COMBIVERT

G6

GB **Safety Manual**
COMBIVERT G6

Safety function
STO

Original Manual	
Mat.No.	Rev.
00G6NEF-0000	1H

KEB

Table of Contents

1. Preface

1.1 General

First we would like to welcome you as a customer of the company Karl E. Brinkmann GmbH and congratulation to the purchase of this product. You have decided for a product on highest technical level.

The described hard- and software are developments of the Karl E. Brinkmann GmbH. The enclosed documents correspond to conditions valid at printing. Misprint, mistakes and technical changes reserved.

The instruction manual must be made available to the user. Before working with the unit the user must become familiar with it. This especially applies to the knowledge and observance of the following safety and warning indications. The used pictograms have following significance:

	Danger Warning Caution	Is used, if life or health of the user are endangered or substantial damage to property can occur.
	Attention observe at all costs	Is used, if a measure is necessary for safe and trouble-free operation.
	Information Aide Tip	Is used, if a measure simplifies the handling or operation of the unit.

1.2 Safety instructions

	Observe safety and operating instructions	Precondition for all further steps is the knowledge and observance of the safety and operating instructions (instruction manual part 1). This is provided accompanied by the device or by the download site of www.keb.de.

Non-observance of the safety and operating instructions leads to the loss of any liability claims. The warnings and safety instructions in this manual work only supplementary. This list is not exhaustive.

1.3 Validity and liability

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 machine manufacturer.

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 application. However, they are considered for information only without responsibility. 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 application by the machine manufacturer. They must be repeated, even if only parts of hardware, software or the unit adjustment are modified.

Unauthorised opening and tampering may lead to bodily injury and property damage and may entail the loss of warranty rights. Original spare parts and authorized accessories by the manufacturer serve as security. The use of other parts excludes liability for the consequences arising out of.

The suspension of liability is especially valid also for operation interruption loss, loss of profit, data loss or other damages. This is also valid, if we referred first to the possibility of such damages.

If single regulations should be or become void, invalid or impracticable, the effectivity of all other regulations or agreements is not affected.

Through multitude applications not each possible case of installation, operation or maintenance can be considered. If you require further information or if special problems occur which are not treated detailed in the documentation, you can request the necessary information via the local KEB agency.

1.4 Copyright

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

KEB®, COMBIVERT®, COMBICONTROL® and COMBIVIS® are registered trademarks of Karl E. Brinkmann GmbH.

Other wordmarks or/and logos are trademarks (™) or registered trademarks (®) of their respective owners and are listed in the footnote on the first occurrence.

When creating our documents we pay attention with the utmost care to the rights of third parties. Should we have not marked a trademark or breach a copyright, please inform us in order to have the possibility of remedy.

1.5 Specified application

The used semiconductors and components of KEB are developed and dimensioned for the use in industrial products. If the KEB COMBIVERT F5 is used in machines, which work under exceptional conditions or if essential functions, life-supporting measures or an extraordinary safety step must be fulfilled, the necessary reliability and security must be ensured by the machine builder. The operation of our products outside the indicated limit values of the technical data leads to the loss of any liability claims. The safety function is limited to a service life of 20 years. After this time the unit must be replaced.

1.6 Product description

The safety manual completes the installation manuals COMBIVERT G6 with the safety function STO. It contains safety-related supplements and regulations for the operation of COMBIVERT G6 in safety applications. The basic standards as well as application and country-specific standards must be observed furthermore. The standards referred in this manual must be observed supplementary. The safety function STO according to IEC 61800-5-2 contains:

- Safe torque off (Safe Torque Off - STO)

The safety function 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 function protects people against mechanical damages. COMBIVERT G6 inverters with integrated STO function correspond to the following numbers code:

Product code							
xx	G6	x	x	x	-	xxxx	
							A, B, C, D, H, I, K, L

	Validity of certificates	The certification of controllers with safety technology since 05.2013 is only valid if the material number corresponds with the specified numerical code **and** the FS logo is printed on the type plate.	**FS**

1.7 Part code

xx G6 x x x - x x x x

Cooling (not valid at customer/special version)	
0	Air-cooling (housing C, D, E); air-cooling/flat rear (housing A, B)
1	Flat rear

Control/keyboard/display (not valid at customer/special version)			
0	Open-loop without keyboard/display	A	like 0 on ASCL hardware
1	Open-loop with keyboard/display	B	like 1 on ASCL hardware
2	SCL without keyboard/display		
3	SCL with keyboard/display		
4	ASCL without keyboard/display		
5	ASCL with keyboard/display		

Switching frequency; short time current limit; overcurrent cut-off (not valid at customer/special version)								
0	2 kHz	125 %	150 %		1	4 kHz	125 %	150 %
2	8 kHz	125 %	150 %		3	16 kHz	125 %	150 %
4	2 kHz	150 %	180 %		5	4 kHz	150 %	180 %
6	8 kHz	150 %	180 %		7	16 kHz	150 %	180 %
8	2 kHz	180 %	216 %		9	4 kHz	180 %	216 %
A	8 kHz	180 %	216 %		B	2 kHz	180 %	216 %

Voltage, connection

further on next side

xx G6 x x x - x x x x

0	1-phase	230 V	AC/DC	3	3-phase	400 V	AC/DC
1	3-phase	230 V	AC/DC	5		400 V	DC
2	1/3-phase	230 V	AC/DC	6	1-phase	230 V	AC
A-Z	Customer-/special version (firmware and download)						

Housing type A, B, C, D, E

Variants

0	without filter, without braking transistor, without safety function STO	A	like 0 with STO	H	like A with f=0Hz
1	without filter, with braking transistor, without safety function STO	B	like 1 with STO	I	like B with f=0Hz
2	internal filter; without braking transistor, without safety function STO	C	like 2 with STO	K	like C with f=0Hz
3	internal filter, with braking transistor, without safety function STO	D	like 3 with STO	L	like D with f=0Hz

Control type

C	Analog/digital (standard)
D	CAN® [1]
E	IO-Link® [2]
F	EtherCAT® [3]
G	PROFINET® [4]

G6 unit type

Inverter size

[1] *CANopen® is registered trademark of CAN in AUTOMATION - International Users and Manufacturers Group e.V.*

[2] *IO-LINK® is registered trademark of PROFIBUS user organisation e.V.*

[3] *EtherCAT® is registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany*

[4] *PROFINET® is registered trademark of Siemens AG*

2. Safety Function STO

	**Electric Shock**	COMBIVERT G6 contain dangerous voltages which can cause death or serious injury. The COMBIVERT G6 can be adjusted by way that in regenerative operation energy is regenerated into the DC link 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.

	**Only Qualified Staff**	Uncontrolled start is possible by improper installation of the safety technology. This may cause death, serious bodily injuries or substantial damage to property. Therefore the safety function may only be installed and put into operation by qualified personnel which are trained in safety technology.

	**Observe Standards**	The COMBIVERT G6 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 G6 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 the safety function is integrated in the drive control in order to minimize or eliminate danger by malfunctions in machines. The integrated safety function replace the complex installation of external safety components. The safety function can be requested or released by an error.

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

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.

	**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. A further advantage is that the recharge and discharge time of the inverter 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 inverter DC link

What is realized by the STO function related to EN 60204 ?

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 !

2.1 Emergency stop according EN 60204

By using suitable safety switchgear units, stop category 0 and 1 according to EN 60204 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.

	**Restart only after confirmation**	The drive restarts if function STO is no longer released. In order to comply with EN 60204, 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.

	**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.

	**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.

Calculation of the jerk:

$$\text{Rotation angle of the jerk } W_R\,[°] = \frac{180°}{\text{Pole-pair number p} \bullet \text{gear reduction ratio g}}$$

The probability of the jerk is < 1.84 *10^{-15} 1/h.
This behaviour can occur by a short circuit of the IGBTs. The error should be regarded as critical, if the drive remains in STO status.

2.2 Classification of STO according IEC 61508

PFH	8.1 *10^-11 1/h
PFD	7.1 * 10^-6 on demand
Proof-Test-Interval	20 years

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

2.3 Classification of STO according EN ISO 13849

Control category	3
$MTTF_D$	>2500 years
DC	medium

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. Installation

	**Before beginning**	Before installation, read and note the EMC and safety instructions and installation manuals of the COMBIVERT G6.

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 section 4.1).

	**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 ± 10%. Pay attention on a sufficient overvoltage category of the voltage supply.

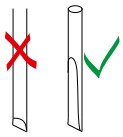
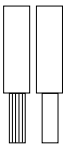
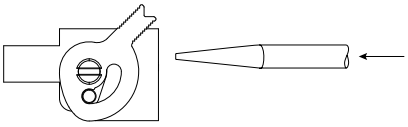
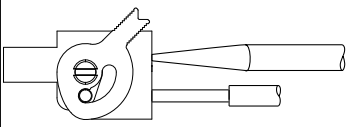
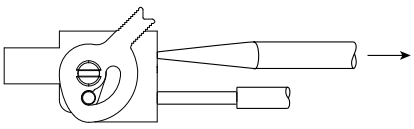
4. Description of the Terminals

X2B	PIN	Name	I/O
	1	STO1+	Input STO channel 1
	2	STO1-	
	3	STO2+	Input STO channel 2
	4	STO2-	
The individual channels are designed potential-free, so 24V and 0 V can be connected. The inputs are designed by way that safety switchgear units with test pulse (OSSD signals) can be connected. The signals are not evaluated, they are only filtered. The OSSD test interval is limited to 10 ms. The filter time for the entire voltage range is 1 ms.			

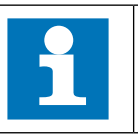
Assembly of connecting wires with wire-end ferrules according to DIN46228/4		
Cross-section / AWG	Metal sleeve length	Stripping length
0.2…0.75 mm² / 24…19	6 mm	8 mm

Assembly of connecting wires without wire-end ferrules (rigidy and flexible	
Cross-section / AWG	Stripping length
0.2…1.5 mm² / 24…16	10 mm

4.1 Assembly of the wires

	Required tools: Screw driver SD 0.4 x 2.5 (DIN 5264)	
1.	Strip cable Use wire-end ferrules as round, square or hexagon pressing.	
2.	Plug screw driver mid into the square slot.	
3.	Plug cable into the round slot, that no wires can be seen from the outside.	
4.	Remove screw driver and check if cables are fixed.	

	A safe clamping can not be guaranteed when using shorter wire-end ferrules.



KEB generally recommends the use of wire-end ferrules in industrial environments.

4.2 Inputs

4.2.1 Specification of the STO inputs

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

5. Functional Description

The control board with the safety function STO fulfills the following functions according to IEC 61800-5-2:

- „Safe torque off“ (Safe Torque Off – STO)

The safety-oriented switching off of the modulation is reached by a two channel disconnection of the control of the IGBT.

The 1st channel switches off the pulse pattern of the control CPU.
The 2nd switches off the supply of the gate control of the IGBT´s in the driver

The switching off of the pulse pattern and the voltage supply of the drivers are monitored.
If for example an input side connected emergency stop unit is activated (STO1 & STO2 = 0V) it is tested by the diagnosis, if both channels have switched off the pulse generation.
In case of inactivated emergency stop unit (STO1 & STO2 = 24V) an on-off-on test is carried out before the modulation release to ensure that a switching off is possible.

	**Test every 24 hours**	In order to ensure safe operation, the safety function must carried out every 24 hours that the on-off-on test is executed.

5.1 Switching off

After STO input voltage disconnection the control of the IGBTs is stopped within 12 ms. Repeated switching on is prevented for the duration of 11 ms after switching off.

5.2 Switching on

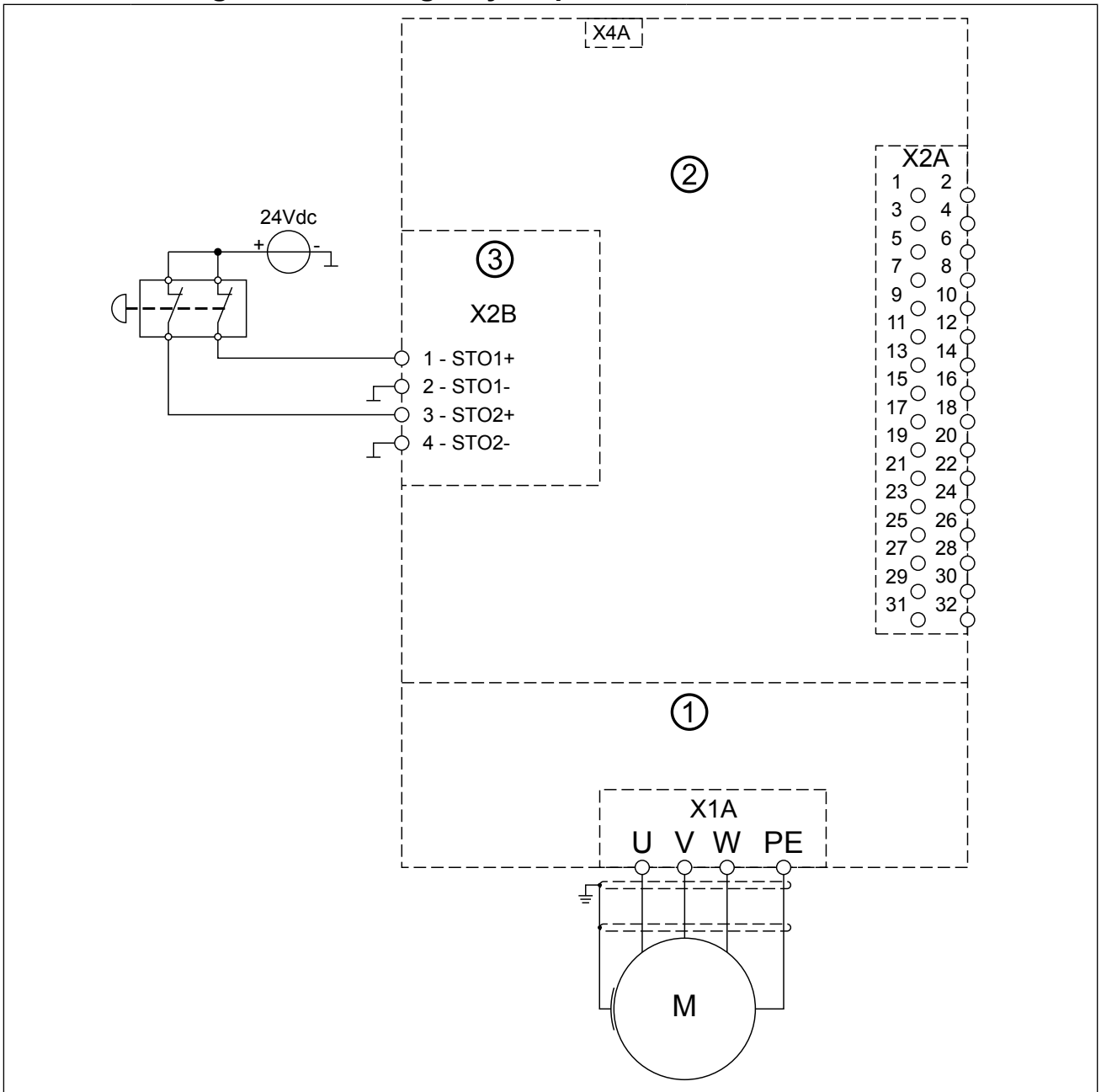
24 V on both STO inputs and a direction of rotation must be set at the control (no LS at parameter ru00) thus the on-off-on test can be executed. The frequency output is delayed by the test about maximum 120 ms.

5.3 Error

If an error occurs during operation, the inverter turns into a „safe condition“ within 25 ms. ru00 displayes “28: Error! Safety function”.
The „Error! Safety function“ can
• not be reset by a digital input
• only be reset by a power-on reset of the frequency inverter.

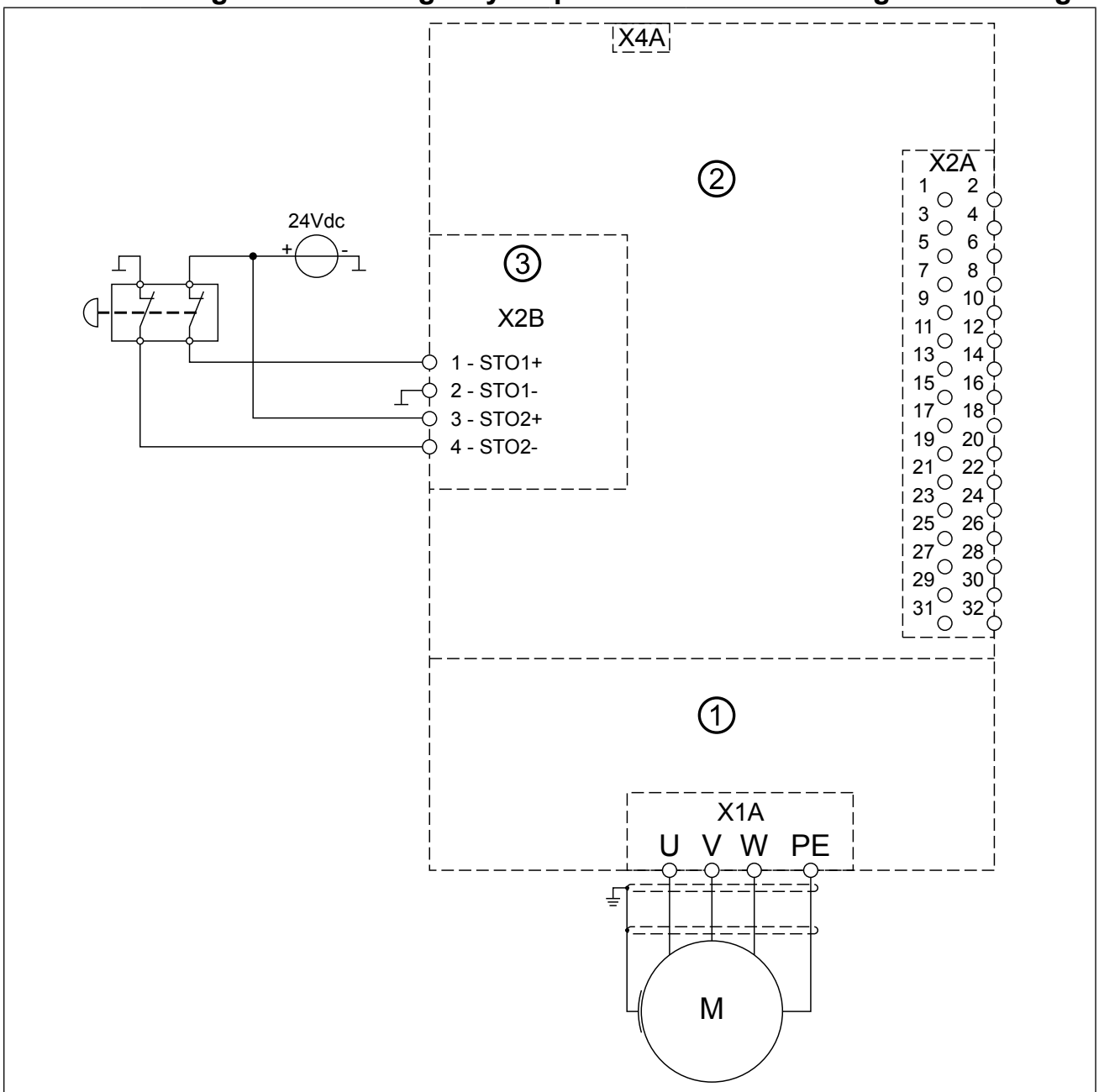
6. Wiring Examples

6.1 Direct switching off with emergency stop switch



①	Power Unit	X1A	Power terminal block
②	Control Circuit	X2A	Control terminal block
③	Safety component	X2B	STO terminal block
		X4A	Diagnostic interface
	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.		

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

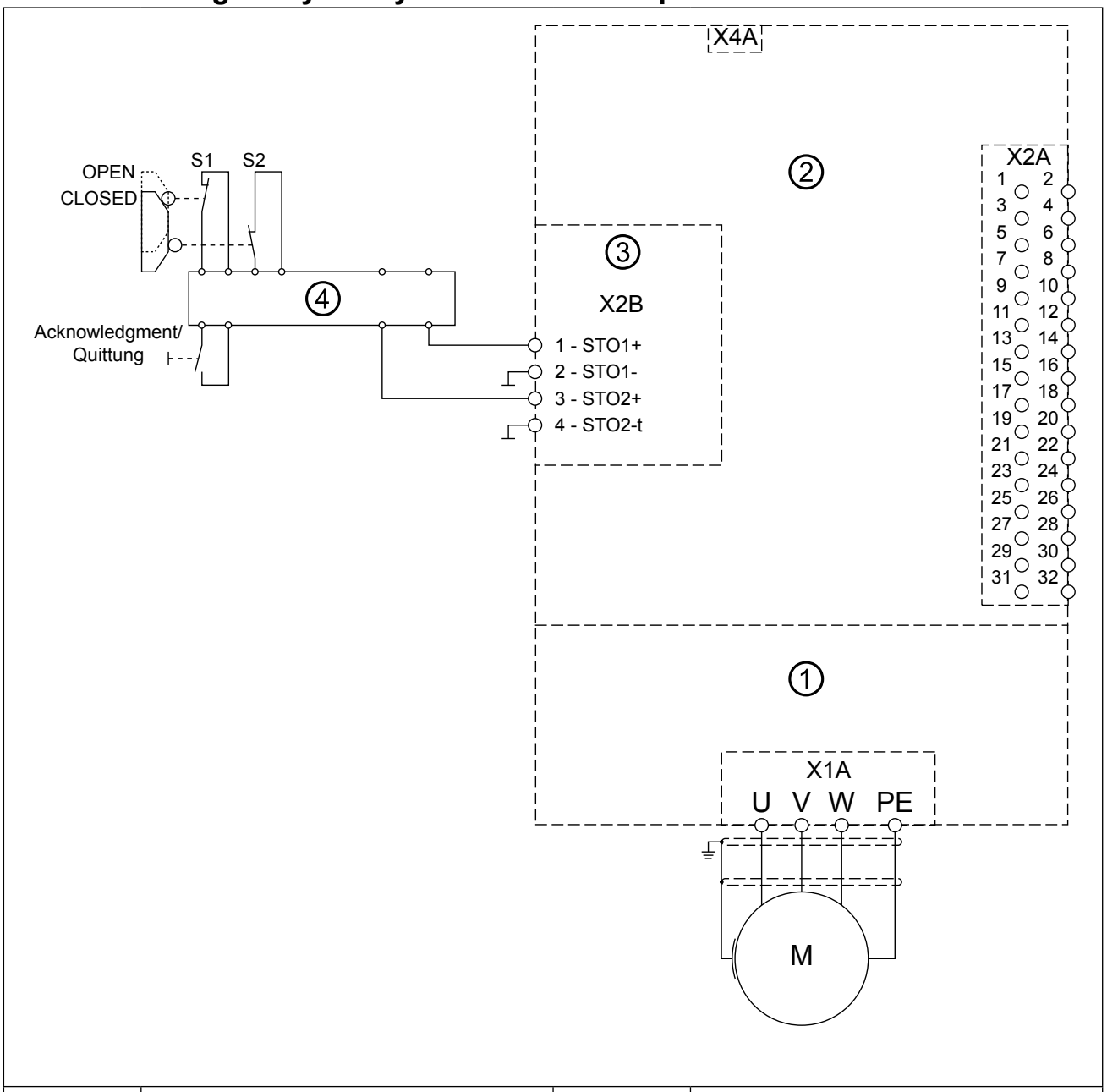


①	Power Unit	X1A	Power terminal block
②	Control Circuit	X2A	Control terminal block
③	Safety component	X2B	STO terminal block
		X4A	Diagnostic interface

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.

6.3 Direct switching off by safety module with test pulses

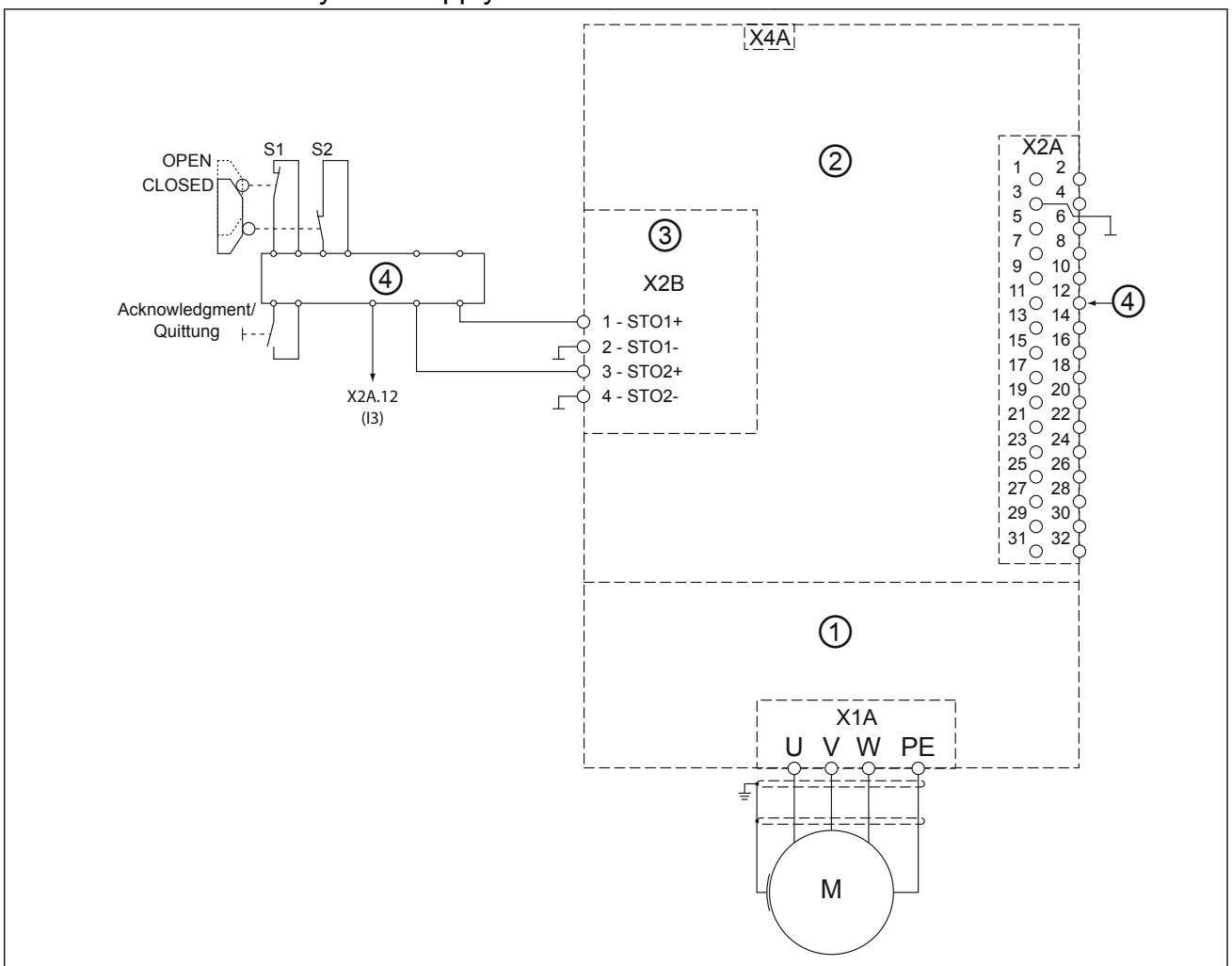


①	Power Unit	X1A	Power terminal block
②	Control Circuit	X2A	Control terminal block
③	Safety component	X2B	STO terminal block
④	Safety module	X4A	Diagnostic interface

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 (X2B.1 and 3) and thus to energy disconnection of the drive. The safety module makes a consistency check of all signal paths via test signals (OSSD).

6.4 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.



①	Power Unit	X1A	Power terminal block
②	Control Circuit	X2A	Control terminal block
③	Safety component	X2B	STO terminal block
④	Safety module	X4A	Diagnostic interface

By activation of the emergency stop unit the drive is stopped with a deceleration ramp via input X2A.12 (I3).
Simultaneously the expiration of the safe time occurs in the safety module. After expiration of the safe period the control signals STO1 and STO2 (X2B.1 and 3) are removed and thus the energy supply of the drive is disconnected.
The following adjustments must be done in COMBIVERT G6 for the function „drive stop“:

Parameter	Adjustment
Pn03 „Reaction to error prg. input“	1: Quick stopping; modulation off; no automatic restart
Pn04 „Source error prog. input“	16: I3 (here in the example)

Function: If the selected input becomes active, the drive decelerates with the quick stopping function and changes then into status 31 „error! External input“.

7. Certification

7.1 Annex to the declaration of conformity

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

Product designation:	Inverter - type series	xxG6xAx-xxxx xxG6xBx-xxxx xxG6xCx-xxxx xxG6xDx-xxxx xxG6xHx-xxxx xxG6xIx-xxxx xxG6xKx-xxxx xxG6xLx-xxxx

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	2004/108/EC
•	Low-Voltage Directive	2006/95/EC

EN standards	Output	Text	Reference	Output
EN 61800-5-1	09/2003	Electrical power drive systems with adjustable speed: security requirements	VDE 0160 Part 105	09/2003

informative:

EN 50178	1997	Installation of high voltage systems with electronic equipment	VDE 0160	04/1998
EN 60664-1	2007	Isolation coordinats for electrical equipment in low-voltage systems	VDE 0110	01/2008
EN 61800-2	10/1998	Basic determinations for AC inverter	VDE 0160 Part 102	08/1999

especially for systems with functional safety additionally:

EN 61800-5-2	2007	Electrical power drive systems with adjustable speed: functional safety requirements	VDE 0160 Part 105-2	04/2008
EN 61508-(1…7)		Functional safety of electrical/electronic/ programmable electronic safety-related systems - Part 1 up to 7	VDE 0803	02/2011
EN 60204-1 +A1	2006 2009	Electrical equipment of machines; Part1: General requirements	VDE 0113-1 +A1	2007 10/2009
EN 62061	09/2013	Safety of machinery functional security requirements	VDE 0113 Part 50	09/2013
EN 13849-(1, 2)		Safety of machinery	–	08/2008

Certification

The conformity was confirmed by the TÜV Rheinland with the EC type examination 01/205/5183/11.

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8. Revision history

Revision	Date	Description
Rev.1E	2011-02	First published version
Rev.1F	2012-01	Inscribed certification number; change DC classification to middle at chapter 2.3; extended chapter 5.2
Rev.1G	2013-02	FS marking inserted; copyright changed
Rev.1H	2014-01	Extended assembly of the wires; error safety function revised; adapted standardization

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