fulfils the safety functions listed in this chapter in accordance with EN 61800-5-2.

11.1 Priority of the safety functions

STO always has the highest priority. The other safety functions all have the same priority.

Priority	Meaning
0	STO is executed, modulation not released (≡► Functional description Safe Torque off (STO) [▶ 65]).

Tab. 11: Priority of the safety functions of the safety module

11.2 Status of the safety module

The status of the safety module can be read out with parameter sb29 "safety mod. status word" of the COMBIVERT. The parameter is bit-coded according to the table (≡► Status of the safety module [▶ 64]):

Bit	Status	Meaning
0	1	Error in the safety module
1	0	STO is executed, modulation not released (≡► Functional description Safe Torque off (STO) [▶ 65]).
2	0	SBC is executed. Brake closed (≡► Functional description safe brake control (SBC) [▶ 66]).
3	1	SS1 is executed (≡► Functional description safe stop 1 (SS1) [▶ 68])
4	1	SS2 is executed
5	1	SOS is executed
6	1	SDI Forward is executed
7	1	SDI reverse is executed
8	1	Fail Safe. The limit of an active safety function has been breached.
9	1	SLS is executed
10	1	SLA is executed
11	1	SLP is executed
12	1	SLP Set Reference Position (reference position set)
13	1	SEL is executed
14	1	SLI is executed
15	1	Activation of a safe increment of the SLI function
16	1	SSM is executed
17	1	SMS is executed

Tab. 12: Status of the safety module

see also

- Functional description Safe Torque off (STO) [▶ 65]
- Functional description safe brake control (SBC) [▶ 66]
- Functional description safe stop 1 (SS1) [▶ 68]

11.3 Functional description Safe Torque off (STO)

The safety-related disconnection according to STO is reached by a two-cannel opto-coupler blockage. This ensures that supply of the opto-couplers also is not possible at STO execution. If the opto-couplers are not longer supplied, no IGBT can be controlled and thus no rotation energy can be supplied to the drive.

• STO status is displayed in status bit 1.

Installation work or troubleshooting can be necessary in hazard areas, whereby protective devices such as line- or motor contactors shall not be activated. The safety function STO can be used there. Depending on the application the use of line or motor contactors can be void by using STO.

In case of error or request, the power semiconductor of the drive module are switched off and the drive is not supplied, which causes a rotation or torque (in case of a linear drive movement or force). The unit can be safe switched off and/or remain if an error occurs.

⚠ DANGER

Continue mains voltage with active STO function!

Electric Shock

a) Always switch off the power supply before working on the device.

b) Await discharge time.

11.3.1 Emergency stop according to EN 60204

By using suitable safety relays, stop category 0 according to EN 60204-1 can be reached in the system by the STO function.

Stop category 0

- „uncontrolled stop“, i.e. stop by immediate removal of power to the actuators.

Emergency stop to EN 60204 must be functional in all operating modes of the drive module. The reset of emergency stop may not lead to an uncontrolled start of the drive.

Restart only after confirmation

- The drive restarts if function STO is no longer released. In order to comply with EN 60204-1, it must be ensured by external measures that the drive restarts only after confirmation.

Without mechanical brake the drive leads to coast; motor is free-wheeling. Additional protective devices must be installed (e.g.locking systems) if damage to persons or property can occur.

NOTICE

Ensure coast of the motor!

a) If danger to persons occur after switching off the motor control by STO, the entrance to hazard areas must remain closed until the drive stops.

NOTICE

Jerks in error case!

a) In case of double malfunction it can lead to unwanted jerk, the rotation angle is depending on the number of poles of the selected drive and the gear ratio.

Calculation of the jerk:

$$Rotation\ angle\ of\ the\ jerk\ W_R\ [^\circ] = \frac{180^\circ}{pole\ pair\ number\ p\ \bullet\ gear\ reduction\ ration\ g}$$

Fig. 32: Formula: Calculation of the jerk

The probability of the jerk is < 1.84 *10^{-15} 1/h.

This behaviour can occur either by a short circuit of the IGBTs or by interconnection (also short circuit) of the control drivers. The error should be regarded as critical, if the drive remains in STO status.

11.3.2 Error response times STO function

Maximum switch-on delay (+ filter time for the safety input + pulse length for the input analysis)	< 3 ms
Maximum switch-off delay (+ filter time for the safety input + pulse length for the input analysis)	< 3 ms

Tab. 13: Error response times

11.4 Functional description safe brake control (SBC)

The safe brake control is exclusively defined for brakes which are active in de-energized condition. These brakes are opened by applying a voltage, so that a single fault, such as the failure of the power supply, may not lead to the loss of the safety function.

The circuit operates on two channels. The brake can only be opened by the control in COMBIVERT if the safety function SBC is no longer executed. Then opening the brake is displayed with "Brake status“ in status bit 2 (1 means brake open).

The two channels are realised with a diverse high-side and low-side switch. These are tested on their switching ability each hour.

11.4.1 Requirements for the brake

Voltage supply	DC 24 V ±10 %
max. current	DC 3.3 A
Free-wheeling circuit	integrated in COMBIVERT

⚠ DANGER

Power-off braking!

a) Use brakes which are closed at power-off state.

A classification of the entire brake system inclusive mechanical brake to SIL 3 and PL e must be evaluated depending on the used brake. Brakes are considered as components with relatively high error probability. A test interval for the brake is set depending on the manufacturer specified error probability of the used brake and depending on the application.

NOTICE

Check the brake!

a) A check of the brake can not be done completely by the safety module.

b) Functions are provided by the safety module that support the user when checking the brake system Brake test and the application examples for it.

⚠ DANGER

Observe safety regulations!

a) The valid safety regulations must be observed independent of the use of a safety-oriented braking system (e.g. prohibition of staying under suspended loads).

11.4.2 Error response times SBC function

Maximum switch-on delay (+ filter time for the safety input + pulse length for the input analysis)	< 3 ms
Maximum switch-off delay (+ filter time for the safety input + pulse length for the input analysis)	< 3 ms

Tab. 14: Error response times

11.4.3 Setting of status bits by the SBC function

The current flowing through the brake is measured at brake release. The following bits are set depending on the measurement:

Current measurement	Bit
>3.3 A	The error is output in the error state.
<100 mA	A warning is output in the error state.

NOTICE

Note the reaction time of the brake!

a) Since the current increases slowly at high brake inductance, the error response time is max. 100 ms to a current <0.1A.

11.4.4 Monitoring of the SBC function

The internal switches are tested at brake release according to the set interval on their switching ability.

For this purpose the signals of the brake outputs are checked by briefly switching off.

Thus a monitoring of the wiring of short circuit to 24V respectively 0V is given. If the safety module detects an error, the control of both channels is disconnected, the LED is set to red and bit 0 is set in the status.

Pay attention to response time

- The maximum error response time is 9 ms.

The voltage supply for switching the brake is monitored. Status bit 0 is set if the voltage is outside 24 V ±10 %. Also an error is output in the error status.

If the safety module is in error state is displayed in the status of the control of COMBIVERT with parameter ru01 = "55“ (error safety module).

11.4.5 Configuration parameters of the safety function SBC

Parameter	Value	Unit
SBC: Safe brake control		
Coupling of SBC with STO	off	
Measurement of the brake current	on	

Fig. 33: SBC Parameters

The above figure shows the configuration parameters for the SBC function.

11.5 Functional description Safe Direction (SDI)

The circuit operates on two channels. The safety function of the control of the COMBIVERT can only be left, if both hardware inputs are voltage supplied or if a corresponding status change has been received via a safe bus system. The SDI status is displayed in the status as follows:

- SDI forward is displayed in the status in status bit 6.
  Positive speeds do not trigger the safety function.

- SDI reverse is displayed in the status in status bit 7.
  Negative speeds do not trigger the safety function.

11.5.1 Activation of the safety function SDI

The circuit operates on two channels. The safety function of the control of the COMBIVERT can only be left, if both hardware inputs are voltage supplied or if a corresponding status change has been received via a safe bus system. The SDI status is displayed in the status as follows:

SDI forward is displayed in the status in status bit 6. Positive speeds do not trigger the safety function.

SDI reverse is displayed in the status in status bit 7. Negative speeds do not trigger the safety function.

11.5.2 Error response times SDI function

Maximum switch-on delay (+ filter time for the safety input + pulse length for the input analysis)	< 2 ms
Maximum switch-on delay (+ filter time for the safety input + pulse length for the input analysis)	< 2 ms

Tab. 15: Error response times

Error function

The error function is executed if the wrong direction of rotation was detected. STO or SS1 can be adjusted.

ID	Name	Value	Unit	Min. value	Max. value
16.01	Error function	STO	-	STO	SS1

Position window at standstill

The position can vary slightly in standstill. By way an incorrect direction of rotation can be detected. This parameter allows the adjustment of a position difference at motor standstill.

ID	Name	Value	Unit	Min. value	Max. value
16.02	Position window at standstill	0	Ps	0	2147483647

Time window of the direction of rotation

Here you can adjust a time period within the motor may deviate from the safe direction of rotation.

ID	Name	Value	Unit	Min. value	Max. value
16.03	Time window of the direction of rotation	0.000000	s	0.000000	1.000000

11.6 Functional description safe stop 1 (SS1)

The safety function SS1 can be executed in two ways:

SS1-r (Monitoring of a speed ramp) (former type B)

SS1-t (Monitoring of a time to standstill) (former type C)

11.6.1 Activation of the safety function SS1

The circuit operates on two channels. The safety function of the control of the COMBIVERT can only be left, if both hardware inputs are voltage supplied or if a corresponding status change has been received via a safe bus system. The SS1 status is displayed in the status bit **3**.

11.6.2 Error response time SS1 function

Maximum switch-on delay (+ filter time for the safety input + pulse length for the input analysis)	< 2 ms
Maximum switch-on delay (+ filter time for the safety input + pulse length for the input analysis)	< 2 ms

Tab. 16: Error response times

The response time of the SS1-r function depends largely on the encoder settings for the speed measurement.

11.6.3 Emergency stop according EN 60204

By using suitable safety switchgear units, stop category 1 according to EN 60204-1 can be reached by the STO function in the system.

Stop category 1

This concerns to „controlled stop“, i.e. power to the actuators is retained to apply braking until the stop is achieved. The energy is only interrupted (STO) when the standstill has been reached.

11.6.4 Description of the SS1- r function

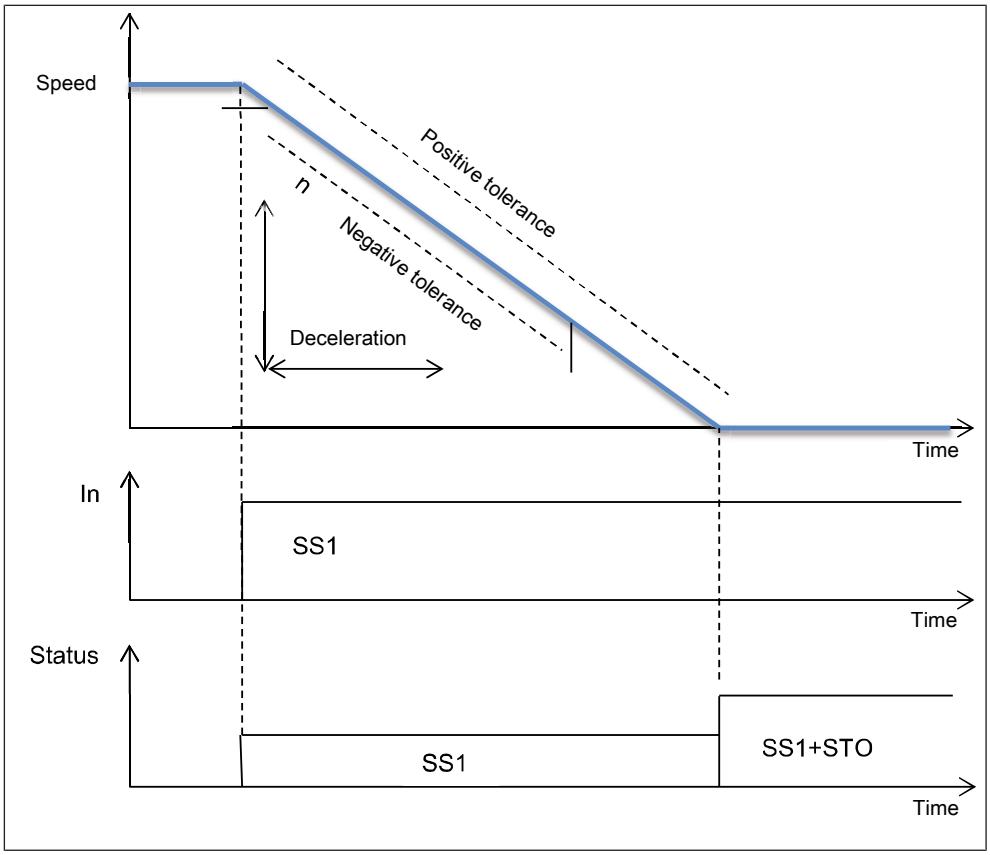

Fig. 34: Safe stop 1 ramp (SS1-r)

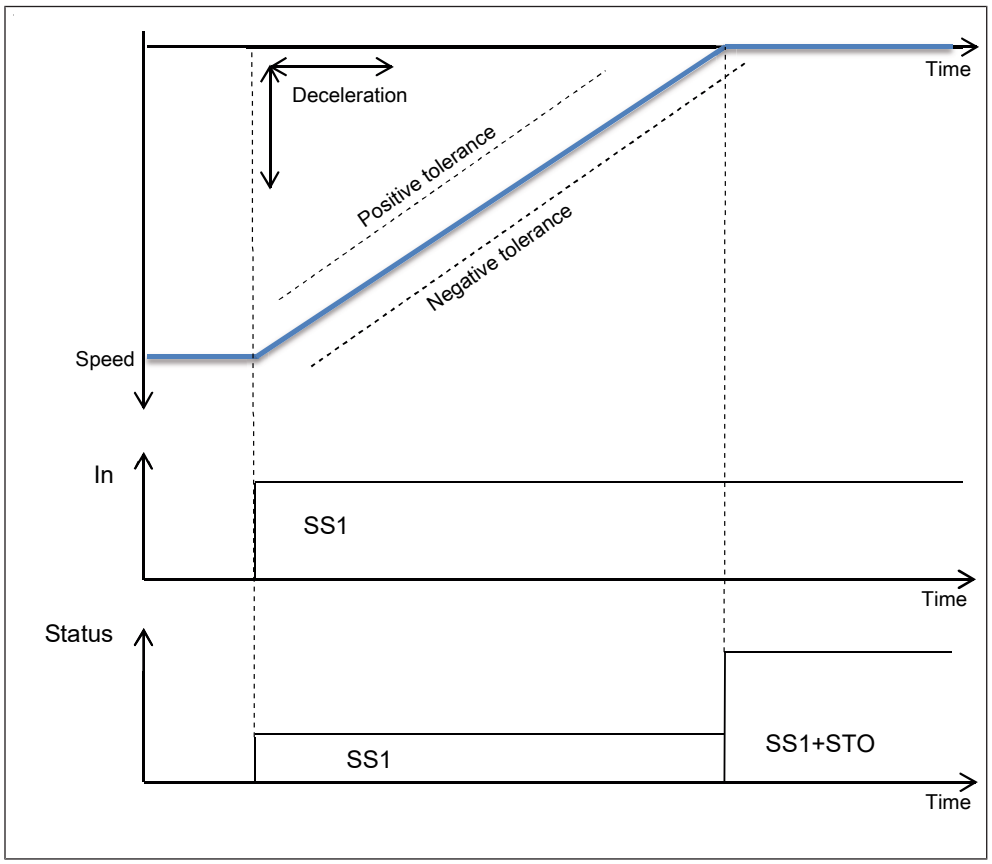

Fig. 35: Safe stop 1 ramp (SS1-r) with negative speed as start value

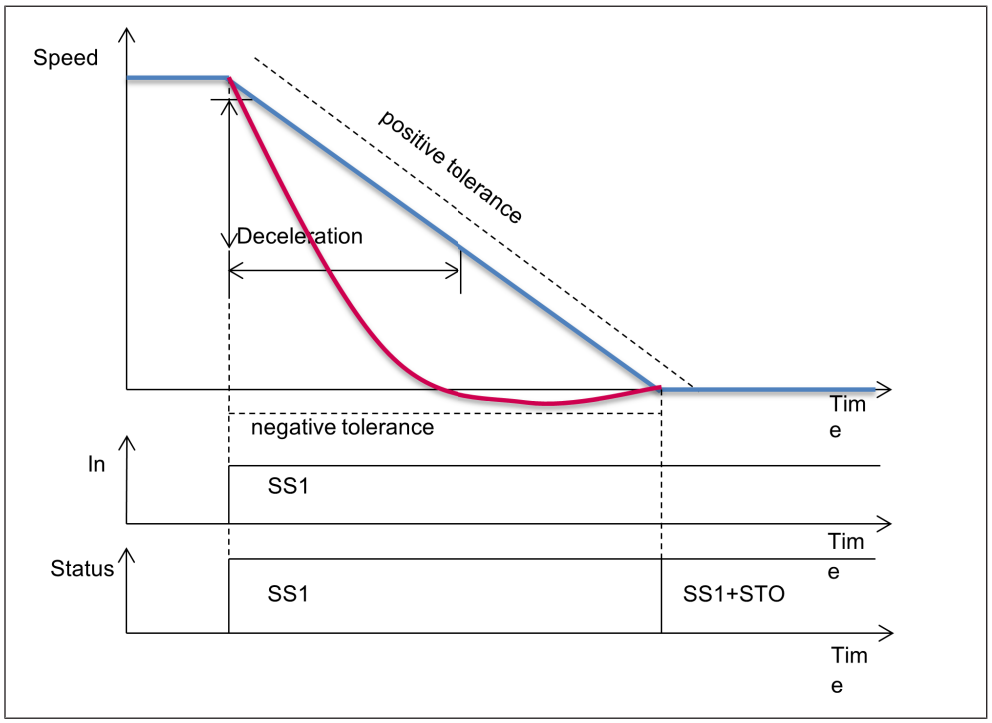

Fig. 36: SS1-r Safety function with higher deceleration permissible

The brake ramp is monitored after triggering of the function.

For monitoring the braking ramp, the deceleration is monitored. State STO is assumed after reaching the standstill.

Errors are faded out via a parameter, which defines a max. tolerable time for short-term deviations from the tolerance window.

From control card firmware 2.5, a stop condition can be set for SS1 and SS2 in pn80. This means when one of the conditions is triggered, the drive automatically moves down at the ramp.

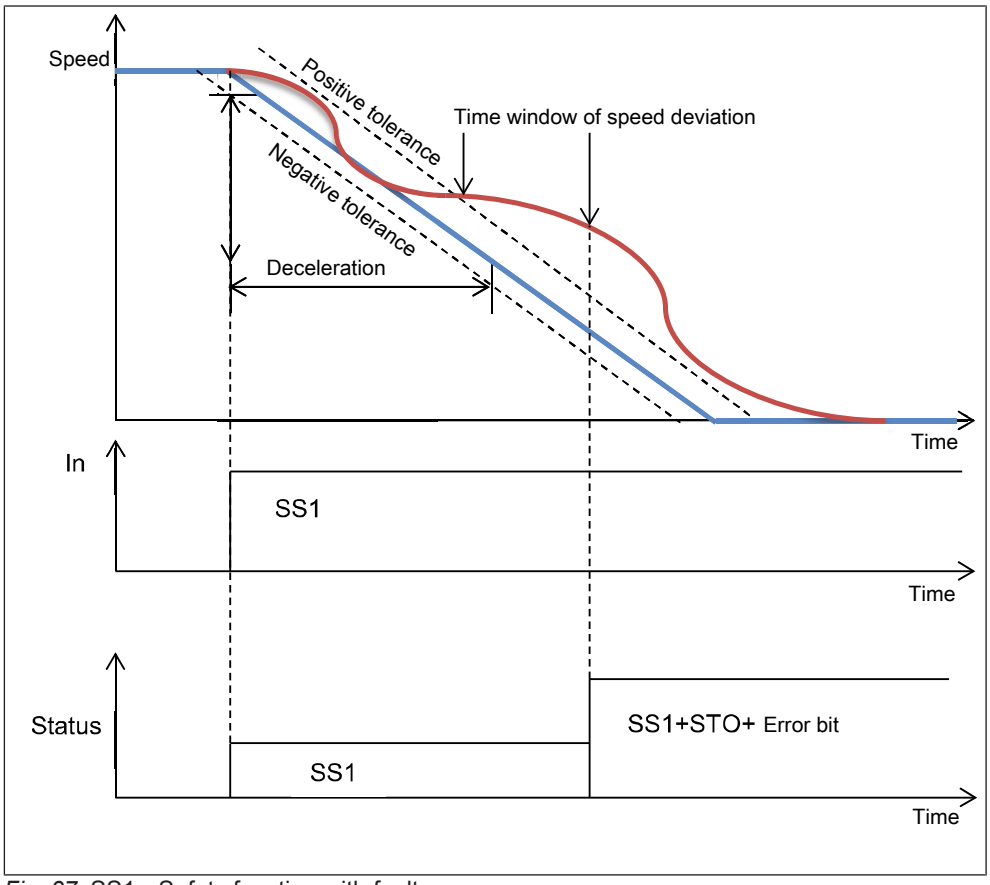

Fig. 37: SS1-r Safety function with faulty ramp

11.6.5 Description of the SS1- t function

After tripping of function SS1, the drive is decelerated due to the effect of the drive control. State STO is assumed after expiration of the configurable time "time period upto safety function".

Selection of the type of the function

ID	Name	Value (default)
xx.01	Selection of the type of the function	Type r and type t (formerly B and C)

xx for index 1 (17) to index 8 (24).

Value list
Type r and type t
STO is executed as soon as the ramp or the time delay has elapsed.

Value list
Type r only STO is executed as soon as the ramp has ended.
Type r only STO is executed as soon as the ramp has ended.

Deceleration

Permits the monitoring of the ramp which decelerates the motor of the COMBIVERT.

This parameter is only effective for SS1-r.

ID	Name	Value	Unit	Min. value	Max. value
xx.02	Deceleration	0.010000	1/s²	0.010000	60000.000000

xx for index 1 (17) to index 8 (24).

Negative tolerance

Allows to define a range, in which speed deviations are tolerated by the ramp.

This parameter is only effective for SS1-r.

ID	Name	Value	Unit	Min. value	Max. value
xx.03	Negative tolerance	0.000000	rpm	0,000000	60000.000000

xx for index 1 (17) to index 8 (24).

Positive tolerance

Allows to define a range, in which speed deviations are tolerated by the ramp.

This parameter is only effective for SS1-r.

ID	Name	Value	Unit	Min. value	Max. value
xx.04	Positive tolerance	0,000000	rpm	0,000000	60000.000000

xx for index 1 (17) to index 8 (24).

Time window for speed deviation

Permits a deviation of the motor from the ramp for the adjusted time. The STO safety function is executed if the time is exceeded. A status change to FailSafe is only triggered if the time from activation of SS1-r until the ramp is violated (incl. tolerance) plus the set tolerance time is shorter than the delay time specified by the setpoint ramp and the output speed. If the time of activation SS1-r plus tolerance time is higher, SS1-r will detect a successful deceleration and STO is set after the deceleration time has elapsed (related to ramp and output speed) and FS is not set.
The counter is incremented when the speed is outside the speed limit. The counter is decremented when the speed is back within the speed limit.

This parameter is only effective for SS1-r.

ID	Name	Value	Unit	Min. value	Max. value
xx.05	Time window for speed tolerance	0.000000	s	0.000000	600.000000

xx for index 1 (17) to index 8 (24).

Type-t time (formerly C)

If the entered time period has expired, the safety function STO is executed. A ramp is not monitored here. The speed must not necessarily zero after the delay time has expired, the change to the STO state occurs without further testing.

This parameter is only effective for SS1-t.

ID	Name	Value	Unit	Min. value	Max. value
xx.06	Type-t time (formerly C)	0.000000	s	0.000000	600.000000

xx for index 1 (17) to index 8 (24).

Higher deceleration allowed

The speed must not be higher than the deceleration + positive tolerance. However, the lower speed limit is 0 - negative tolerance. Thus the drive can also decelerate faster.

If the tolerance range is left longer than the defined time in the time window, it is changed into state STO.

ID	Name	Value	Unit	Min. value	Max. value
xx.07	Higher deceleration allowed	0.000000	s	0.000000	600.000000

xx for index 1 (17) to index 8 (24).

11.7 Functional description safe stop 2 (SS2)

The safety function SS2 can be executed in two ways:

SS2-r (Monitoring of a speed ramp) (former type B)

SS2-t (Monitoring of a time to standstill) (former type C)

11.7.1 Activation of the safety function SS1

The circuit operates on two channels. The safety function of the control of the COMBIVERT can only be left, if both hardware inputs are voltage supplied or if a corresponding status change has been received via a safe bus system. The SS2 status is displayed in status bit **4**.

11.7.2 Error response time SS2 function

Maximum switch-on delay (+ filter time for the safety input + pulse length for the input analysis)	< 2 ms
Maximum switch-on delay (+ filter time for the safety input + pulse length for the input analysis)	< 2 ms

Tab. 17: Error response times

The response time of the SS2 function depends largely on the encoder settings for the speed measurement.

11.7.3 Description of the SS2-r function

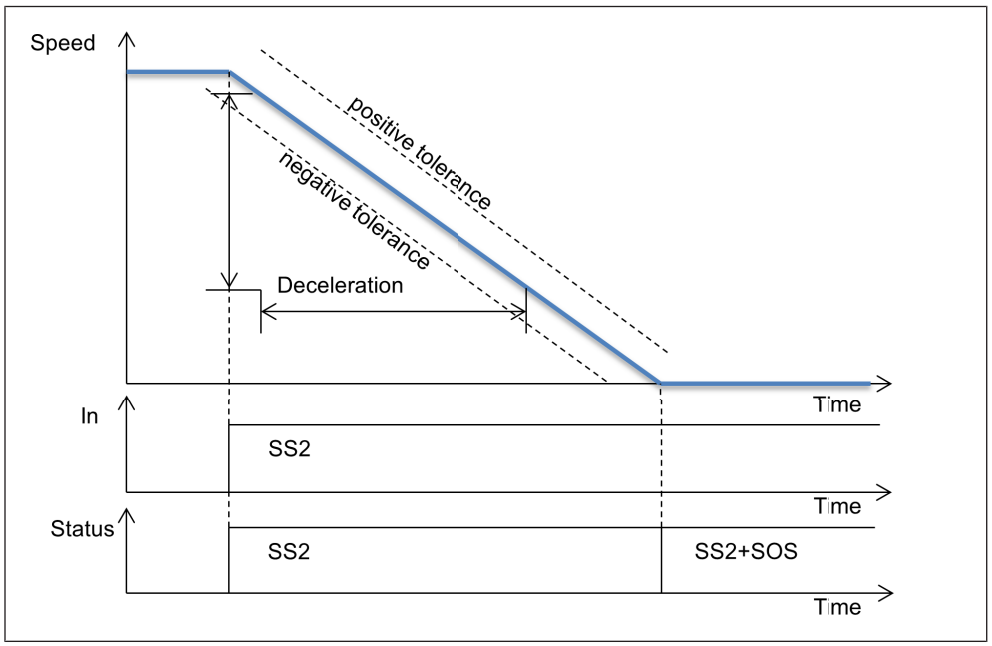

Fig. 38: SS2-r safety function

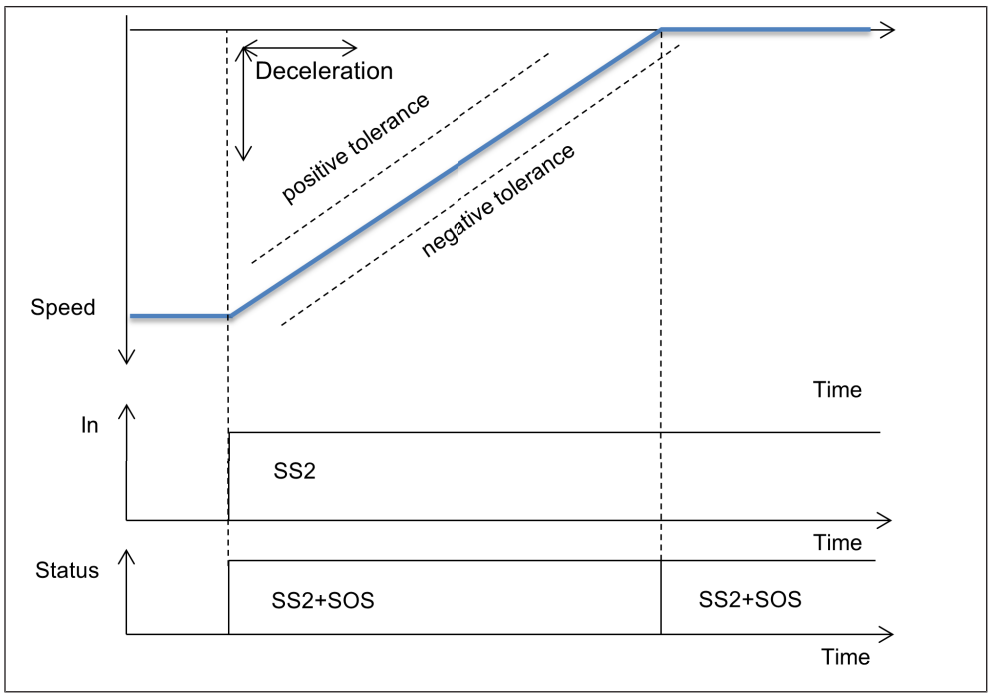

Fig. 39: SS2-r safety function with negative speed

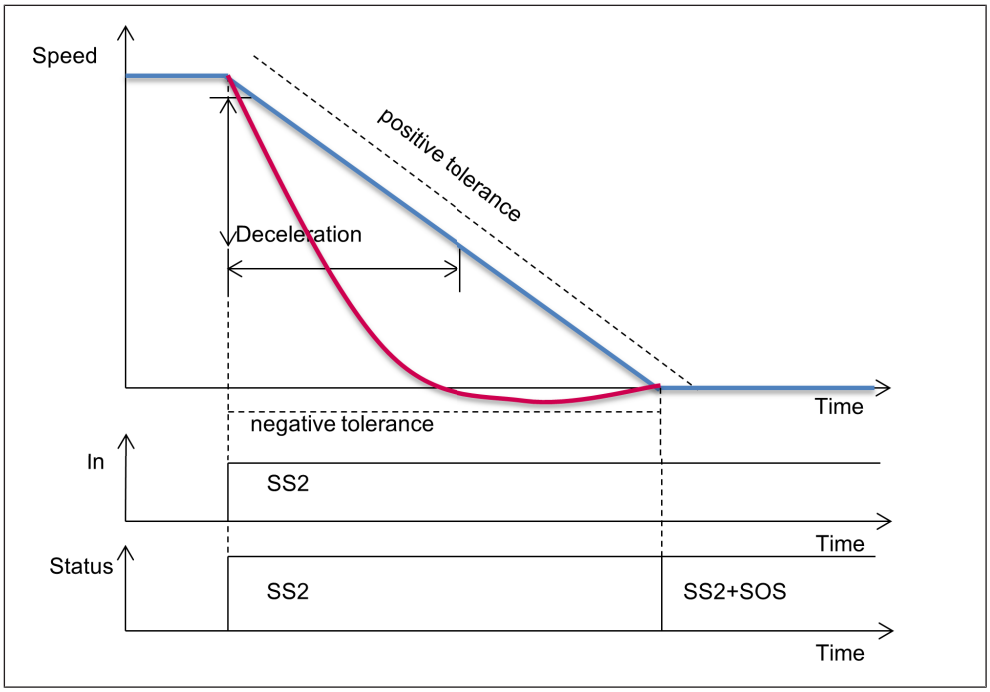

Fig. 40: SS2-r safety function with higher deceleration permissible

The brake ramp is monitored after triggering of the function, as in the SS1-r function. After reaching standstill the function SOS is executed.

From control card firmware 2.5, a stop condition can be set for SS1 and SS2 in pn80. This means when one of the conditions is triggered, the drive automatically moves down at the ramp.

11.7.4 Description of the SS2-t function

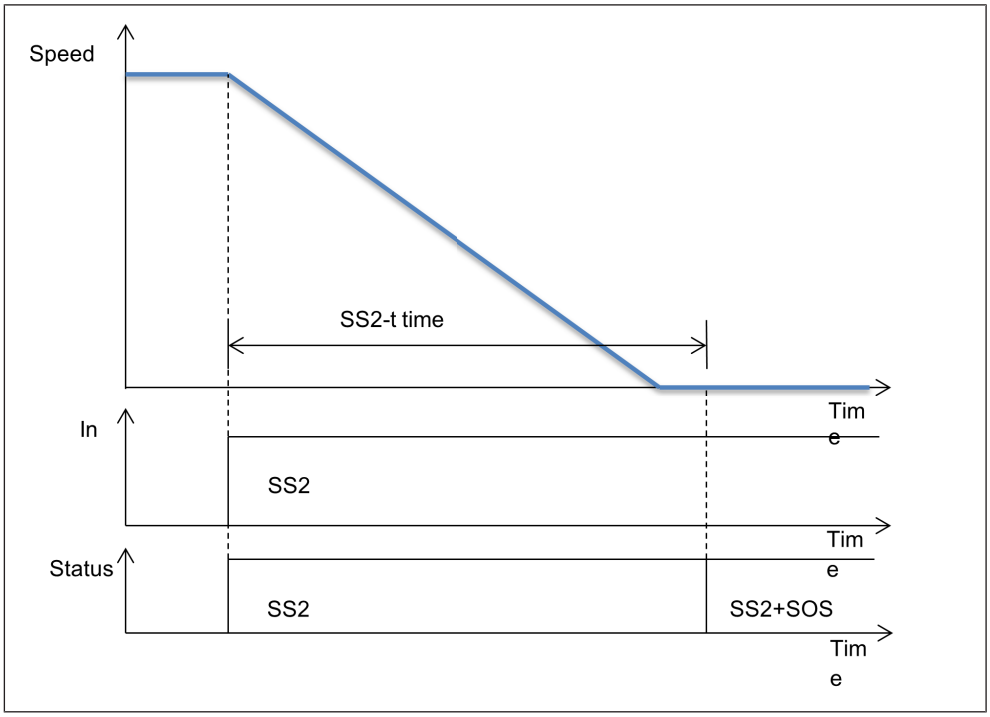

Fig. 41: SS2-t function

After tripping of function SS1, the drive is decelerated due to the effect of the drive control. State SOS is assumed after expiration of the configurable "SS2-t time“.

Selection of the type of the function

ID	Name	Value (default)
xx.01	Selection of the type of the function	Type r and type t (formerly B and C)

xx for index 1 (25) to index 8 (32).

Value list
Type r and type t STO is executed as soon as the ramp or the time delay has elapsed.
Type r only STO is executed as soon as the ramp has ended.
Type r only STO is executed as soon as the ramp has ended.

Deceleration

Permits the monitoring of the ramp which decelerates the motor of the COMBIVERT.

This parameter is only effective for SS1-r.

ID	Name	Value	Unit	Min. value	Max. value
xx.02	Deceleration	0.010000	1/s²	0.010000	60000.000000

xx for index 1 (25) to index 8 (32).

Negative tolerance

Allows to define a range, in which speed deviations are tolerated by the ramp.

This parameter is only effective for SS1-r.

ID	Name	Value	Unit	Min. value	Max. value
xx.03	Negative tolerance	0.000000	rpm	0.000000	60000.000000

xx for index 1 (25) to index 8 (33).

Positive tolerance

Allows to define a range, in which speed deviations are tolerated by the ramp.

This parameter is only effective for SS1-r.

ID	Name	Value	Unit	Min. value	Max. value
xx.04	Positive tolerance	0.000000	rpm	0.000000	60000.000000

xx for index 1 (25) to index 8 (32).

Time window for speed deviation

Permits a deviation of the motor from the ramp for the adjusted time. The STO safety function is executed if the time is exceeded. A status change to FailSafe is only triggered if the time from activation of SS1-r until the ramp is violated (incl. tol-

erance) plus the set tolerance time is shorter than the delay time specified by the setpoint ramp and the output speed. If the time of activation SS1-r plus tolerance time is higher, SS1-r will detect a successful deceleration and STO is set after the deceleration time has elapsed (related to ramp and output speed) and FS is not set.
The counter is incremented when the speed is outside the speed limit. The counter is decremented when the speed is back within the speed limit.

This parameter is only effective for SS1-r.

ID	Name	Value	Unit	Min. value	Max. value
xx.05	Time window for speed tolerance	0.000000	s	0.000000	600.000000

xx for index 1 (25) to index 8 (32).

Type-t time (formerly C)

If the entered time period has expired, the safety function STO is executed. A ramp is not monitored here. The speed must not necessarily zero after the delay time has expired, the change to the STO state occurs without further testing.

This parameter is only effective for SS1-t.

ID	Name	Value	Unit	Min. value	Max. value
xx.06	Type-t time (formerly C)	0.000000	s	0.000000	600.000000

xx for index 1 (25) to index 8 (33).

Higher deceleration allowed

The speed must not be higher than the deceleration + positive tolerance. However, the lower speed limit is 0 - negative tolerance. Thus the drive can also decelerate faster.

If the tolerance range is left longer than the defined time in the time window, it is changed into state STO.

ID	Name	Value	Unit	Min. value	Max. value
xx.07	Higher deceleration allowed	0.000000	s	0.000000	600.000000

xx for index 1 (25) to index 8 (32).

11.8 Functional description safe limited speed (SLS)

The SLS safety function ensures that the drive does not exceed the upper speed limit and does not fall below the lower speed limit.

Errors are faded out via a further parameter, which defines a max. tolerable time for short-term deviations of the tolerance window.

An adjustable error function is triggered in error case.

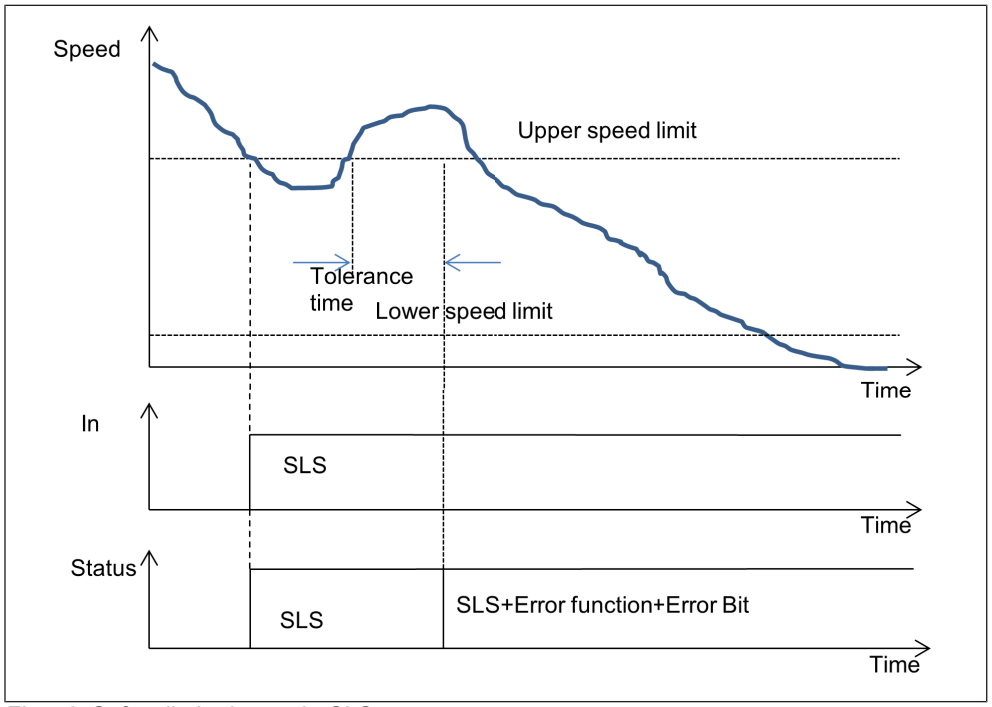

Fig. 42: Safety limited speed - SLS

11.8.1 Activation of the safety function SLS

The circuit operates on two channels. The safety function of the control of the COMBIVERT can only be left, if both hardware inputs are voltage supplied or if a corresponding status change has been received via a safe bus system. The **SLS status** is displayed in status bit 9.

11.8.2 Configuration parameters of the safety function SLS

Parameter	Value	Unit
SLS: Safely-limited speed		
speed limit	0.000000	1/min
Tolerance time	0.000000	s
Error function	STO	

Fig. 43: Configuration parameters for the safety function SLS

The maximum permitted speed in forward direction.

The minimum permissible speed in reverse direction.

This is the time within the upper or lower speed limit shall be exceeded. The counter is incremented when the speed is outside the speed limit. The counter is decremented when the speed is back within the speed limit.

When exceeding the adjusted maximum speed by the tolerance time, this error function is executed. STO or SS1.

11.8.3 Error response times SLS function

Maximum switch-on delay (+ filter time for the safety input + pulse length for the input analysis)	< 2 ms
Maximum switch-on delay (+ filter time for the safety input + pulse length for the input analysis)	< 2 ms

Tab. 18: Error response times

Upper speed limit

The maximum permitted speed in forward direction.

ID	Name	Value	Unit	Min. value	Max. value
xx.01	Upper speed limit	60000.000000	rpm	-60000.000000	60000.000000

xx for index 1 (33) to index 8 (40).

Lower speed limit

The maximum permitted speed in anti-clockwise direction.

ID	Name	Value	Unit	Min. value	Max. value
xx.03	Lower speed limit	-60000.000000	rpm	-60.000000	60000.000000

xx for index 1 (33) to index 8 (40).

Tolerance time

This is the time within the upper or lower speed limit shall be exceeded. The counter is incremented when the speed is outside the speed limit. The counter is decremented when the speed is back within the speed limit.

ID	Name	Value	Unit	Min. value	Max. value
xx.03	Tolerance time	0.000000	s	0.000000	60.000000

xx for index 1 (33) to index 8 (40).

Error function

Selection of the error function that is executed if the set maximum speed is exceeded by the tolerance time.

ID	Name	Value	Unit	Min. value	Max. value
xx.04	Error function	STO	-	STO	SS1

xx for index 1 (33) to index 8 (40).

11.9 Functional description Safe Speed Monitoring (SSM)

The safety function provides a safe output signal if the speed does not exceed a defined value. The safe output is switched off if the value of the parameterized speed plus hysteresis is exceeded. The safe output is only set if the value falls below the parameterized speed plus hysteresis.

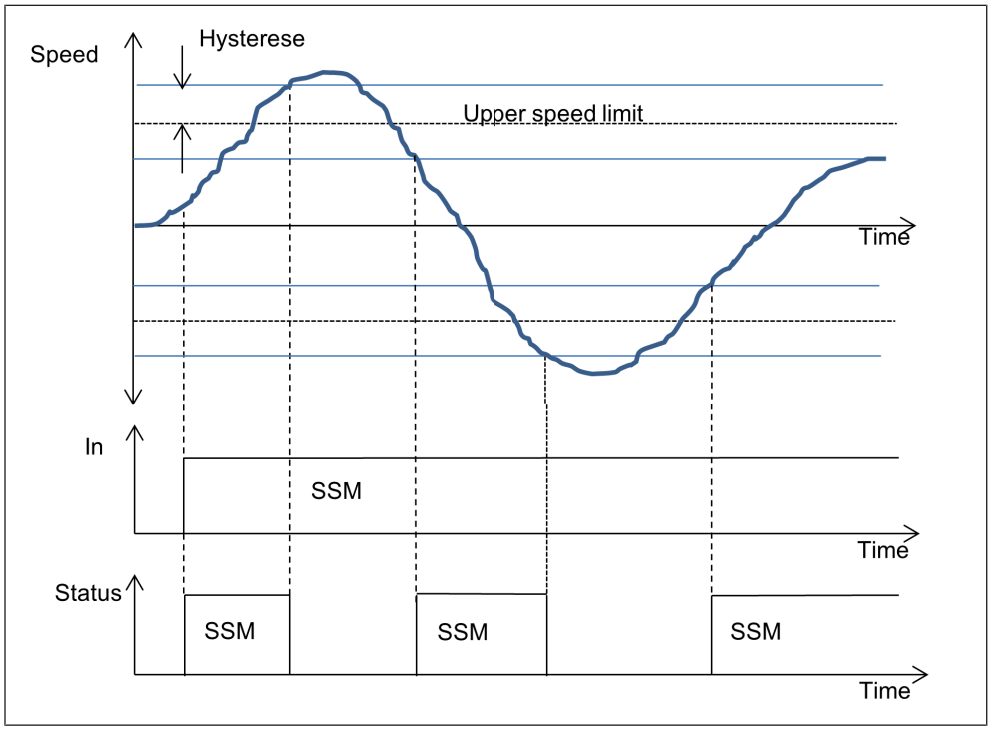

Fig. 44: Safe Speed Monitor – SSM

11.9.1 Activation of the safety function SSM

The circuit operates on two channels. The safety function of the control of the COMBIVERT can only be left, if both hardware inputs are voltage supplied or if a corresponding status change has been received via a safe bus system. The SSM status is displayed in status bit 16.

11.9.2 Error response times SSM function

Maximum switch-on delay (+ filter time for the safety input + pulse length for the input analysis)	< 2 ms
Maximum switch-on delay (+ filter time for the safety input + pulse length for the input analysis)	< 2 ms

Tab. 19: Error response times

11.9.3 Upper speed limit

Upper speed level when the SSM status shall be set.

ID	Name	Value	Unit	Min. value	Max. value
xx.01	Upper speed limit	120000.000000	rpm	0.000000	120000.000000

xx for index 1 (26) to index 8 (33).

11.9.4 Lower speed limit

Lower speed level when the SSM status shall be set.

ID	Name	Value	Unit	Min. value	Max. value
xx.02	Lower speed limit	120000.000000	rpm	0.000000	120000.000000

xx for index 1 (26) to index 8 (33).

11.9.5 Hysterese

Specification of the hysteresis.

The SSM status is reset on exceeding the hysteresis + speed level. The SSM status is set again if the speed limit – hysteresis is fallen below.

ID	Name	Value	Unit	Min. value	Max. value
xx.03	Hysterese	120000.000000	rpm	0,000000	120000.000000

xx for index 1 (26) to index 8 (33).

11.9.6 Monitoring always active

The speed level can be monitored even without the configuration of an input for the function SSM.

ID	Name	Value	Unit	Min. value	Max. value
xx.04	Monitoring always active	off	-	off	on

xx for index 1 (26) to index 8 (33).

11.10 Functional description Safe Maximum Speed (SMS)

The safety function SMS ensures that the drive does not exceed the upper speed limit and does not fall below the lower speed limit.

Errors are faded out via a further parameter, which defines a max. tolerable time for short-term deviations of the tolerance window.

An adjustable error function is triggered in error case.

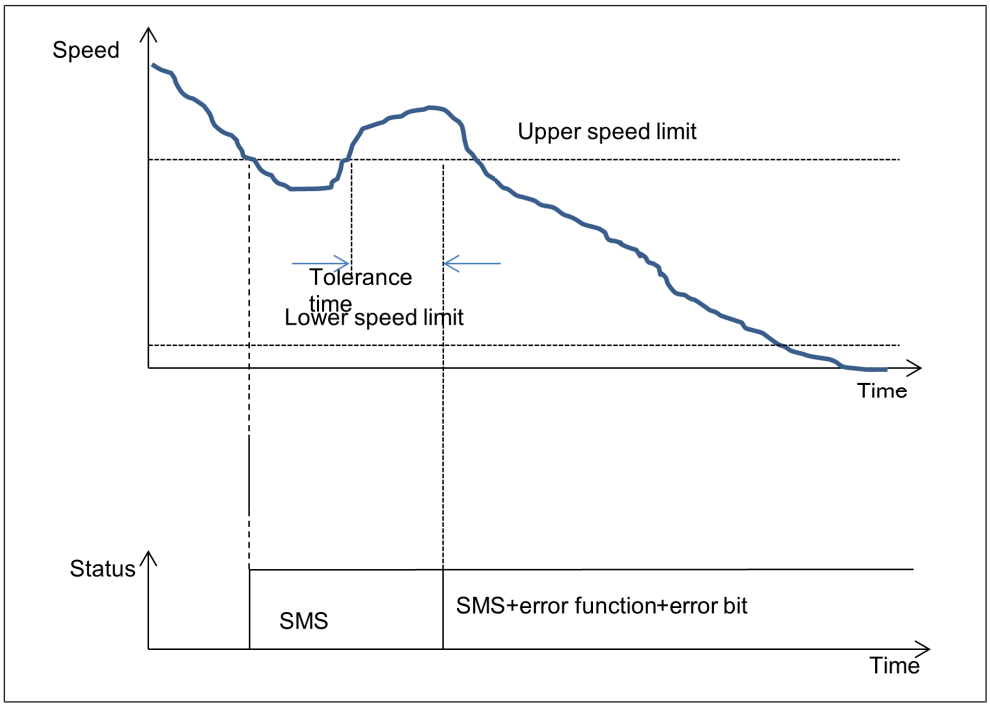

Fig. 45: Safe maximum speed - SMS

11.10.1 Activation of the safety function SMS

SMS is always activated. If the speed limits are set that they correspond to the maximum permissible speed of the safety module, SMS is effectively switched off. The SMS status is displayed in parameter SMS status in status bit 17.

11.10.2 Error response times SMS function

Maximum switch-off delay	< 2 ms

Tab. 20: Error response times

Upper speed limit

Maximum permissible speed for the positive direction of rotation.

ID	Name	Value	Unit	Min. value	Max. value
xx.01	Upper speed limit	60000.000000	rpm	-60000.000000	60000.000000

xx for index 1 (49) to index 8 (56).

Lower speed limit

Maximum permissible speed for the negative direction of rotation.

ID	Name	Value	Unit	Min. value	Max. value
xx.02	Lower speed limit	60000.000000	rpm	-60000.000000	60000.000000

x for index 1 (49) to index 8 (56).

Tolerance time

This is the time within the max. or min. speed shall be exceeded. The counter is incremented when the speed is outside the speed limit. The counter is decremented when the speed is back within the speed limit.

ID	Name	Value	Unit	Min. value	Max. value
xx.03	Tolerance time	0.000000	s	0.000000	60.000000

x for index 1 (49) to index 8 (56).

Error function

When exceeding the adjusted max. speed by the tolerance time, this error function is executed. STO or SS1.

ID	Name	Value	Unit	Min. value	Max. value
xx.04	Error function	STO	-	STO	SS1

x for index 1 (49) to index 8 (56).

11.11 Function description Safely Limited Acceleration (SLA)

The SLA safety function ensures that the drive does not exceed a maximum acceleration or fall below a minimum acceleration limit. This applies both to the positive and negative direction of rotation. An adjustable malfunction is executed in error case.

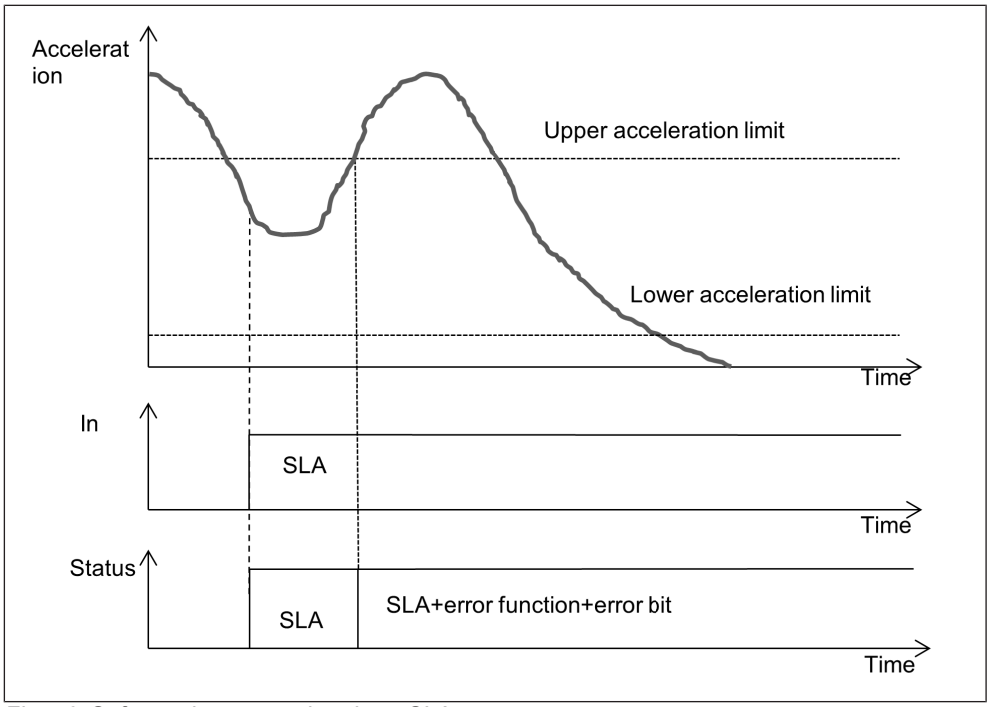

Fig. 46: Safe maximum acceleration - SLA

11.11.1 Acceleration limits

The upper and lower acceleration limits have a dependence on the speed scan time and speed PT1 time. The parameters described in chapter 10.5 are also valid for the SLA function.

The SLA safety function checks the acceleration in a 250 µs grid. The following formula is valid:

Limit / 4000 * 60 > V2 – V1.

V2-V1 are calculated by the safety module in a 250 µs grid in rpm.

Example:

With an upper acceleration limit of 2000 1/s², the differential speed must not exceed 30 rpm per 250 µs grid. Calculation: (Limit / 4000) * 60 > V2 – V1.

Procedure for triggering the error function:

Speed fluctuations are much more problematic at SLA than with other safety functions, since the difference of the speed between two scanning steps (250us) is always examined. A high PT1 filter time can improve the behavior (e.g. 100ms). But attention, a high PT1 filter time has adverse effects on the behavior of other speed-sensitive safety functions. These trigger later, or they do not recognize very briefly overspeed.

The log can be evaluated to detect the acceleration from the safety module.

Position	Speed	Time slots per 62.5 µs	Details
261856	253.5122 1/min	13647	66179: STO + Brake closed + Fail safe + SLA + SMS
-2147483648	252.7471 1/min	13643	513: STO + Brake open + SLA + SMS

Fig. 47: Log entries for the SLA safety function

As soon as acceleration above the set limits is detected, 2 log entries are generated. The top log entry shows the triggering of SLA with the fail safe bit and the next log entry 250us before the error was detected.

The acceleration can be calculated with this formula:

(Speed 1 – Speed 2) / 60s / 250us = acceleration

In this example that means:

(253.5122 rpm – 252.7471 rpm) /60s /0.00025s = 51 1/s². The adjusted upper acceleration limit was 50 1/s².

The position at time Speed2 is not stored. Therefore this position is always indicated with -2147483648.

11.11.2 Activation of the safety function SLA

The circuit operates on two channels. The safety function of the control of the COMBIVERT can only be left, if both hardware inputs are voltage supplied or if a corresponding status change has been received via a safe bus system. The SLA status is displayed in status bit 10.

11.11.3 Error response times SLA function

Maximum switch-on delay (+ filter time for the safety input + pulse length for the input analysis)	< 2 ms
Maximum switch-on delay (+ filter time for the safety input + pulse length for the input analysis)	< 2 ms

Tab. 21: Error response times

11.11.4 Upper acceleration limit

Maximum permitted acceleration when accelerating the drive for both directions of rotation.

ID	Name	Value	Unit	Min. value	Max. value
5x.01	Upper acceleration limit	0,000000	1/s²	0.000000	500000.000000

x for index 1 (0) to index 8 (7).

ID	Name	Value	Unit	Min. value	Max. value
xx.01	Upper acceleration limit	0.000000	1/s²	-100000.000000	1000000.000000

xx for index 1 (57) to index 8 (64).

11.11.5 Lower acceleration limit

Maximum permitted acceleration during deceleration (deceleration limit) of the drive in both directions of rotation.

ID	Name	Value	Unit	Min. value	Max. value
5x.02	Lower acceleration limit	0.000000	1/s²	0.000000	500000.000000

x for index 1 (0) to index 8 (7).

ID	Name	Value	Unit	Min. value	Max. value
xx.02	Lower acceleration limit	-1000000.000000	1/s²	0.000000	1000000.000000

x for index 1 (57) to index 8 (64).

11.11.6 Error function

This error function is carried out if the upper acceleration limit is exceeded, or if the lower acceleration limit is fallen below. STO or SS1.

ID	Name	Value	Unit	Min. value	Max. value
5x.03	Error function	STO	-	STO	SS1

x for index 1 (0) to index 8 (7).

ID	Name	Value	Unit	Min. value	Max. value
xx.03	Error function	STO	-	STO	SS1

x for index 1 (57) to index 8 (64).

11.12 Functional description Safe Operating Stop (SOS)

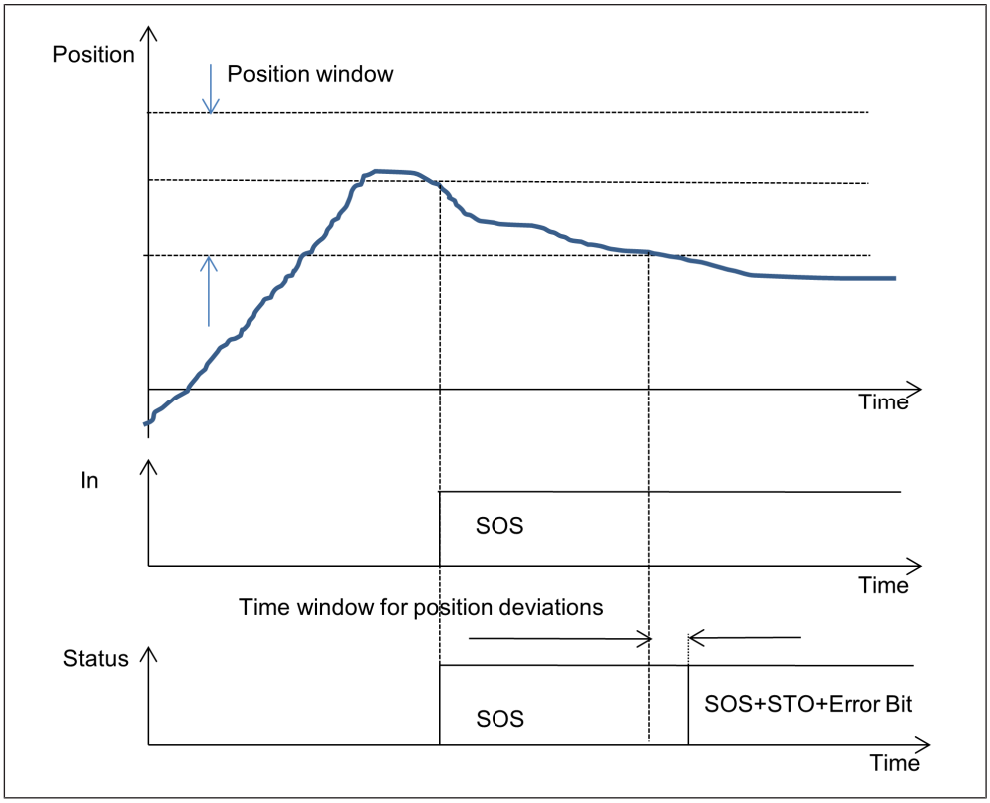

Fig. 48: SOS safety function

The SOS function monitors whether the drive remains in its standstill position and rejects external torques. Since analog sensor signals are processed for position detection and no static sensor signals are present even at absolute standstill, it is necessary to define a tolerance window by a parameter.

Errors are faded out via a further parameter, which defines a max. tolerable time for short-term deviations of the tolerance window.

11.12.1 Activation of the safety function SOS

The circuit operates on two channels. The safety function of the control of the COMBIVERT can only be left, if both hardware inputs are voltage supplied or if a corresponding status change has been received via a safe bus system. The SOS status is displayed in parameter SOS Status in status bit **5**.

11.12.2 Error response time SOS function

Maximum switch-on delay (+ filter time for the safety input + pulse length for the input analysis)	< 2 ms

Maximum switch-on delay (+ filter time for the safety input + pulse length for the input analysis)	< 2 ms

Tab. 22: Error response times

Position window

The drive shall not leave this position window.

ID	Name	Value	Unit	Min. value	Max. value
xx.01	Position window	0	Ps	-2147483648	2147483647

x für Index 1 (65) bis Index 8 (72).

Time window for position deviations

If the position window is left longer than the time window for position deviations, then the safety function STO is executed. The counter is incremented when the speed is outside the speed limit. The counter is decremented when the speed is back within the speed limit.

ID	Name	Value	Unit	Min. value	Max. value
xx.02	Time window for position deviations	0.000000	s	0,000000	60.000000

x für Index 1 (65) bis Index 8 (72).

11.13 Functional description Safely-Limited Increment (SLI)

The safety function prevents that the drive shaft exceeds the defined limited position increments. The activation of an input configured with the function SLI of the safety module causes first the stop of the drive in the SOS function.

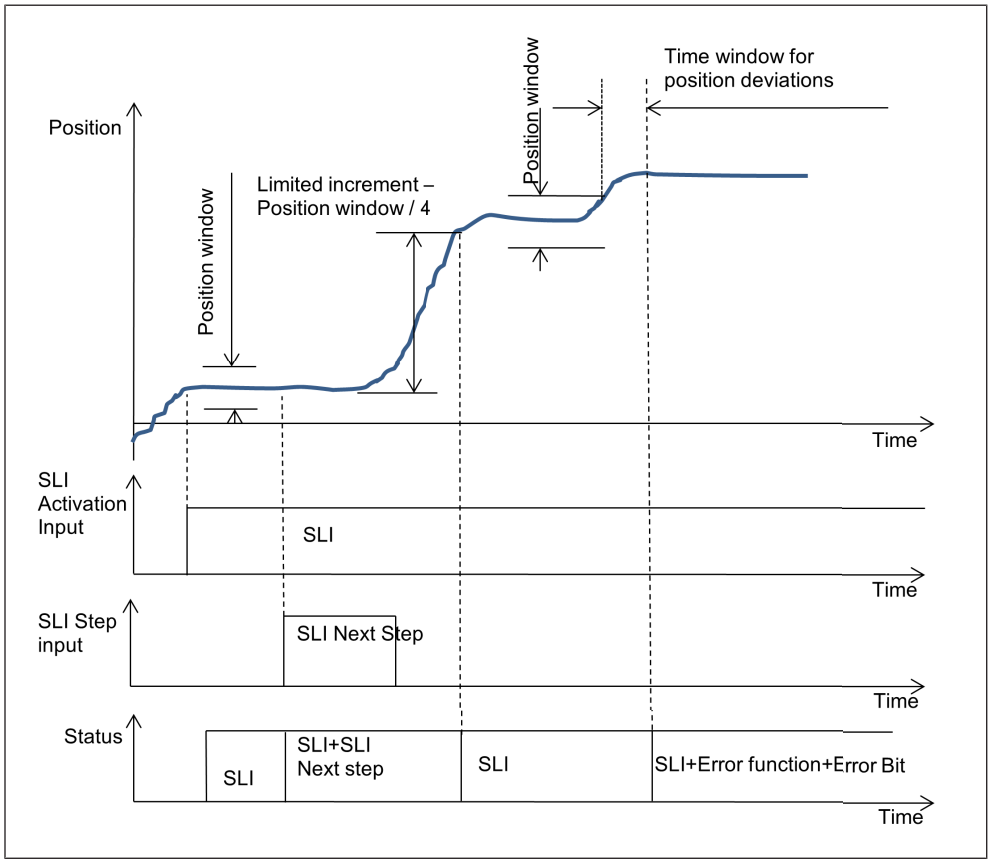

Fig. 49: Safely-Limited Increment – SLI

Upon leaving the position windows, an error function is activated which triggers the function STO or SS1.

SLI Next Step can only be used if SLI has been previously activated.

11.13.1 Activation of the safety function SLI

The circuit operates on two channels. The safety function of the control of the COMBIVERT can only be left, if both hardware inputs are voltage supplied or if a corresponding status change has been received via a safe bus system. The SLI status is displayed in state as follows:

SLI status is displayed in status bit 14.

SLI Next Step activation status is displayed in status bit 15.

11.13.2 Error response times SLI function

Maximum switch-on delay (+ filter time for the safety input + pulse length for the input analysis)	< 2 ms
Maximum switch-on delay (+ filter time for the safety input + pulse length for the input analysis)	< 2 ms

Tab. 23: Error response times

Limited increment

As soon as the next step was activated, the safety module waits until the step was executed. This is the case, if the new position has reached the limited increment - (position window / 4) with positive direction of rotation. With negative direction, the next position is reached when the limited (-increment) + (position window /4) is reached.

ID	Name	Value	Unit	Min. value	Max. value
xx.01	Limited increment	0	Ps	0	4294967295

xx for index 1 (73) to index 8 (80).

Minimum stay in the position window

This is the minimum retention time in the safety function SOS after a step was executed.

ID	Name	Value	Unit	Min. value	Max. value
xx.02	Minimum stay in the position window	0.000000	s	0.000000	1.000000

xx for index 1 (73) to index 8 (80).

Error function

In error case STO or SS1 is executed.

ID	Name	Value	Unit	Min. value	Max. value
xx.03	Error function	STO	-	STO	SS1

xx for index 1 (73) to index 8 (80).

Position window

The position window, where the position can move, if no step is executed.

ID	Name	Value	Unit	Min. value	Max. value
xx.04	Position window	0	Ps	-2147483648	2147483647

x für Index 1 (73) bis Index 8 (80).

Time window for position deviation

The position may differ from the position window for a short time. The error function is triggered if the position deviation is longer than this time window. The counter is incremented when the speed is outside the speed limit. The counter is decremented when the speed is back within the speed limit.

ID	Name	Value	Unit	Min. value	Max. value
xx.05	Time window for position deviations	0.000000	s	0.000000	1.000000

x für Index 1 (73) bis Index 8 (80).

11.14 Functional description SLP: Reference position

The function SLP reference position sets the reference position for the safety function "Safely-Limited Position (SLP)". Approach to reference point must be executed again after re-configuration of the safety module.

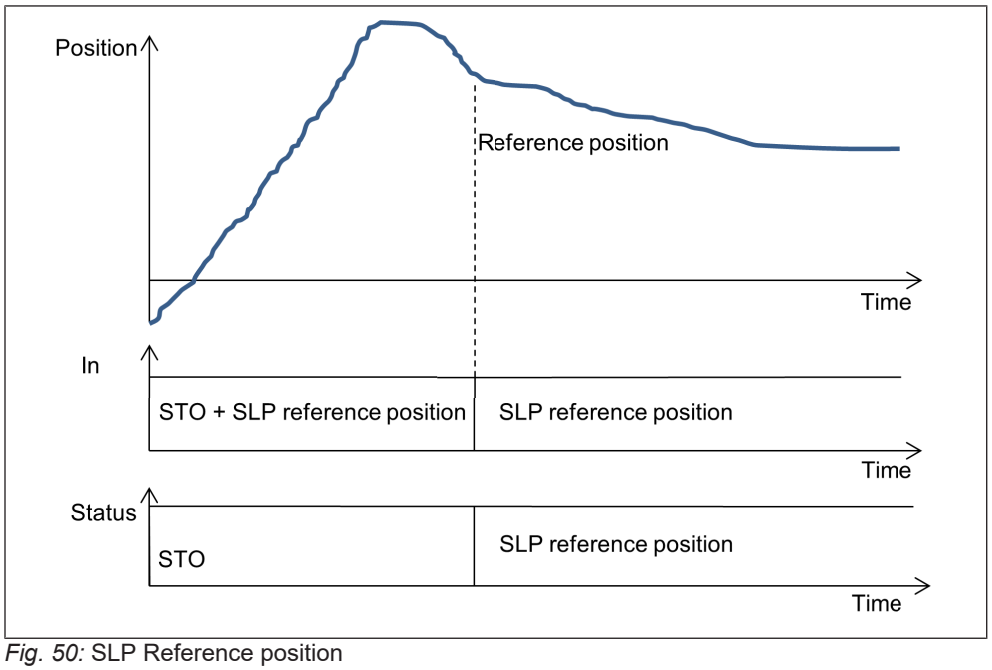

Fig. 50: SLP Reference position

11.14.1 Activation of the function SLP reference position

A reference position must be set previously, in order that the safety function "Safely-Limited Position (SLP)" can be executed. The following must be observed.

- The reference position can only be set if no safety function with higher priority is active. If STO is activated via the inputs, no reference position can be set.
- The reference position can only be set once.
- The reference position is set exactly when the configured inputs are not supplied or the request was given via a safe bus system.

If the reference position has been set, bit SLP Set Reference Position is set permanently in the status of the safety module.

If an output was configured for the function SLP: reference position, this output is switched permanently after the reference position has been set.

If the SLP reference position is set, this is displayed in parameter SLP reference position set in status bit 12.

11.14.2 Configuration parameters SLP reference position

SLP: Reference position		
Absolute reference position	0	Bpr

Fig. 51: Configuration parameters of the function SLP reference position

11.14.3 Absolute reference position

This is the reference position, which determines the maximum and minimum drive position. When interconnecting a push-button must be reserved for SLP reference position and another for SLP. The safety function SLP can only be executed if the reference position was previously set via push-button.

ID	Name	Value	Unit	Min. value	Max. value
81.01	Position window	0	Ps	-2147483648	2147483647

11.15 Functional description Safely-Limited Position (SLP)

The safety function SLP ensures that the drive shaft does not exceed the parameterized absolute position limits.

The maximum, limited range of the drive is defined with parameters "max. position limit" and "min. position limit".

The detection of the reference position occurs (e.g.) via a position switch, which assigns a safe input of the safety module. During the detection of the position switch by the input of the safety module the absolute value of the reference position is stored as actual absolute position. The position limits are monitored based on encoder increments on two channels.

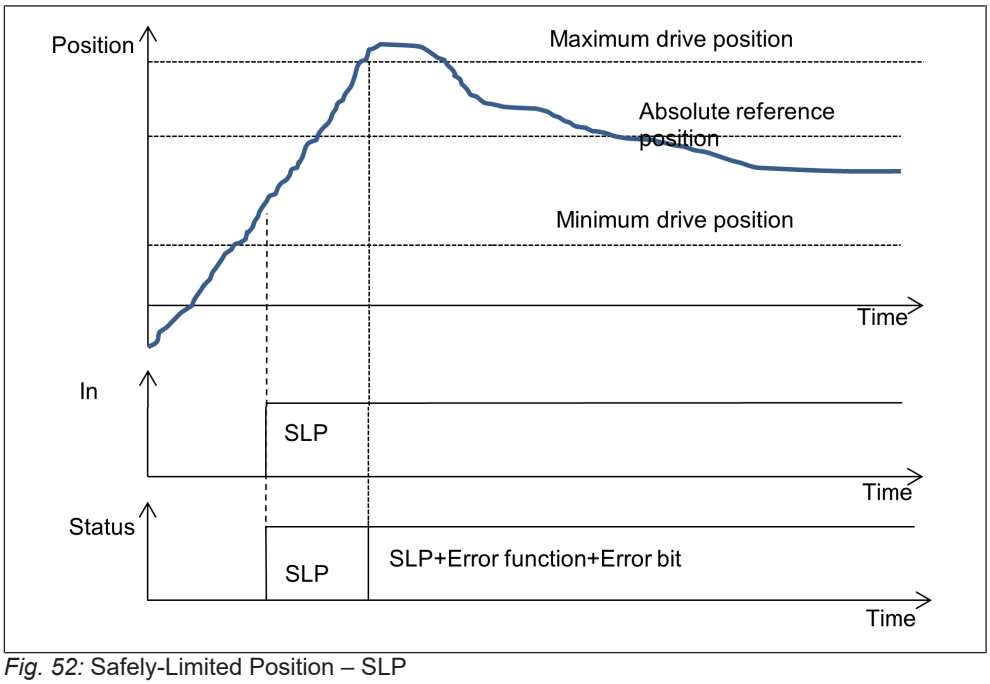

Fig. 52: Safely-Limited Position – SLP

11.15.1 Activation of the safety function SLP

The circuit operates on two channels. The safety function of the control of the COMBIVERT can only be left, if both inputs are voltage supplied (Function1 or Function2 inputs => 4). If both inputs are not set, the following is displayed in the state:

- SLP status in status bit 12.
- SEL status in status bit 13.

11.15.2 Configuration parameters of the safety function SLP

Parameter	Value	Unit
SLP: Safely-limited position [1]		
Maximum drive position	0	Ps
Minimum drive position	0	Ps
Error function	STO	
SEL: Difference position	0	Ps
SEL: Speed limit	0.000000	1/min

Fig. 53: Configuration parameters of the safety function SLP

Parameterisation

11.15.3 Error response times SLP function

Maximum switch-on delay (+ filter time for the safety input + pulse length for the input analysis)	< 2 ms
Maximum switch-on delay (+ filter time for the safety input + pulse length for the input analysis)	< 2 ms

Tab. 24: Error response times

11.15.4 Functional description Safe Emergency Limits (SEL)

The safety function SEL (Safe Emergency Limits) can be activated additionally to SLP. SEL is activated as soon as the SEL difference position is set to a value higher than 0.

From the difference position, the speed may no longer exceed the set SEL limit for the speed. The permissible speed decreases squarely close to the SLP maximum or minimum position. The following formula is valid:

$$Speed\ \ limit = SEL\ \ Limit * \sqrt{\frac{Position\ \ difference}{SEL\ \ Difference}}$$

Fig. 54: Formula speed limit

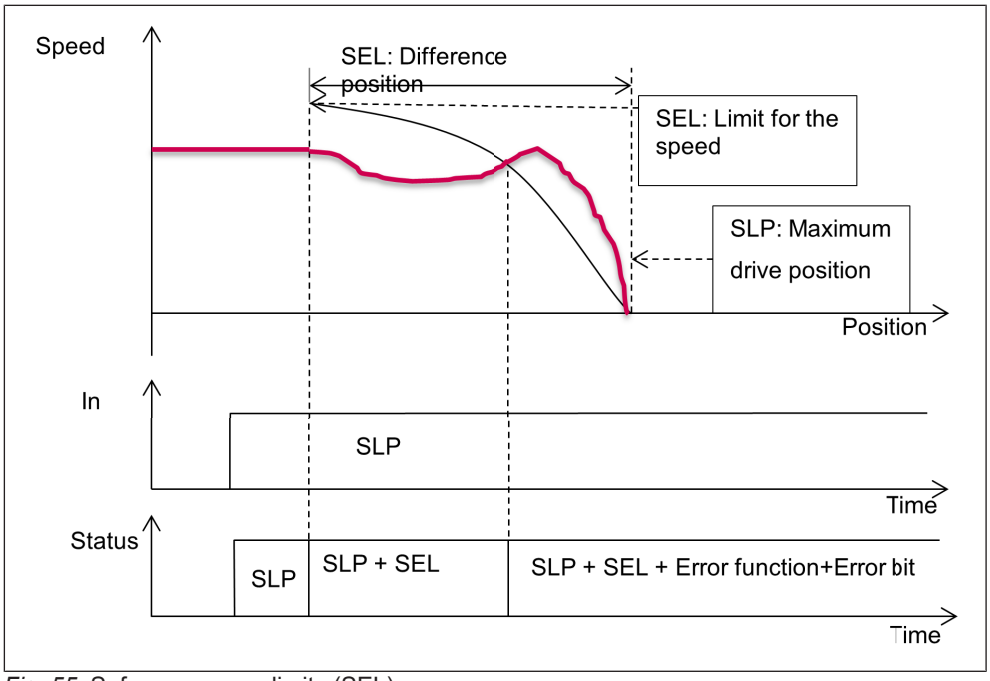

Fig. 55: Safe emergency limits (SEL)

11.15.5 Absolute reference position

This is the reference position, which determines the maximum and minimum drive position. When interconnecting a push-button must be reserved for SLP reference position and another for SLP. The safety function SLP can only be executed if the reference position was previously set via push-button.

ID	Name	Value	Unit	Min. value	Max. value
81.01	Position window	0	Ps	-2147483648	2147483647

11.15.6 Maximum drive position

The motor must never exceed this maximum possible drive position. The adjustment is depending on the absolute reference position.

ID	Name	Value	Unit	Min. value	Max. value
xx.01	Maximum drive position	0	Ps	-2147483648	2147483647

xx for index 1 (82) to index 8 (89).

11.15.7 Minimum drive position

The motor must never fall below this minimum possible drive position. The adjustment is depending on the absolute reference position.

ID	Name	Value	Unit	Min. value	Max. value
xx.02	Minimum drive position	0	Ps	-2147483648	2147483647

xx for index 1 (82) to index 8 (89).

11.15.8 Error function

This error function is triggered on exceeding the adjusted maximum or minimum drive position. STO or SS1.

ID	Name	Value	Unit	Min. value	Max. value
xx.03	Error function	STO	-	STO	SS1

xx for index 1 (82) to index 8 (89).

11.15.9 SEL difference position

The safety function SEL is activated as soon as the difference position to the max. or min. position has been reached. If this safety function is activated, then the speed of the drive may not exceed the set SEL limit for the speed.

ID	Name	Value	Unit	Min. value	Max. value
xx.04	SEL difference position	0	Ps	-2147483648	2147483647

xx for index 1 (82) to index 8 (89).

11.15.10 SEL limit for the speed

If the safety function SEL is activated, the speed of the drive must not be increased beyond the limit. This is a ramp up to SLP maximum drive position.

ID	Name	Value	Unit	Min. value	Max. value
xx.04	SEL limit for the speed	0,000000	rpm	0.000000	60000.000000

xx for index 1 (82) to index 8 (89).

12 Safety over EtherCAT® (FSoE)

12.1 Setting the fieldbus address

In addition to the safety module address, there is also the fieldbus address. This address can be set on the status page of COMBIVIS.

The fieldbus address should always be set before the download of the configuration data because, the safety module changes into error state with the change of the fieldbus address. The error state is only left when a configuration with the same fieldbus address is downloaded.

12.2 Bus settings

The address is specified in two places: In addition to the non-safety-oriented adjustable identification address (adjustable via the tab 'Settings' of the Safety Module Editor) (🌐► Identification (safety module address)) the fieldbus address setting in the safe parameterisation data is required for operating the safe bus. Both addresses must be identical.

The identification address should always be set before downloading safe configuration data, since after the configuration download the address from the safe configuration is compared with the set identification address and the safety module changes into the error state if the addresses do not match. Downloading a configuration with an identical, expected fieldbus address resets the error state.

12.2.1 Bus type

Selection of a safe bus type.

ID	Name	Value (default)
66.01	Bus type	No bus

ID	Name	Value (default)
90.01	Bus type	No bus

Value list
No bus No secure bus system is used. The safety module is controlled solely via the inputs.
FSoE The Safety over EtherCAT® bus system is used.
PROFIsafe The PROFIsafe® bus system is used.

12.2.2 Safety module address

The safety module address must agree with the fieldbus address, which is set in the safety module. By default this address is set to the value 0 (invalid).

ID	Name	Value	Unit	Min. value	Max. value
66.02	Safety address	0	-	0	65535

ID	Name	Value	Unit	Min. value	Max. value
90.02	Safety address	0	-	0	65535

12.2.3 Safe bus data length

If a safe bus system has been selected, the length of the safe data can be adjusted here. This length must agree with the configuration in the safe control.

ID	Name	Value	Unit	Min. value	Max. value
66.03	Safe bus data length	11	-	6	19

ID	Name	Value	Unit	Min. value	Max. value
90.03	Safe bus data length	11	-	6	19

Valid values for FSoE
6 Byte
7 Byte
11 Byte
15 Byte

12.2.4 Safe bus data telegram selection

ID	Name	Value (default)
90.04	Safe bus data telegram selection	0x000h

Values
0x000h
Standard telegram 30
Standard telegram 31
0x900h, 0x901h, 0x902h, 0x903h, 0x904h
0x910h, 0x911h, 0x912h, 0x913h
0x920h, 0x921h, 0x922h, 0x923h, 0x924h, 0x925h, 0x926h, 0x927h, 0x928h
0x980h, 0x981h, 0x982h, 0x983h, 0x984h, 0x985h, 0x986h, 0x987h, 0x988h, 0x989h
0x980h,

12.3 FSoE functional description and parameterization

For this purpose, a separate document has been created which shows the functionality of FSoE in connection with the safety module type 3.

13 Wiring Examples

13.1 Example of an interconnection of clock outputs with inputs

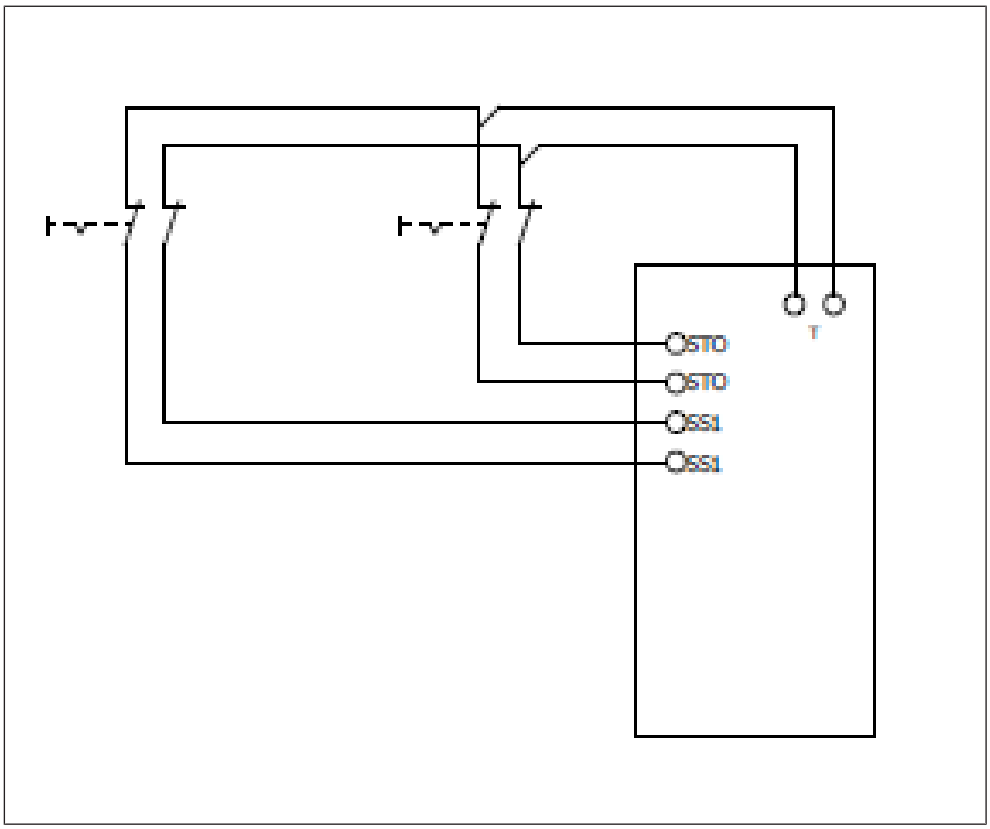

Fig. 56: Clock outputs wired with inputs

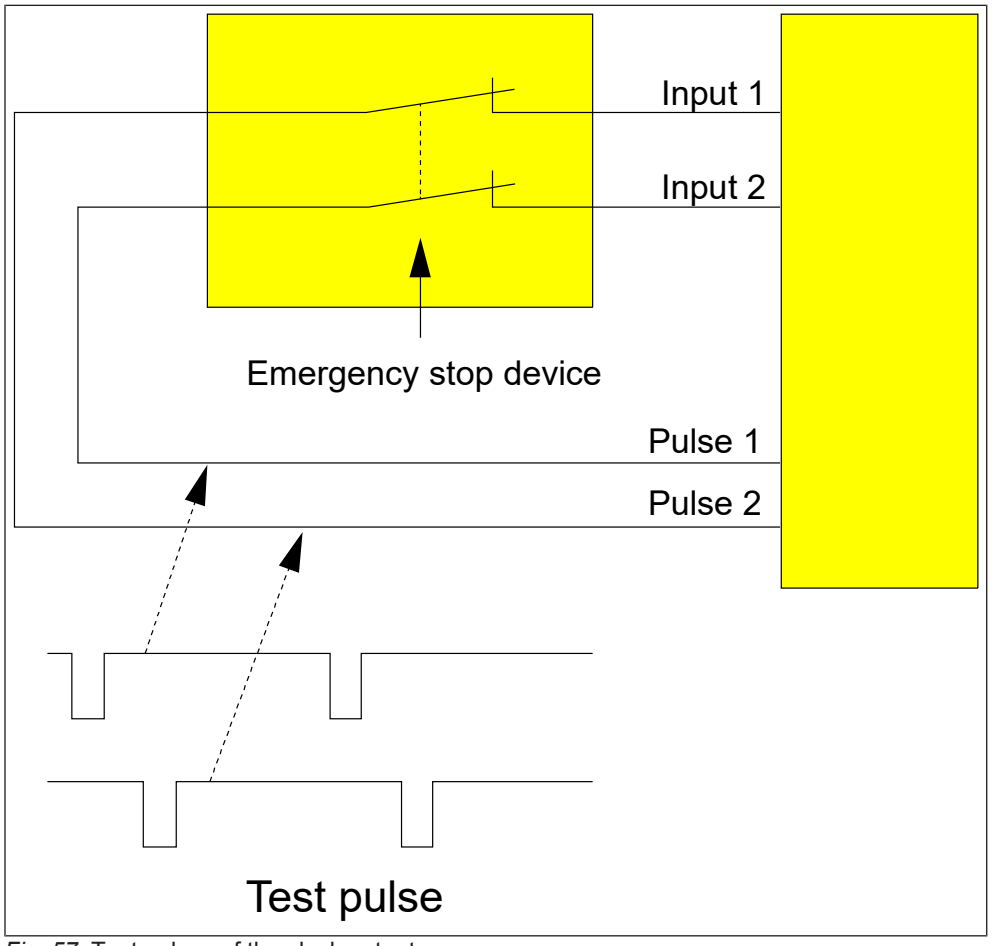

Fig. 57: Test pulses of the clock outputs

Figure 75 shows an example of the wiring of the clock outputs with the STO and SS1 input.

Mechanical contact pairs are supplied via phase-shifted clock outputs to detect dangerous, external line short-circuits between two related inputs and to voltage supply potentials. The module provides two clock signals.

NOTICE

Avoid line short circuits!

a) Since external line short circuits to inputs with the same phase of the clock pulses can not be detected, wiring precautions shall be taken to avoid this error.

13.2 Parameterisation of the clock outputs and inputs

The parameterisation of the clock signal inputs and outputs are described in (≡▶ Parameterisation of the clock outputs and inputs [▶ 98]) and (≡▶ Parameterisation of the clock outputs and inputs [▶ 98]) .

Parameter	Value	Unit
Test signal input configuration		
Test signal period	7.000000	s
Test signal pulse length	0.001000	s
Check of the test-signal for the STO-Inputs	on	
Check of the test-signal for the SBC-Inputs	off	
Check of the test-signal for the Function1-Inputs	off	
Check of the test-signal for the Function2-Inputs	off	

Fig. 58: Configuration of the clock signal inputs

Parameter	Value	Unit
Clock output configuration		
Period of the Clock-Output	7.000000	s
Pulse length of the Clock-Output	0.001000	s

Fig. 59: Configuration of the clock signal outputs

13.3 Example of a ripple chain

13.3.1 Closed ripple chain with 2 safety modules start-up behavior

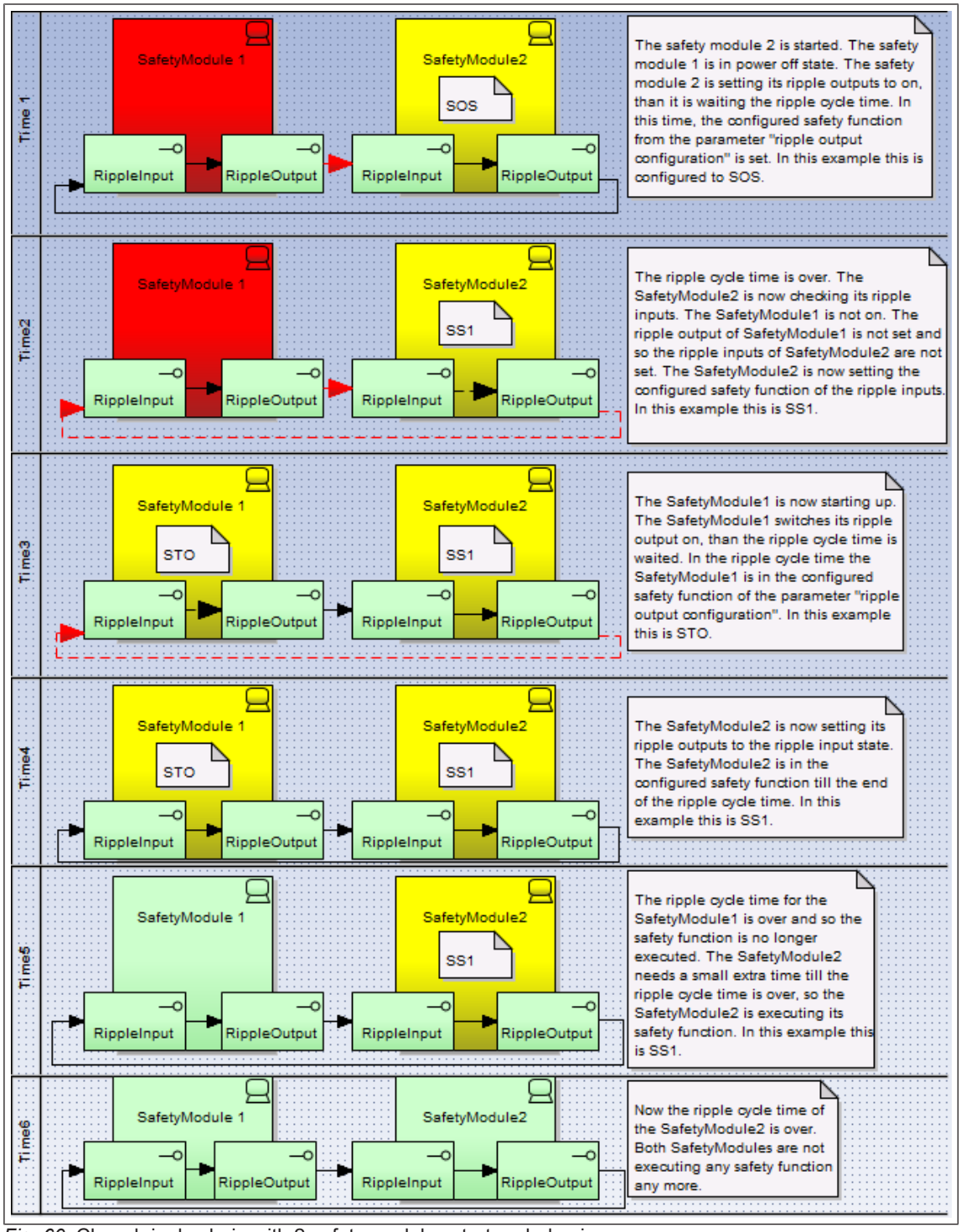

Fig. 60: Closed ripple chain with 2 safety modules start-up behavior

13.3.2 Closed ripple chain with 3 safety modules

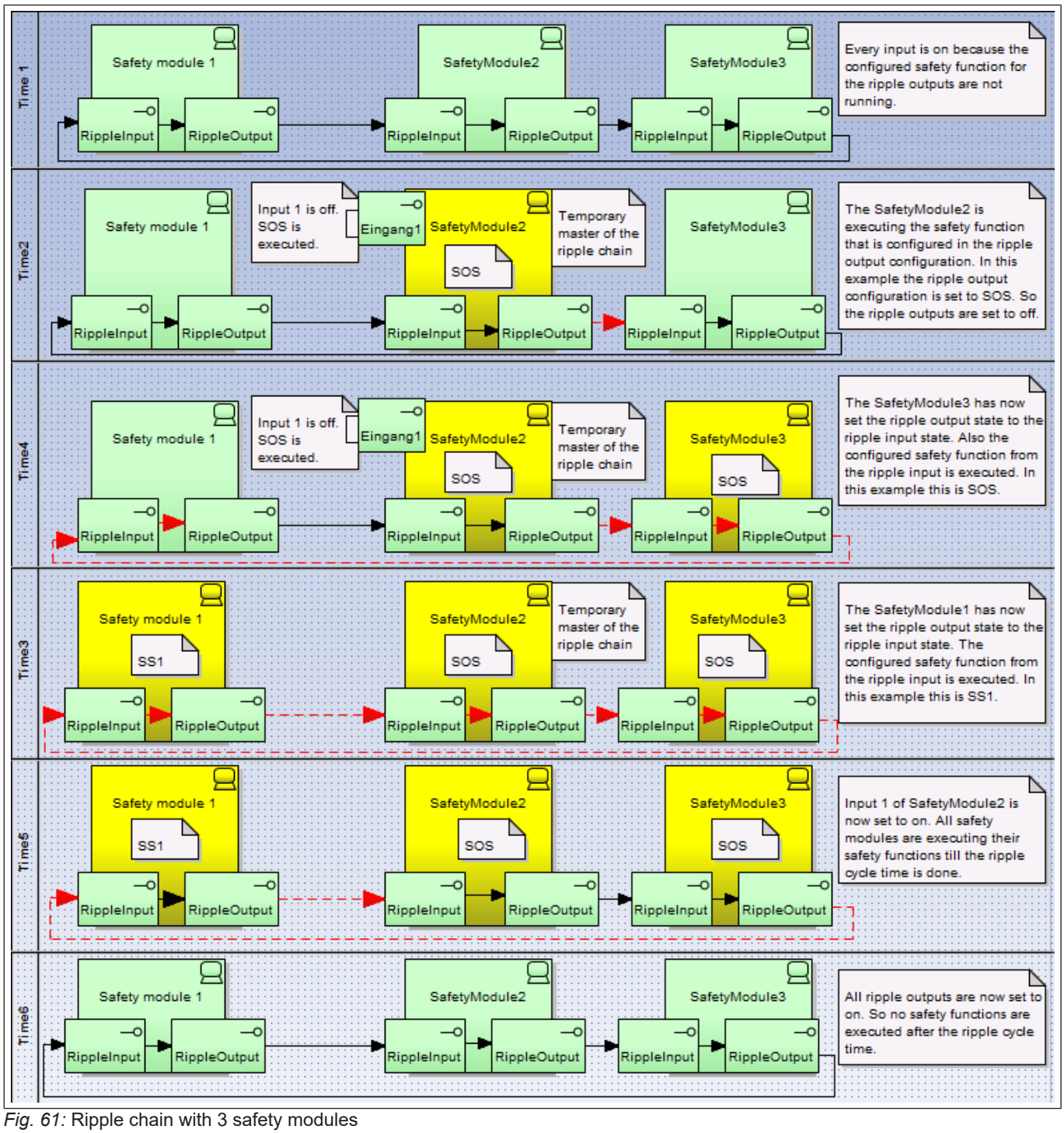

Fig. 61: Ripple chain with 3 safety modules

13.3.3 Circuit example with STO, SS1 and SS2 and ripple chain

This is a circuit example for a ripple chain with six COMBIVERT.

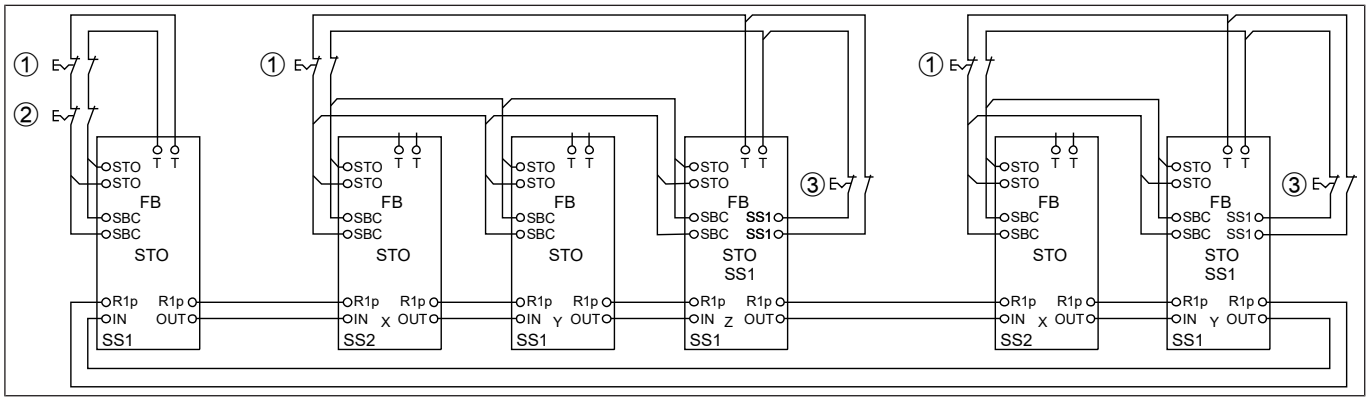

Fig. 62: Circuit example with emergency stop, door, STO, SS1 and SS2

1 Emergency-off-switch
2 Emergency stop switch 2
3 Door switch

13.3.3.1 Parameterisation for COMBIVERT FB

As shown in Figure 81 for the first COMBIVERT FB, the ripple inputs must be configured as an SS1 safety function. The error time for the input is left at the default value, see Figure 82.

- The ripple output configuration is set as shown in Figure 83.
  The following applies:
  Ripple cycle time per COMBIVERT is 3.2 ms (see chapter 9.2) (4 ms is used here) * 6 COMBIVERT = 24 ms. The ripple output configuration is set to STO and this COMBIVERT is not the ripple master. Attention, the filter time for the ripple inputs must be added here.
- The clock signal input configuration must also be configured, see Figure 84. The evaluation of the clock signal for the STO and SBC input must be switched on here.
- Additionally to these two settings also the encoder must be configured and the SS1 safety function must be parameterized.

Parameter	Value	
Ripple input configuration		
Configuration of the Ripple-Inputs	SS1	
Tolerance time of the Ripple-Inputs	0.010000	s

Fig. 63: Ripple input configuration for the COMBIVERT FB

Parameter	Value	Unit
Ripple output configuration		
Configuration of the Ripple-Output	1	
Ripple Master	off	
Cycle time	0.024000	s

Fig. 64: Ripple output configuration for the COMBIVERT FB

Parameter	Value	Unit
Test signal input configuration		
Test signal period	10.000000	s
Test signal pulse length	0.001000	s
Check of the test-signal for the STO-Inputs	on	
Check of the test-signal for the SBC-Inputs	on	
Check of the test-signal for the Function1-Inputs	off	
Check of the test-signal for the Function2-Inputs	off	

Fig. 65: Clock signal input configuration for the COMBIVERT FB

13.3.3.2 Parameterisation for the COMBIVERT B1X

The ripple input configuration is set to the safety function SS2 and the error time for the input is left at the default value, => Figure 85.

- The ripple output configuration corresponds to that of the COMBIVERT FB, see Figure 73.
- The clock signal input configuration is set to the period duration of 5 s, as this period duration is then different to the COMBIVERT FB and wiring errors can be recognised by the safety module, => Figure 86. The evaluation of the clock signal is switched on for the STO and SBC input.
- Additionally to these two settings also the encoder must be configured and the SS1 safety function must be parameterized.

Parameter	Value	Unit
Ripple input configuration		
Configuration of the Ripple-Inputs	SS2	
Tolerance time of the Ripple-Inputs	0.010000	s

Fig. 66: Ripple input configuration for the COMBIVERT B1X

Parameter	Value	Unit
Test signal input configuration		
Test signal period	5.000000	s
Test signal pulse length	0.001000	s
Check of the test-signal for the STO-Inputs	on	
Check of the test-signal for the SBC-Inputs	on	
Check of the test-signal for the Function1-Inputs	off	
Check of the test-signal for the Function2-Inputs	off	

Fig. 67: Clock signal input configuration for the COMBIVERT B1X

13.3.3.3 Parameterisation for the COMBIVERT B1Y

- As shown in Figure 81 for the third COMBIVERT B1Y, the ripple inputs must be configured as an SS1 safety function. The error time for the input is left at the default value, => Figure 82.
  The ripple output configuration corresponds to that of the COMBIVERT FB, => Figure 83.
  The clock signal input configuration corresponds to that of the COMBIVERT B1X, => Figure 86.
- Additionally to these two settings also the encoder must be configured and the SS1 safety function must be parameterized.

13.3.3.4 Parameterisation for the COMBIVERT B1Z

As shown in Figure 81 for the fourth COMBIVERT B1Z, the ripple inputs must be configured as an SS1 safety function. The error time for the input is left at the default value, => Figure 82.

- The following applies to the ripple output configuration:
  The ripple output must be reset for both STO and SS1. The value 5 (STO value 1 + SS1 value 4) is set for the ripple output configuration, => Figure 87.
- The clock signal input configuration corresponds to the configuration of the COMBIVERT B1X, with one exception:

The evaluation of the clock signal is also switched on for input 1, => Figure 88.

- The clock output configuration is adjusted to a cycle time of 5s and a pulse length of 0.001s. This agrees then with the other two COMBIVERT wherefore the evaluation of the clock signal was adjusted. Parameterisation => Figure 89.
- The Input1 input configuration is set to the SS1 configuration and the error time is left at the default value. The input status is equivalent, as both switches are switched in the same way. Parameterisation => Figure 90.
- Additionally to these two settings also the encoder must be configured and the SS1 safety function must be parameterized.

Parameter	Value	Unit
Ripple output configuration		
Configuration of the Ripple-Output	5	
Ripple Master	off	
Cycle time	0.024000	s

Fig. 68: Ripple output configuration for the COMBIVERT B1Z

Parameter	Value	Unit
Test signal input configuration		
Test signal period	5.000000	s
Test signal pulse length	0.001000	s
Check of the test-signal for the STO-Inputs	on	
Check of the test-signal for the SBC-Inputs	on	
Check of the test-signal for the Function1-Inputs	on	
Check of the test-signal for the Function2-Inputs	off	

Fig. 69: Clock signal input configuration for the COMBIVERT B1Z

Parameter	Value	Unit
Clock output configuration		
Period of the Clock-Output	5.000000	s
Pulse length of the Clock-Output	0.001000	s

Fig. 70: Clock output configuration for the COMBIVERT B1Z

Parameter	Value	Unit
Function 1 input configuration		
Configuration of the Function1-Inputs	SS1	
Tolerance time of the Function1-Inputs	0.010000	s
Status of the Function1-Inputs	equivalent	

Fig. 71: Input1 input configuration for the COMBIVERT B1Z

13.3.3.5 Parameterisation for the COMBIVERT B2X

The ripple input configuration is set to the safety function SS2 and the error time for the input is left at the

Parameter	Value	Unit
Test signal input configuration		
Test signal period	7.000000	s
Test signal pulse length	0.001000	s
Check of the test-signal for the STO-Inputs	on	
Check of the test-signal for the SBC-Inputs	on	
Check of the test-signal for the Function1-Inputs	off	
Check of the test-signal for the Function2-Inputs	off	

Fig. 72: Clock signal input configuration for the COMBIVERT B2X

default value, => figure 85.

- The Ripple output configuration corresponds to that of the COMBIVERT FB, => Figure 83.

- The clock signal input configuration is set to the period duration of 7s, as this period duration is then different to the COMBIVERT FB and B1 and wiring errors can be recognised by the safety module, => Figure 91. The evaluation of the clock signal is switched on for the STO and SBC input.

• Additionally to these two settings also the encoder must be configured and the SS1 safety function must be parameterized.

13.3.3.6 Parameterisation for the COMBIVERT B2Y

As shown in Figure 81 for the sixth COMBIVERT B2Y, the ripple inputs must be configured as an SS1 safety function. The error time for the input is left at the default value, => Figure 82.

- The following applies to the ripple output configuration:
  The ripple output must be reset for both STO and SS1. The value 5 (STO value 1 + SS1 value 4) is set for the ripple output configuration, => Figure 85.
- The clock signal input configuration corresponds to that of the COMBIVERT B1X, with one exception:
  The evaluation of the clock signal is also switched on for input 1, => Figure 92.
- The clock output configuration is adjusted to a cycle time of 7s and a pulse length of 0.001s. This agrees then with the COMBIVERT B2X wherefore the evaluation of the clock signal was adjusted. Parameterisation => Figure 89.
- Input1 input configuration is set to configuration SS1 and the error time is left at the default value. The input status is equivalent, as both switches are switched in the same way. Parameterisation => Figure 94.
- Additionally to these two settings also the encoder must be configured and the SS1 safety function must be parameterized.

Parameter	Value	Unit
Test signal input configuration		
Test signal period	7.000000	s
Test signal pulse length	0.001000	s
Check of the test-signal for the STO-Inputs	on	
Check of the test-signal for the SBC-Inputs	on	
Check of the test-signal for the Function1-Inputs	on	
Check of the test-signal for the Function2-Inputs	off	

Fig. 73: Clock signal input configuration for the COMBIVERT B2Y

Parameter	Value	Unit
Clock output configuration		
Period of the Clock-Output	7.000000	s
Pulse length of the Clock-Output	0.001000	s

Fig. 74: Clock output configuration for the COMBIVERT B2Y

Parameter	Value	Unit
Function 1 input configuration		
Configuration of the Function1-Inputs	SS1	
Tolerance time of the Function1-Inputs	0.010000	s
Status of the Function1-Inputs	equivalent	

Fig. 75: Input1 input configuration for the COMBIVERT B2Y

14 Acceptance tests and configuration check

DIN EN 61800-5-2 chapter 7.1 point f prescribes a configuration check of the safety functions in cases when the integrity of the configuration of a safety function can not be guaranteed.

COMBIVIS has an integrated configuration tool, which has the acceptance according to IEC 61800-5-2 and thus is suitable to display the configuration error-free and to transfer it to the safety module. It is therefore not necessary to accept the configuration. Nevertheless, the safety functions and the selected limit values must be checked and this must be documented in the acceptance protocol.

14.1 Sense of the acceptance tests

The acceptance test is used to validate the configured safety function with regard to the system behaviour. To this end the limits of the safety function are violated systematically and the error response is recorded. If the configuration is changed, then a new acceptance test must be carried out.

14.2 Inspector

One person must be determined as inspector, who is able to carry out the test due to their technical training and knowledge of the configured safety functions.

14.3 Protocol of the acceptance test

A protocol must be created during execution of the acceptance test.

NOTICE

Configuration changes

a) If configuration parameters are changed, the test must be repeated and the result must be recorded in the test report.

14.4 Execution of the acceptance test and scope of the audit

Documentation of the system and safety devices

Description of the system including overview screen

Document configured safety functions including parameter version and CRC.

Check functionality of the used safety functions (functional test)

STO: Check function "Safe torque off“.

SBC: Check function "Safe brake control“.

SS1: Check function "Safe stop 1“.

SLS: Check function "Safely limited speed “.

SSM: Check function "Safe speed monitoring".

SDLC: Check function "Safe Door-Lock Control“.

SLA: Check function "Safely-Limited Acceleration".

BCF: Function

FB Warning

BR1P

BR1M

SMS

Completion of the test report and record the test results
Document the functional test.
Note the name of the inspectors including signature.
Check the selected user in the safety module including the rights.
Insert the measurement reports and other notations of the test report.

14.5 Execution of the acceptance test and scope of the audit

Documentation of the system and safety devices
Description of the system including an overview picture.
Document configured safety functions including parameter version and CRC.

Check functionality of the used safety functions (functional test)
STO: Check function "Safe Torque Off“.
SBC: Check function "Safe Brake Control“.
SDI: Check function "Safe Direction“.
SS1: Check function "Safe Stop 1“.
SS2: Check function "Safe Stop 2“.
SLS: Check function "Safely-Limited Speed“.
SSM: Check function "Safe Speed Monitor".
SMS: Check the "Safe maximum speed" function.
SLA: Check function "Safe Limited Acceleration".
SOS: Check function "Safe Operating Stop“.
SLI: Check function "Safely-Limited Increment“.
SLP: Check "Safely limited position" and "Reference position" function

Completion of the test report and record the test results
Document the functional test.
Note the name of the inspectors including signature.
Check the selected user in the safety module including the rights.
Insert the measurement reports and other notations of the test report.

15 Maintenance and modifications at the safety module

Repairs, hardware changes and firmware changes must be carried out only by KEB.

NOTICE

Manipulations!

a) Through an engage into the device, e.g., soldering, replacement of components leads to the cancellation of the safety authorisation and the warranty by KEB.

An exchange of the safety module by the user is not possible. Please contact the support of KEB.

16 Certification

Current certificates, declarations and revision lists for your product can be viewed or downloaded from our website at the following link:

(🌐► keb-automation.com/search)

By entering the article number, you will receive a list of the corresponding documents in the "Certificates" drop-down menu.

If you need help or further documentation, please contact our customer service.

16.1 FS marking

The safety-relevant functions integrated in this product have been developed, implemented and tested in accordance with the applicable standards and guidelines for functional safety. These safety functions were approved as part of a qualified testing and assessment procedure.

The function of the safety-related functions was documented and successfully validated. This ensures that the safety functions fulfil the specified requirements and work reliably under the intended operating conditions.

A corresponding certificate and further information on functional safety are available on our website.

Please note that changes to the product, especially to safety-relevant components, may affect the validity of the acceptance and thus the certificate. In such cases, a re-examination is required.

17 Revision history

Edition	Revision	Note
26.11.2014	01	Pre-series version
27.11.2014	01	Images replaced by links.
27.11.2014	01	Changes in the texts
10.04.2015	01	Firmware 1.1.3, Changes in the texts; Changeover to revision 02.
07.09.2016	02	Safety module type 3 first version of the instructions. Creation DocumentID 20148769.
28.03.2017	03	Referencing Fw V3.0.0.0 Supplement FSoE descriptions.
11.07.2017	04	SS1 revised. Formula of PT1 filter time simplified.
12.12.2017	04	Chapter 3.1 Validity of material number adjusted. Chapter 4.1 Connection terminal Description of shield removed. Chapter 11.11 SLI next step described without SLI. Chapter 11.12.1 Description of SDI specified.
26.01.2018	05	Serial version of the instructions. Inclusion of the type examination number. Chapter 3.3 Addition of SAR and SSR. Chapters 5.2.5 and 5.2.7 Note on import included.
20.02.2018	06	SICK SKM36S-HFA0-K02 sine / cosine encoder included as recommended encoder.
02.05.2019	07	Chapter 3.3 SLR changed to SLS. Chapters 8.3 to 8.7 SLI Activation and SLI Next Step corrected. Selection of indices via configurable inputs newly described. Chapter 9.1 Note on function test of OSSD signals added. Chapter 11.2 Bit 8 and 9 exchanged Chapter 11.5 SS1 functions renamed. Chapter 11.15 Graphic changed p.102. Editorial changes.
11.09.2025	08	Adaptation of the parameter descriptions to the new safety module editor. The type examination section has been removed and replaced with a download notice. Transfer to editorial system with editorial changes.

Tab. 25: Revision history

List of figures

List of tables

18 Glossary

Application

The application is the intended use of the KEB product.

Category

According to ISO 13849-1, categories (B, 1, 2, 3, 4) are defined, each of which contains all the requirements to be fulfilled.

COMBIVERT

Proper name for a KEB Drive Controller.

COMBIVIS

KEB start-up and parameterizing software.

Customer

The customer has purchased a product from KEB and integrates the KEB product into his product (customer product) or resells the KEB product (reseller).

DC-Value

Diagnostic coverage measures the quality of testing and monitoring measures in accordance with ISO 13849-1.

DGUV Regulation

Electrical installations and equipment

Directive 2006/42/EC

Machinery Directive

Directive 2014/30/EU

Electromagnetic Compatibility (EMC) Directive

EN 60204-1

Safety of machinery - Electrical equipment of machines - Part 1: General requirements (VDE 0113-1, IEC 44/709/CDV).

EN 61131-2

Programmable controllers - Part 2: Equipment requirements and tests. German version VDE 0411-500.

EN 61800-5-2

Adjustable speed electrical power drive systems. Part 5-2: Safety requirements - Functional safety (VDE 0160-105-2, UL 61800-5-2, IEC 22G/264/CD)

HD 60364

Low-voltage electrical installations.

HFT

The hardware fault tolerance indicates whether a safety function can be executed despite one or more faults.

IEC 61508

Functional safety of electrical/electronic/programmable electronic safety-related systems.

IEC 61800-5-2

Adjustable speed electric power drive systems - Part 5-2: Safety requirements - functional safety. German version EN 61800-5-2.

IEC 62061

Safety of machinery - Functional safety of safety-related control systems.

ISO 13849-1

Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design.

MTTF(D)

The Mean Time To Dangerous Failure is a special form of MTTF. It is required to calculate the PL in accordance with ISO 13849.

PFD

PFD (Probability of Failure on Demand) is a measure of the failures per demand in accordance with IEC 61508. It is used to determine the reliability of safety-related systems.

PFH

The PFH value (Probability of Failure on Demand per Hour) indicates the average probability of a dangerous failure per hour.

PL

The performance level is a result of the risk assessment in accordance with EN ISO 13849-1. It is categorised into five levels a (low) to e (high).

PTI

Interval for the repeat test (proof test interval)

SAR

Safe acceleration range; as SLA, but with upper and lower limit with the same sign.

SBC

Safe Brake Control.

SDI

Safe direction

SFF

Safe failure fraction is a measure of the probability that an unrecognised, dangerous failure will occur.

SIL

The safety integrity level is a unit of measurement for quantifying risk reduction in accordance with IEC 61508.

SLA

Safely limited acceleration

SLI

Safely limited increment

SLP

Safely limited position

SLS

Safely limited speed

SMS

Safe maximum speed

SOS

Safe operating stop

SS1

Safe stop 1emergency stop according to IEC 60204-1 Stop category 1

SS2

Safe stop 2; emergency stop according to IEC 60204-1 Stop category 2

SSM

Safe speed monitor

SSR

Safe speed range; like SLS but with an upper and lower limit with the same sign.

STO

Safe torque off (STO).

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