



Funktionale Sicherheit

Functional safety

COMBIVERT F6 | H6 | S6

INSTRUCTIONS FOR USE | SAFETY MODULE TYPE 1 | STO AND SBC

Translation of the original manual
Document 20109577 EN 04



Preface

The hardware and software described in this document are products of KEB. The information contained in this document is valid at the time of publishing. KEB reserves the right to update this document in response to misprints, mistakes or technical changes.

Signal words and symbols

Certain procedures within this document can cause safety hazards during the installation or operation of the device. Refer to the safety warnings in this document when performing these procedures. Safety signs are also located on the device where applicable. A safety warning is marked by one of the following warning signs:

DANGER	Dangerous situation, which will cause death or serious injury if this safety warning is ignored.
WARNING	Dangerous situation, which may cause death or serious injury if this safety warning is ignored.
CAUTION	Dangerous situation, which may cause minor injury if this safety warning is ignored.
NOTICE	Situation, which can cause damage to property if this safety warning is ignored.

RESTRICTION

Used when the following statements depend on certain conditions or are only valid for certain ranges of values.



Used for informational messages or recommended procedures.

More symbols

- ▶ This arrow starts an action step.
- / - Enumerations are marked with dots or indents.
- => Cross reference to another chapter or another page.



Note to further documentation.
www.keb.de/service/downloads



Laws and guidelines

KEB Automation KG confirms with the EC declaration of conformity and the CE mark on the device nameplate that it complies with the essential safety requirements.

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

Warranty and liability

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



Here you will find our general sales conditions.
www.keb.de/terms-and-conditions



Further agreements or specifications require a written confirmation.

Support

Although multiple applications are referenced, not every case has been taking into account. If you require further information or if problems occur which are not referenced in the documentation, you can request the necessary information via the local KEB agency.

The use of our units in the target products is outside of our control and therefore lies exclusively in the area of responsibility of the customer.

The information contained in the technical documentation, as well as any user-specific advice in spoken and written and through tests, are made to best of our knowledge and information about the intended use. However, they are regarded as being only informal and changes are expressly reserved, in particular due to technical changes. This also applies to any violation of industrial property rights of a third-party. Selection of our units in view of their suitability for the intended use must be done generally by the user.

Tests can only be done within 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.

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 and remain valid in its entirety.

This KEB product or parts thereof may contain third-party software, including free and/or open source software. If applicable, the license terms of this software are contained in the instructions for use. The instructions for use are already available to you, can be downloaded free of charge from the KEB website or can be requested from the respective KEB contact person.

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Glossary

0V	Earth-potential-free common point	Endat	Bidirectional encoder interface of the company Heidenhain
1ph	1-phase mains	EtherCAT	Real-time Ethernet bus system of the company Beckhoff
3ph	3-phase mains	Ethernet	Real-time bus system - defines protocols, plugs, types of cables
AC	AC current or voltage	FE	Functional earth
AFE	From 07/2019 AIC replaces the previous name AFE	FSoE	Functional Safety over Ethernet
AFE filter	From 07/2019 AIC filter replaces the previous name AFE filter	FU	Drive converter
AIC	Active Infeed Converter	GND	Reference potential, ground
AIC filter	Filter for Active Infeed Converter	GTR7	Braking transistor
Application	The application is the intended use of the KEB product	HF filter	High frequency filter to the mains
ASCL	Asynchronous sensorless closed loop	Hiperface	Bidirectional encoder interface of the company Sick-Stegmann
Auto motor ident.	Automatically motor identification; calibration of resistance and inductance	HMI	Human machine interface (touch screen)
AWG	American wire gauge	HSP5	Fast, serial protocol
B2B	Business-to-business	HTL	Incremental signal with an output voltage (up to 30V) -> TTL
BiSS	Open source real-time interface for sensors and actuators (DIN 5008)	IEC	International standard
CAN	Fieldbus system	IP xx	Degree of protection (xx for level)
CDF	Cyclic duration factor	KEB product	The KEB product is subject of this manual
CDM	Complete drive module including auxiliary equipment (control cabinet)	KTY	Silicium temperature sensor (polarized)
COMBIVERT	KEB drive converters	Manufacturer	The manufacturer is KEB, unless otherwise specified (e.g. as manufacturer of machines, engines, vehicles or adhesives)
COMBIVIS	KEB start-up and parameterizing software	MCM	American unit for large wire cross sections
Customer	The customer has purchased a KEB product from KEB and integrates the KEB product into his product (customer product) or resells the KEB product (dealer)	Modulation	Means in drive technology that the power semiconductors are controlled
DC	DC current or voltage	MTTF	Mean service life to failure
DI	Demineralized water, also referred to as deionized (DI) water	NN	Sea level
DIN	German Institut for standardization	OC	Overcurrent
DS 402	CiA DS 402 - CAN device profile for drives	OH	Overheat
EMC	Electromagnetic compatibility	OL	Overload
Emergency stop	Shutdown of a drive in emergency case (not de-energized)	OSSD	Output signal swithcing device; - an output signal that is checked in regular intervals on its shutdown. (safety technology)
Emergency switching off	Switching off the voltage supply in emergency case	PDS	Power drive system incl. motor and measuring probe
EMS	Energy Management System	PE	Protective earth
EN	European standard	PELV	Protective Extra Low Voltage
Encoder emulation	Software-generated encoder output	PFD	Term used in the safety technology (EN 61508-1...7) for the size of error probability
End customer	The end customer is the user of the customer product		

GLOSSARY

PFH	Term used in the safety technology (EN 61508-1...7) for the size of error probability per hour
PLC	Programmable logic controller
PT100	Temperature sensor with $R_0=100\Omega$
PT1000	Temperature sensor with $R_0=1000\Omega$
PTC	PTC-resistor for temperature detection
PWM	Pulse width modulation
RJ45	Modular connector with 8 lines
SCL	Synchronous sensorless closed loop
SELV	Safety Extra Low Voltage (<60V)
SIL	The security integrity level is a measure for quantifying the risk reduction. Term used in the safety technology (EN 61508 -1...7)
SS1	Safety function „Safe stop 1“ in accordance with IEC 61800-5-2
SSI	Synchronous serial interface for encoder
STO	Safety function „Safe Torque Off“ in accordance with IEC 61800-5-2
TTL	Incremental signal with an output voltage up to 5V
USB	Universal serial bus
VARAN	Real-time Ethernet bus system

Standards for drive converters / control cabinets

Product standards that apply directly to the drive converter

EN61800-2	Adjustable speed electrical power drive systems - Part 2: General requirements - Rating specifications for low voltage adjustable frequency a.c. power drive systems (VDE 0160-102, IEC 61800-2)
EN61800-3	Speed-adjustable electrical drives. Part 3: EMC requirements and specific test methods (VDE 0160-103, IEC 61800-3)
EN61800-5-1	Adjustable speed electrical power drive systems - Part 5-1: Safety requirements - Electrical, thermal and energy (IEC 61800-5-1); German version EN 61800-5-1
EN61800-5-2	Adjustable speed electrical power drive systems - Part 5-2: Safety Requirements - Functional (IEC 22G/264/CD)
UL61800-5-1	American version of the EN61800-5-1 with „National Deviations“

Basic standards to which drive converter standards refer directly

EN 55011	Industrial, scientific and medical equipment - Radio frequency disturbance characteristics - Limits and methods of measurement (CISPR 11); German version EN 55011
EN 55021	Interference to mobile radiocommunications in the presence of impulse noise - Methods of judging degradation and measures to improve performance (IEC/ CISPR/D/230/FDIS); German version prEN 55021
EN 61000-2-1	Electromagnetic compatibility (EMC) - Part 2: Environment - Section 1: Description of the environment - Electromagnetic environment for low-frequency conducted disturbances and signalling in public power supply systems
EN 61000-2-4	Electromagnetic compatibility (EMC) - Part 2-4: Environment; Compatibility levels in industrial plants for low-frequency conducted disturbances (IEC 61000-2-4); German version EN 61000-2-4
EN 61000-4-2	Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test (IEC 61000-4-2); German version EN 61000-4-2
EN 61000-4-3	Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test (IEC 61000-4-3); German version EN 61000-4-3
EN 61000-4-4	Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test (IEC 61000-4-4); German version EN 61000-4-4
EN 61000-4-5	Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test (IEC 61000-4-5); German version EN 61000-4-5
EN 61000-4-6	Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields (IEC 61000-4-6); German version EN 61000-4-6
EN 61000-4-34	Electromagnetic compatibility (EMC) - Part 4-34: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests for equipment with mains current more than 16 A per phase (IEC 61000-4-34); German version EN 61000-4-34
EN 61000-6-7	Electromagnetic compatibility (EMC) - Part 6-7: Generic standards - Immunity requirements for equipment intended to perform functions in a safety-related system (functional safety) in industrial locations (IEC 61000-6-7).

STANDARDS FOR DRIVE CONVERTERS/CONTROL CABINETS

EN61508-1...7	Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 1...7 (VDE 0803-1...7, IEC 61508-1...7)
EN62061	Safety of machinery - functional safety of electrical, electronic and programmable electronic safety-related systems (VDE 0113-50, IEC 62061)
EN ISO 13849-1	Safety of machinery - safety-related parts of control systems - Part 1: General principles for design (ISO 13849-1); German version EN ISO 13849-1

Standards that are used in the environment of the drive converter

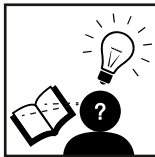
DGUV regulation 3	Electrical installations and equipment
DIN 46228-1	Wire-end ferrules; Tube without plastic sleeve
DIN 46228-4	Wire-end ferrules; Tube with plastic sleeve
DIN IEC 60364-5-54	Low-voltage electrical installations - Part 5-54: Selection and erection of electrical equipment - Earthing arrangements, protective conductors and protective bonding conductors (IEC 64/1610/CD)
DIN VDE 0100-729	Low-voltage electrical installations - Part 7-729: Requirements for special installations or locations - Operating or maintenance gangways (IEC 60364-7-729:2007, modified); German implementation HD 60364-7-729:2009
DNVGL-CG-0339	Environmental test specification for electrical, electronic and programmable equipment and systems
EN 1037	Safety of machinery - Prevention of unexpected start-up; German version EN 1037
EN 60204-1	Safety of machinery - electrical equipment of machines Part 1: General requirements (VDE 0113-1, IEC 44/709/CDV)
EN 60439-1	Low-voltage switchgear and controlgear assemblies - Part 1: Type-tested and partially type-tested assemblies (IEC 60439-1); German version EN 60439-1
EN 60947-7-1	Low-voltage switchgear and controlgear - Part 7-1: Ancillary equipment - Terminal blocks for copper conductors (IEC 60947-7-1:2009); German version EN 60947-7-1:2009
EN 60947-8	Low-voltage switchgear and controlgear - Part 8: Control units for built-in thermal protection (PTC) for rotating electrical machines (IEC 60947-8:2003 + A1:2006 + A2:2011)
EN 61373	Railway applications - Rolling stock equipment - Shock and vibration tests (IEC 61373); German version EN 61373
EN 61439-1	Low-voltage switchgear and controlgear assemblies - Part 1: General rules (IEC 121B/40/CDV); German version FprEN 61439-1

1 Basic Safety Instructions

The COMBIVERT is designed and constructed in accordance with state-of-the-art technology and the recognized safety rules and regulations. However, the use of such devices may cause functional hazards for life and limb of the user or third parties, or damages to the system 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. Violation 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.

- ▶ Read the instructions for use !
- ▶ Observe the safety and warning instructions !
- ▶ If anything is unclear, please contact KEB Automation KG !

1.1 Target group

This instruction manual is determined exclusively for electrical personnel. Electrical personnel for the purpose of this instruction manual must have the following qualifications:

- 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 *DIN IEC 60364-5-54*.
- Knowledge of national safety regulations.

1.1 Validity of this manual

This manual describes the safety module type 1 for COMBIVERT S6.

The manual

- contains only supplementary safety instructions.
- is only valid in connection with the power unit manual of the COMBIVERT.

1.2 Electrical connection

DANGER



Voltage at the terminals and in the device!

Danger to life due to electric shock !

- ▶ For any work on the unit switch off the supply voltage and secure it against switching on.
- ▶ Wait until the drive has stopped in order, that perhaps regenerative energy can be generated.
- ▶ Wait until the DC-Link capacitors are discharged (5 minutes). Verify by measuring the DC voltage at the terminals.
- ▶ Never bridge upstream protective devices (also not for test purposes).

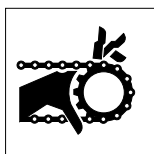
For a trouble-free and safe operation, please pay attention to the following instructions:

- The electrical installation shall be carried out in accordance with the relevant requirements.
- Cable cross-sections and fuses must be dimensioned by the user accordly to the specified minimum / maximum values for the operation.
- Within systems or machines the person installing electrical wiring must ensure that on existing or new wired safe ELV circuits the EN requirement for safe insulation is still met!
- For drive converters that are not isolated from the supply circuit (in accordance with [EN 61800-5-1](#)) all control lines must be included in other protective measures (e.g. double insulation or shielded, earthed and insulated).
- When using components without isolated inputs/outputs, it is necessary that equipotential bonding exists between the components to be connected (e.g. by the equipotential line). Disregard can cause destruction of the components by equalizing currents.

1.3 Start-up and operation

The drive controller must not be started until it is determined that the installation complies with the machine directive; Account is to be taken of [EN 60204-1](#).

WARNING



Software protection and programming!

Hazards caused by unintentional behavior of the drive!

- ▶ Check especially during initial start-up or replacement of the drive controller if parameterization is compatible to application.
- ▶ Securing a unit solely with software-supported functions is not sufficient. It is imperative to install external protective measures (e.g. limit switch) that are independent of the drive controller.
- ▶ Secure motors against automatic restart.

2 Product Description

The safety manual completes the installation manual of the COMBIVERT with the safety module of type 1. It contains safety-related supplements and regulations for the operation of devices in safety applications. The basic standards as well as application and country-specific standards must be observed furthermore. The standards referred in this instruction manual must be observed supplementary!

The safety module type 1 according to IEC 61800-5-2 contains:

- Safe torque off (Safe Torque Off - STO)
- Safe brake control (Safe Brake Control – SBC)

The safety functions meet the requirements in accordance with performance level e (ISO13849-1) and SIL 3 (IEC 61508 and IEC 62061). In case of proper project design, installation and operation the safety functions protect people against mechanical damages.

2.1 Device identification

Numerical code:

Safety module type 1	Used in	COMBIVERT
01H6x10-0027	Servo controller	xxS6A1x-xxxx
	Inverter	xxF6A1x-xxxx
01H6x10-0029 01H6x10-0028	Single axis controller	xxH6ABx-xxxx
	Double axis controller	xxH6BBx-xxxx

Table 1: Numerical code



Validity of certificates

The certification of COMBIVERT with safety technology is only valid if the material number corresponds with the specified numerical code und the FS logo is printed on the type plate.

3 Safety Functions

3.1 General instructions

⚠ Danger



Electric Shock

The COMBIVERT is operated with dangerous voltages which can cause death or serious injury.

The COMBIVERT can be adjusted by way that in regenerative operation energy is regenerated into the mains also during mains power failure. Therefore a dangerous high tension can exist in the unit after switching off the supply system.

Before working with the unit check the isolation from supply by measurements in the unit.

Care should be taken to ensure correct and safe operation to minimise risk to personnel and equipment.

⚠ Danger



Qualified Staff Only

Uncontrolled start (STO) and free running (SBC) of the drive is possible by improper installation of the safety technology. This may cause death, serious bodily injuries or substantial damage to property.

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

Attention



Observe Standards

The COMBIVERT must not be started until it is determined that the installation complies with 2006/42/EC (machine directive) as well as the EMC directive (2004/108/EC)(note EN60204).

The COMBIVERT meets the requirements of the Low-Voltage Directive 2006/95/EC. The harmonized standard of the series EN 61800-5-1 (VDE 0160) is used.

This is a product of limited availability in accordance with IEC 61800-3. This product may cause radio interference in residential areas. In this case the operator may need to take corresponding measures.

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.

⚠Warning

Regular checks

In order to ensure permanent security, the functions must be checked in regular intervals according to the results of the risk analysis.

3.2 Safe torque off (Safe Torque Off - STO)

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



Electric Shock

Continue mains voltage with active STO function.

Compared to the disconnection by line contactors or motor contactors the integrated safety function enables a simple integration of drives to functional groups of a system. Thereby safe torque off can be limited to certain systems. Another advantage is that the recharge and discharge time of the COMBIVERT DC link must not be considered. Thus the unit is faster again ready for operation after an interruption.

Regular electromechanical equipment are liable to abrasion. Loss of these equipment occurs by using the STO function and the maintenance costs are reduced.

Characteristic data for „Safe torque off“

- Power supply for the rotation direction of the motor is interrupted (free-wheeling motor)
- Used when monitoring of standstill is not necessary
- Unintentional starting of the motor is prevented
- No galvanic isolation of the motor from the drive module DC link

What is realized by the STO function related to EN60204 -1 ?

- Emergency stop can be realized by the STO function, since the mains voltage may remain effective.
- Emergency stop can be realized only in connection with a line contactor, which disconnects the mains voltage!

3.2.1 Emergency stop according EN 60204

By using suitable safety switchgear units, stop category 0 and 1 according to EN 60204 -1 can be reached by the STO function in the system. Note chapter 6 for safety switchgear units.

Stop category 0	„uncontrolled stop“, i.e. stop by immediate removal of power to the actuators.
Stop category 1	„controlled stop“, i.e. power to the actuators is retained to apply braking until the stop is achieved. The energy is switched off at standstill.

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.

Attention

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.

Danger



Ensure coast of the motor

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.

Attention

Jerks in error case

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.

3.2.1.1 Calculation of the rotation angle triggered by the jerk

Rotation angle of the jerk $WR [^\circ] =$	$\frac{180^\circ}{\text{Pole-pair number } p \cdot \text{gear reduction ratio } g}$
<i>Table 2: Calculation of the jerk</i>	

The probability of the jerk is $< 1.84 \cdot 10^{-15}$ 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.

3.2.2 Classification of STO according IEC 61508

PFH	$2.6 \cdot 10^{-12}$ 1/h
PFD	$2.3 \cdot 10^{-7}$ on demand
Proof-Test-Interval T	20 years

For SIL classification in connection with the applications consider the failure rates of the external switch devices for final evaluation.

3.2.3 Classification of STO according ENISO 13849

Category	4
MTTF _D	>1000 years
DC	high
<i>Table 3: Classifications of STO</i>	

For the classification within a performance level in connection with the applications consider the failure rates of the external switch devices for final evaluation.

3.3 Safe brake control (Safe Brake Control – SBC)

The safety module type1 can safety control an external brake. The circuit operates on two channels. Thereby brake release is only possible by the control in the COMBIVERT if both inputs are supplied (SBC inputs see chapter 4).

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

3.3.1 Requirements for the brake

Voltage supply	24Vdc ±10%
Absolute maximum current	3.3A (limited by safety module type 1) ¹⁾
Free-wheeling circuit	integrated in COMBIVERT
<i>Table 4: Requirements for the brake</i>	

- 1) A lower maximum current can be permissible depending on the control board and the operating mode. For more information, see the COMBIVERT installation manual.

Attention

Power-off braking

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.

Attention

Check the brake

A check of the brake can not be done by the safety module. The examination must be ensured by the user.

⚠ Danger



Floating loads

Because of high failure probability of mechanical brakes it is not permitted to stay under hanging or floating loads. The same is valid for inertia mass, which do not stay in idle position.

3.3.2 Classification of SBC according IEC 61508

PFH	$6.3 \cdot 10^{-11}$ 1/h
PFD	$5.5 \cdot 10^{-6}$ on demand
Proof-Test-Interval T	20 years

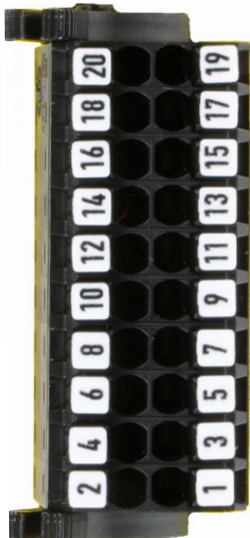

For SIL classification in connection with the applications consider the failure rates of the external switch devices for final evaluation.

3.3.3 Classification of SBC according EN ISO 13849

Control category	3
MTTF _D	>1000 years
DC	medium
<i>Table 5: Classifications of SBC</i>	

For the classification within a performance level in connection with the applications consider the failure rates of the external switch devices for final evaluation.

4 Description of the Terminals

Safety module type 1			
Terminal	PIN	Name	Function
	1 / 2	STO1+	Input STO channel 1
	3 / 4	STO1-	
	5 / 6	STO2+	Input STO channel 2
	7 / 8	STO2-	
	9 / 10	SBC1+	Input SBC channel 1
	11 / 12	SBC1-	
	13 / 14	SBC2+	Input SBC channel 2
	15 / 16	SBC2-	
	17 / 18	Status STO	Output STO
	19 / 20	Status SBC	Output SBC
		PE	For H6 drive modules: Earth, make sure to connect the mains earth!

The individual channels are designed potential-free, so 24V and 0V can be connected. The inputs are designed by way that safety switchgear units with test pulses (OSSD signals) can be connected. The signals are not evaluated, they are only filtered. The OSSD test interval is limited to 10 ms.

Figure 1: Description of the Terminals

Mechanical specification of terminal strip X2B			
	Terminal cross-section		Stripping length
Stranded wire (rigidly and flexibly)	0.14...1.5 mm ²	26-18 AWG	12mm
Ferrule plastic collar	0.14...1 mm ²		

Table 6: Mechanical specification of terminal strip X2B

4.1 Inputs

4.1.1 Specification of the STO inputs

STO Inputs	Status 0		Status 1	
	UL [V]	IL [mA]	UH [V]	IH [mA]
max.	5	55	30	55
min.	-3	not defined	15	5

Table 7: Specification of the STO inputs

The maximum short-term starting current of the input is limited to 0.6 mA.

4.1.2 STO with OSSD signals

The filter time depends on the minimum input voltage and can be specified as follows:

Input voltage [V]	OSSD pulse width [ms]
15	0.08
18	0.5
20	1.0
24	1.4
30	1.8

Table 8: STO with OSSD signals

4.1.3 Specification of the SBC inputs

The inputs of the SBC function are specified as follows according to IEC61131-2 type 1:

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

Table 9: Specification of the SBC inputs

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

Attention

Consistency check

Since a consistency check of the input signals takes place, a slew rate of > 1 V/ms must be available at a status change.

4.1.4 SBC with OSSD signals

The filter time for the entire voltage range is at least 1 ms.

4.2 Outputs

The short-circuit proof, digital outputs are specified in accordance with IEC61131-2. The output rated current is 100 mA.

4.2.1 Output STO

Output (status-STO) provides a 24V signal if the modulation is possible.

4.2.2 Output SBC

Output (status SBC) provides a 24V signal if the brakes are released (see „6.3 Functional description SBC“).

4.2.3 Brake output

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

4.3 Status LEDs

The arrangement of the LEDs is stored in the corresponding COMBIVERT manual.

4.3.1 Status-LED safety module

The LED indicate the state of the safety module.

LED	Status
Off	No voltage supply of the safety module
Green	Safety module in operation
Red	Safety module in error

Table 10: Status-LED safety module

Further status messages see chapter „6 Functional Descriptions“.

5 Installation

Attention

Before beginning

Before installation, read and note the EMC and safety instructions and installation manual of the COMBIVIS.

5.1 Additional instructions:

- The unit must be isolated from mains by main switch when working on parts under voltage.
- Mechanical brakes must be installed additionally if external forces have effect to the drive axis, e.g. vertical axes (hanging loads) or rotary axes with asymmetrical weight distribution.
- 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).
- Make sure that no small parts fall into the COMBIVERT during assembly and wiring. This also applies to mechanical components, which can lose small parts during operation.
- Check the safety functions and error responses and generate an acceptance report after installation.
- 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.
- Dimension the safety application by way that the corresponding input current of the safety functions is available for the inputs (see chapter => 4.1). If several COMBIVERT or safety functions are connected to one safety switchgear unit, this unit must be able to supply all COMBIVERT.

⚠ Danger



Ensure coast of the motor

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.

⚠ Warning

Selection of suitable voltage sources

Use for the connection only suitable voltage sources with safe isolation (SELV / PELV) in accordance with VDE 0100 with nominal voltage of 24 Vdc \pm 10%. Pay attention on a sufficient overvoltage category of the voltage supply.

6 Functional Descriptions

The safety module type1 fulfils the following functions according to IEC 61800-5-2:

- Safe torque off (Safe Torque Off - STO)
- Safe brake control (Safe Brake Control – SBC)

6.1 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 in accordance with the following table:

Bit	Condition	Meaning, if bit is set (=1)
0	Status	Error in safety module
1	Status	Modulation released
2	Status	Brake A released
3	Warning	Brake-voltage supply too low
4	Warning	Brake-voltage supply too high
5	Status	Brake A High-Side-switch on
6	Status	Low-Side-switch on
7	Error	Brake A current too high
8	Warning	Brake A not connected or current measurement deactivated
9	Error	Brake A High-Side-switch high-resistance
10	Error	Brake A High-Side-switch short circuited
11	Error	Low-Side-switch high-resistance
12	Error	Low-Side-switch short-circuited
13	Status	VTRO on
14	Status	VTRU on
15	Warning	5V reference too low
16	Status	Brake A brake release requested by the control
17	Error	Error base load resistor VTRO
18	Error	Error base load resistor VTRU
19	Status	Brake B released
20	Status	Brake B High-Side-switch on
21	Error	Brake B current too high
22	Warning	Brake B not connected or current measurement deactivated
23	Error	Brake B High-Side-switch high-resistance
24	Error	Brake B High-Side-switch short-circuited
25	Status	Brake B brake release requested by the control

Table 11: Status of the safety module

6.2 Function description STO

The safety-related disconnection according to STO is reached by a two-channel opto-coupler blockage. The supply of the opto-couplers, which are responsible for the commutation of the connected drive occurs via transformation coupling of the input voltage. This ensures at input voltage loss that no supply of the opto-couplers is possible. If the opto-couplers are not longer supplied, no IGBT can be controlled and thus no energy can be supplied to the drive.

The two channels are reached by way that input STO1 prevents the voltage supply (VTRO) of the upper opto-couplers of the inverter bridge and input STO2 the lower opto-couplers (VTRU).

The voltage supplies of the opto-couplers (VRTO &-U) are measured safety decoupled by the diagnosis CPU and the status is displayed in bits 13 and 14. Only if both voltage supplies are available, bit 1 (modulation is released) and the output (Status STO) is set.

Technical data of the STO function	
Maximum ON delay ($U_{IN} = 15V$)	< 7 ms
Maximum OFF delay ($U_{IN} = 30V$) at	
... active modulation	< 15 ms
... inactive modulation until safe state of the driver voltage is reached	< 50 ms

6.3 Functional description SBC

The circuit operates on two channels. Thereby brake release is only possible by the control in the COMBIVERT if both inputs are supplied (SBC inputs see chapter => 4).

The SBC1 input switches the High-Side switch and the SBC2 input switches the Low-Side switch.

The respective brake handling of the axis is activated with co21 bit 4 = 1. This setting is assumed at power on only. That means, the unit must be switched off and on once to activate the changed parameter settings. Output (Status SBC) is set, if the brake is opened at all activated axes.

Technical data of the SBC function	
Maximum ON delay ($U_{IN} = 15V$)	< 5 ms
Maximum OFF delay ($U_{IN} = 30V$)	< 10 ms

6.3.1 Single axis module

If both inputs are set, the opening of

- brake A is displayed in status bit 2.

co21 Bit 4 Brake ctrl mode	Brake release	State SBC
1	0	0
1	1	1
0	0	0

Table 12: Braking handling single axis module

6.3.2 Double axis module

If both inputs are set, the opening of

- brake A is displayed in status bit 2.
- brake B is displayed in status bit 19.

Drive A		Drive B		Output
co21 Bit 4 Brake ctrl mode	Brake release	co21 Bit 4 Brake ctrl mode B	Brake release	Status SBC
1	0	0	0	0
1	1	0	0	1
0	0	1	0	0
0	0	1	1	1
1	0	1	0	0
1	1	1	0	0
1	0	1	1	0
1	1	1	1	1

Table 13: Braking handling double axis module

6.3.3 Setting of status bits by the SBC function

The current through the brake can measured at brake release.

co82	ext. modules ctrl word		
	Bit 0	safety module current sense	
	Value	COMBIVIS text	Function
	0	SM-CS-off	Brake current measurement off; at the state of the safety module (sb29) only the bits 8 & 22 are set. Bit 0, 7 & 21 are unaffected by the current measurement.
	1	SM-CS-on	Brake current measurement on (default)

Depending on the hardware, the number of activated brakes, the setting of co82 and the current measurement the following bits in sb29 are set:

Single axis module											
Current measurement		on (co82 = 1)					off (co82 = 0)				
activated Brake	Current	bit in sb29					bits in sb29				
				0	7	8			0	7	8
A co21 bit 4=1	<0.1A	–	0	1			–	0	1		
	0.1A...lmax	–	0	0			–	0	1		
	>lmax	1	1	0			–	0	1		

Table 14: Setting of status bits by the SBC function

Double axis module												
Current measurement		on (co82 = 1)					off (co82 = 0)					
activated brake(s)	Current	bit in sb29					bits in sb29					
				0	7	8	21	22	0	7	8	21
A co21 bit 4=1	<0.1A	–	0	1	–	–	–	0	1	0	1	
	0.1A...lmax	–	0	0	–	–	–	0	1	0	1	
	>lmax	1	1	0	–	–	–	0	1	0	1	
B co21(B) bit 4=1	<0.1A	–	–	–	0	1	–	0	1	0	1	
	0.1A...lmax	–	–	–	0	0	–	0	1	0	1	
	>lmax	1	–	–	1	0	–	0	1	0	1	

Table 15: Setting of status bits by the SBC function

„–“ in the table means, the respective bit is not affected by the function.

The control of the brake is reset to not released and the status LED is set to red when there is an error caused by the current measurement.

Attention

Pay attention to response time

Since the current rise is slowly at high inductances of the brakes, the error response time to a fault current is max. 100 ms.

6.3.4 Monitoring of the SBC function

The switches are tested at brake release each hour on their switching ability.

A short circuit monitoring against 24V respectively 0V is given.

If the diagnosis CPU monitors a fault, the control of both channels is disconnected, the LED is set to red and bit 0 is set in the status. Additionally the errors are displayed with bits 9-12 and 23-24.

ATTENTION

Pay attention to response time

The maximum error response time is 10ms.

The voltage supply for switching the brake is monitored. Status bits 3 or 4 of sb29 are set if the voltage is outside of $24V \pm 10\%$.

If the safety module is in error status is displayed in the status of the control of the COMBIVERT with parameter ru.01 = „55" (error safety module).

7 Wiring Examples

7.1 Direct switching off with emergency stop switch

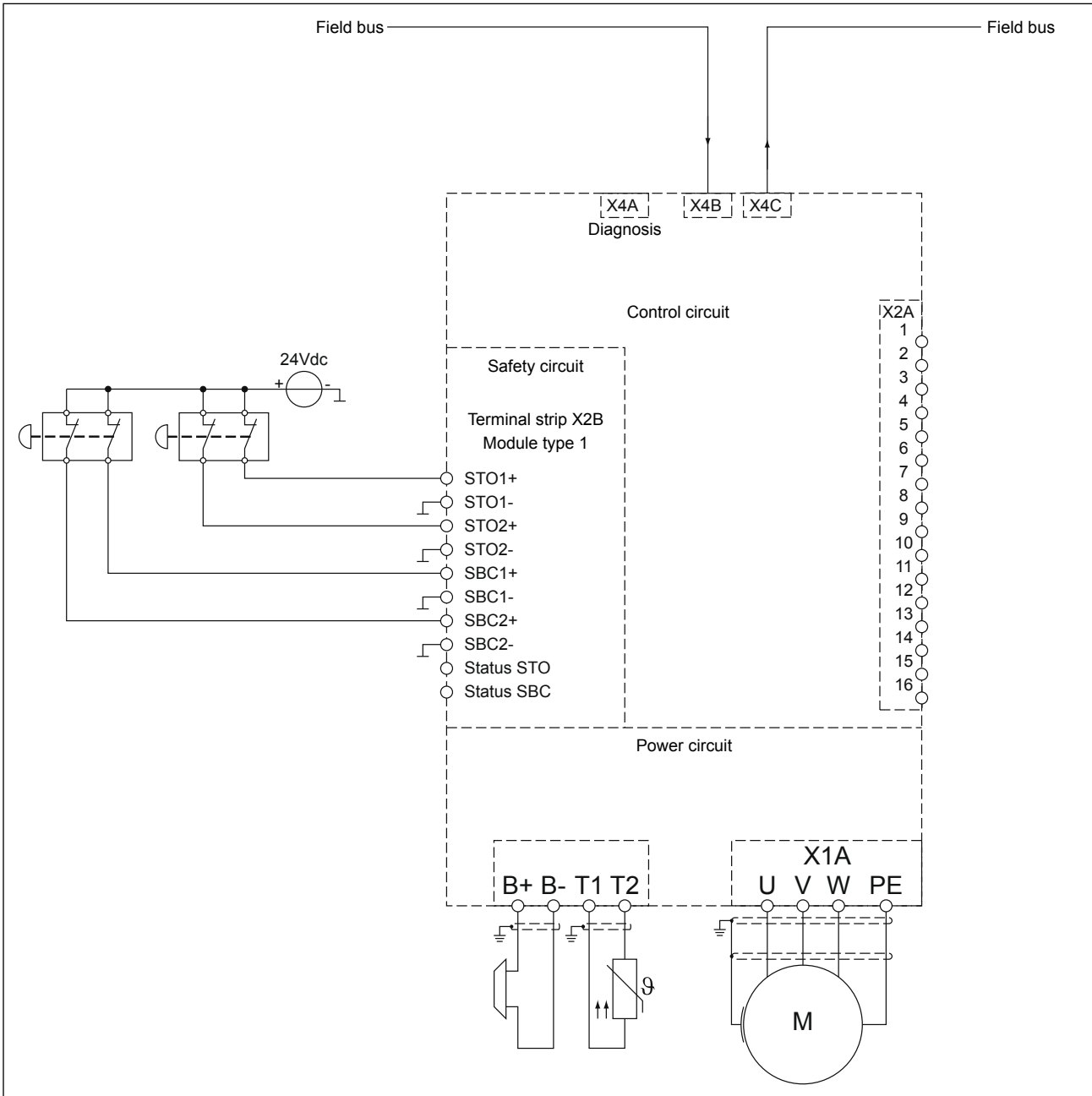


Figure 2: Direct switching off with emergency stop switch

ATTENTION

Operation of an emergency stop unit

At operation of an emergency stop unit, when both contacts are connected together against a positive supply signal, make sure that there are no crossfaults. The wiring must be suitable arranged.

7.2 Direct switching off with emergency stop switch and monitoring of the wiring

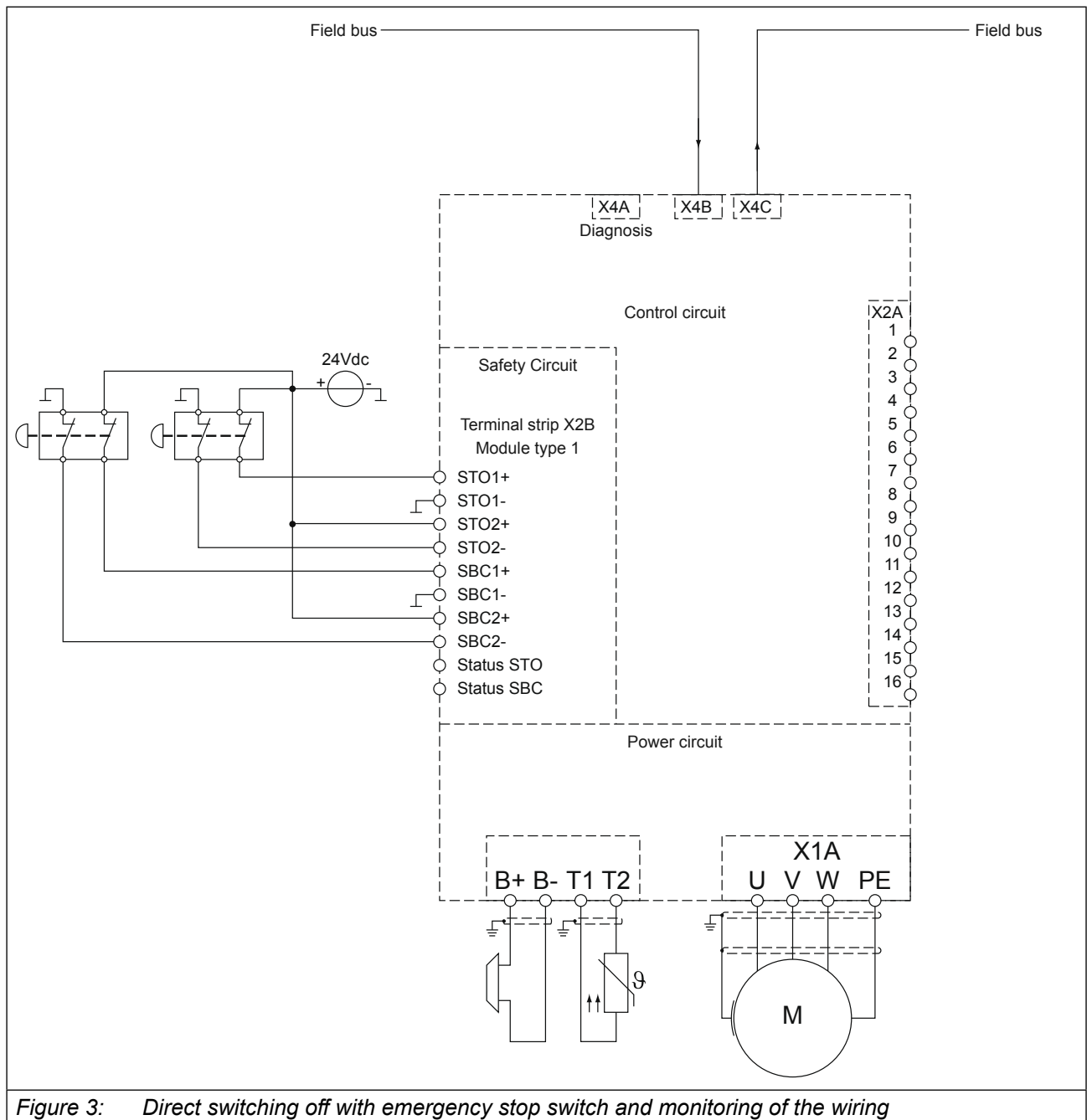


Figure 3: Direct switching off with emergency stop switch and monitoring of the wiring

The displayed circuit shows wiring errors in the area of the emergency stop unit and supply line. A possible short circuit on the primary side of the emergency stop switchgear (mass and 24 Vdc) and a short circuit on the secondary side of the unit or within the wiring leads either directly or with closed contacts to a short circuit of the supply, whereby a series-connected 24V fuse triggers.

Besides the two displayed applications with an emergency stop switchgear, other sensors (like door switches etc.) can be used similarly.

7.3 Direct switching off by safety module with test pulses

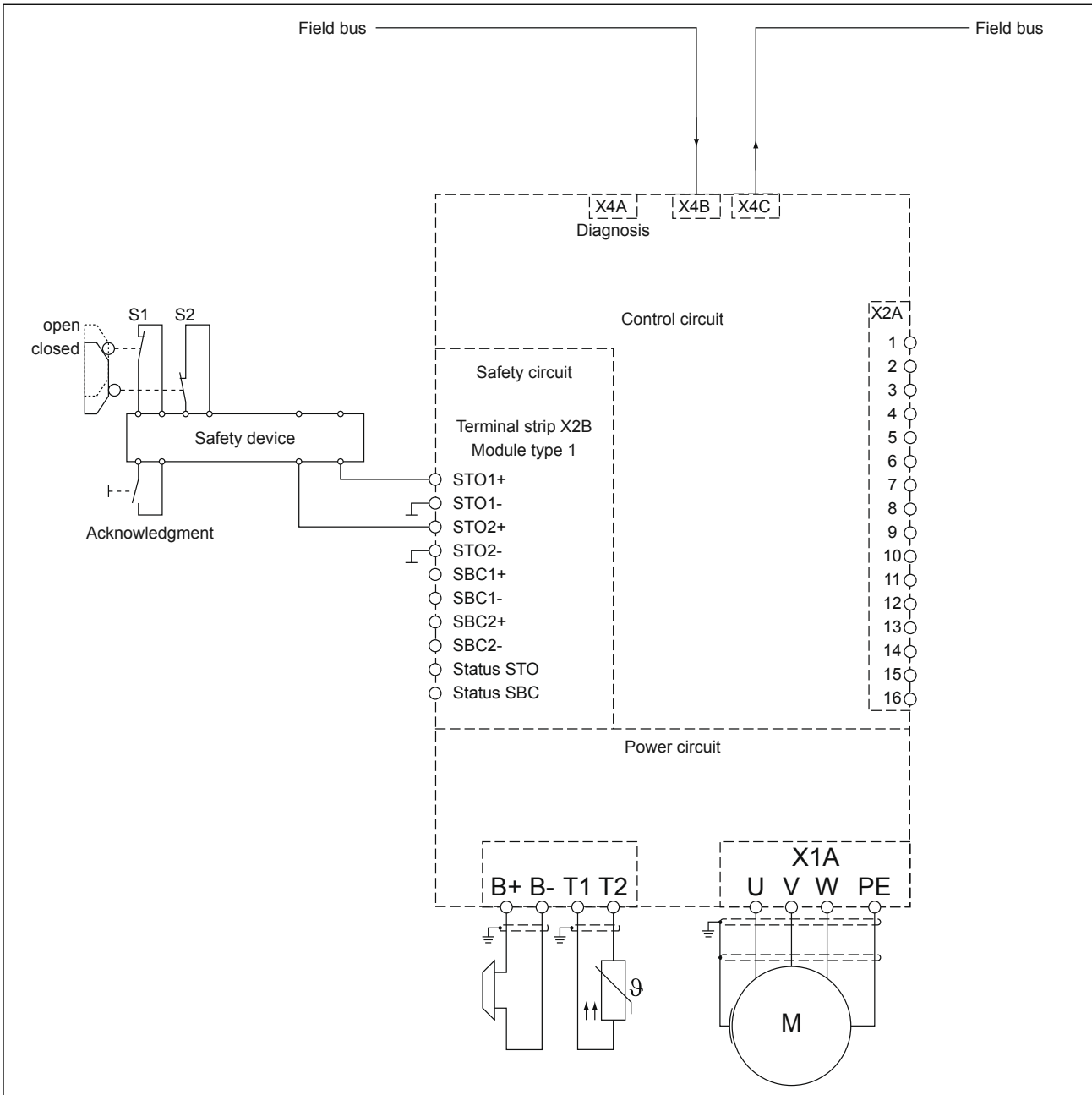


Figure 4: Direct switching off by safety module with test pulses

With operation of the emergency stop unit, e.g. by protection door, the release paths of the safety module are disconnected. This leads to the loss of the STO signals (STO1+ und STO2+) and thus to energy disconnection of the drive. The safety module makes a consistency check of all signal paths via test signals (OSSD).

7.4 Wiring SS1

At tripping SS1 (Safe Stop 1) the drive is only disconnected from supply when it has reached a standstill [IEC 61800-5-2]. The stop mode is not directly requested, but the maximum time until reaching the standstill is estimated. This period is loaded in a safe time relay, which disconnects the drive finally from supply.

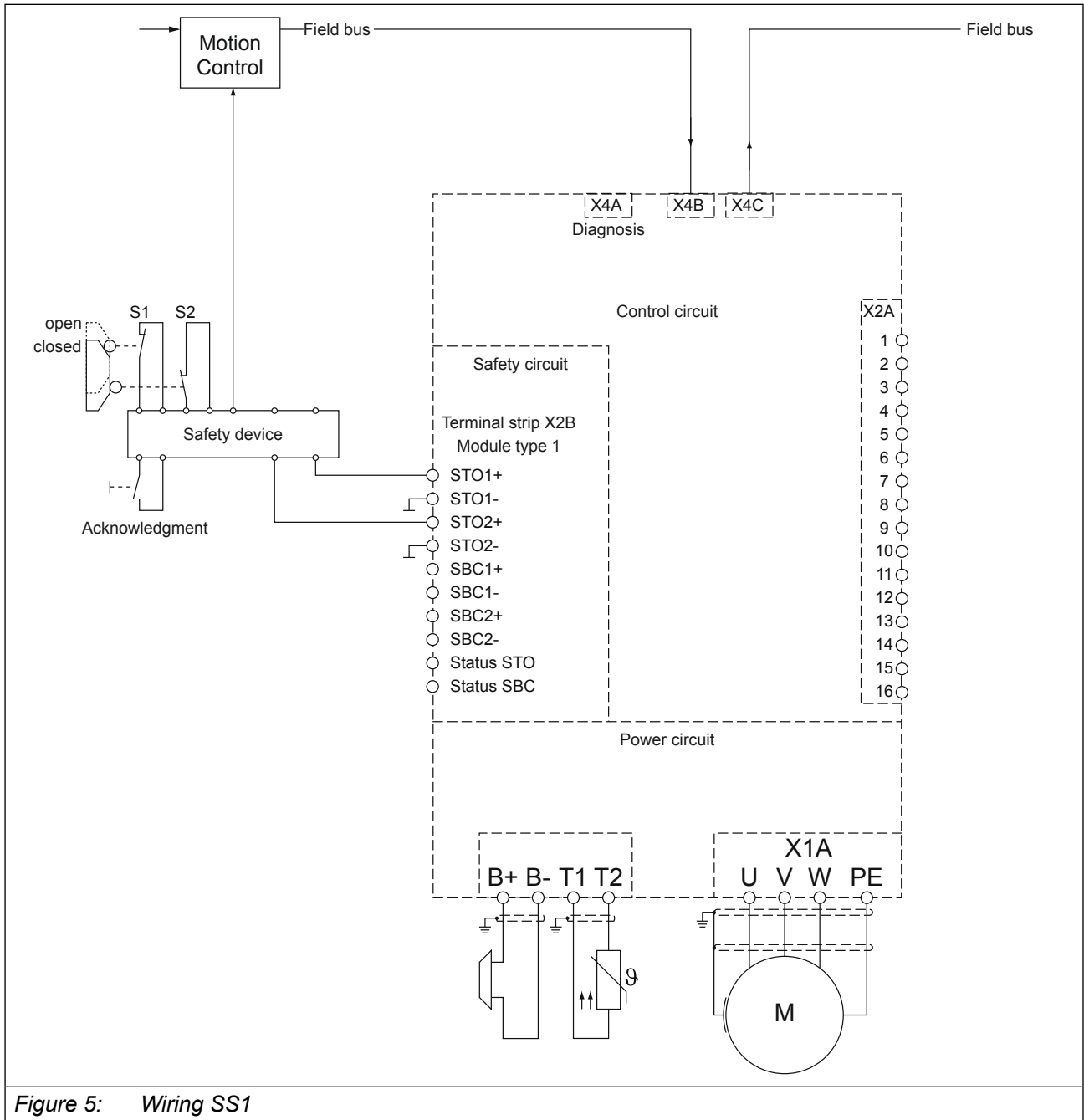


Figure 5: Wiring SS1

By activation of the emergency stop unit the master motion control is instructed via an output to stop the drive with a deceleration ramp. Simultaneously the expiration of the safe time occurs in the safety module. After expiration of the safe period the control signals STO1+ und STO2+ are removed and thus the energy supply of the drive is disconnected.

8 Change of the Safety Module

⚠ Danger**Electric Shock**

Before working with the unit disconnect it from mains. Check the isolation from supply by measurements in the unit. Await min. 15 minutes until the capacities of the DC link are discharged.

A change of the safety module is displayed by the control in the COMBIVIS with status 61 „ERROR safety mod. changed“. The user must confirm the change by writing of parameter de.38 "serial number safety module" with the entered value. Only then the error can be reset.

The parameters for acknowledge the safety module change are password protected. The work can be carried out only by qualified persons.

⚠ CAUTION**Working after the change**

The change may be done only by qualified persons. Check the safety functions and error responses and generate an acceptance report after the change.

9 Certification

9.1 Annex to the declaration of conformity

Annex to the declaration of conformity EC for systems with functional safety:

For information about the declaration of conformity visit our homepage www.keb.de => Service => Downloads. Search entry: Safety H6; file type: certificates.

Herewith we declare that the safety module described above corresponds with all relevant regulations of the machinery safety directive 2006/42/EC.

The above mentioned safety module meets the requirements of the following guidelines and standards:

- Machinery safety directive 2006/42/EC
- EMC directive 2014/30/EC
- Low-Voltage Directive 2014/35/EC
- Dangerous substances 2011/65/EC

Standard	Text	Reference
EN 61800-5-1	Electrical power drive systems with adjustable speed: security requirements	VDE 0160 Part 105
EN 61800-2	Adjustable speed electrical drive systems: General requirements, rating specifications for low voltage adjustable frequency a.c. power drive systems	VDE 0160-102
EN 61800-3	Adjustable speed electrical power drive systems - Part 3: EMC requirements and specific test methods	VDE 0160-103

Standard	Text	Reference
EN 61800-5-2	Adjustable speed electrical power drive systems - Part 5-2: Safety requirements - Functional	VDE 0160-105-2
EN 61508-(1...7)	Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 1...7	VDE 0803
EN 62061	Safety of machinery – Functional safety of electrical, electronic and programmable electronic control systems	VDE 0113-50
DIN EN ISO 13849	Safety of machinery – Safety-related parts of control systems	

Table 16: Annex to the declaration of conformity

continued on next page

CERTIFICATION

Standard	Text	Reference
DIN EN 61000-6-7	Electromagnetic compatibility (EMC) - Part 6-7: Generic standards - Immunity requirements for equipment intended to perform functions in a safety-related system (functional safety) in industrial locations (IEC 61000-6-7)	VDE 0839-6-7
EN 60204-1	Safety of machinery – Electrical equipment of machines – Part 1: General requirements	VDE 0113-1

The conformity was confirmed by the TÜV Rheinland with the EC type examination 01/205/5056.03/20.

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10 Revision history

Revision	Date	Description
Rev.1F	2010-10	First published version
Rev.1G	2010-11	Extended declaration of conformity.
Rev.1H	2010-12	Installation extended.
Rev.1J	2012-02	Functional description of co21 bit 4 inserted, pin description of safety module -0029 inserted.
Rev.1K	2012-03	Wiring diagrams modified.
Rev.1L	2013-01	FS marking inserted; status message added; braking check changed; example „wiring SS1“ enhanced; extended wait time to 15 minutes for maintenance; new terminal inserted.
V00	2016-09	Change to document management; Changed cover picture; Changed product description; Revision/generalization for the use with F6A and S6A.
V01	2016-12	Change to new formats; Change of the company name and address.
V02	2017-02	Change to the new KEB corporate identity optics.
V03	2020-05	List of standards updated; standards at the annex of the declaration of conformity adapted.
V04	2021-11	Insert new number of certificate

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