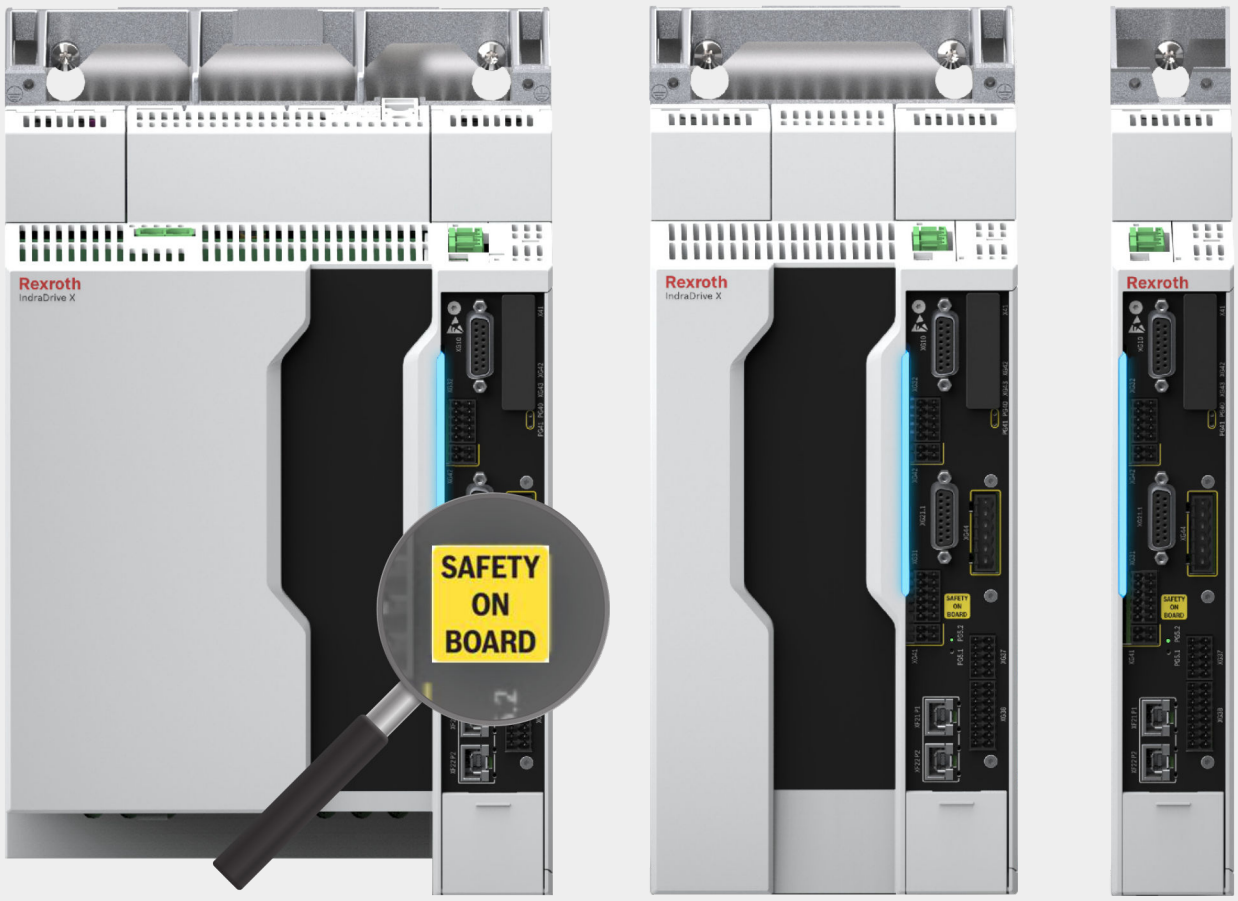
rexroth
A Bosch Company

ctrlX SAFETY

"Safe Torque Off" Safety Option in ctrlX DRIVE

Application Manual
R911383774

Edition 03



Title	ctrlX SAFETY "Safe Torque Off" Safety Option in ctrlX DRIVE
Type of Documentation	Application Manual
Document Typecode	DOK-XDRV**-SI-TX******-AP03-EN-P
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Purpose of Documentation	This documentation • familiarizes the user with the subject of "Safe Torque Off". • contains information on mounting and maintenance, on proper and safe operation and on the decommissioning of the "Safe Torque Off" safety option of ctrlX DRIVE. • is addressed to individuals who mount, operate and maintain ctrlX DRIVE with the "Safe Torque Off" safety option.

Edition	Edition 03, 2020-05 Record of revisions see ""Editions of this documentation" on page 1"

Editorial Department	Engineering Drives, Firmware [ReBa, ThKl (SvAn; BaBo)]

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1 Introduction

1.1 About this documentation

Editions of this documentation

Edition	Release date	Notes
01	2018-04	Edition for C sample
02	2019-03	Edition for series release • Included declaration of conformity • Included other devices equipped with the optional safety technology module "T0"
03	2020-05	Edition for AXS-V-0202 firmware release • Replaced working title "IndraDrive X" by "ctrlX DRIVE" • Updated documentation type codes

Tab. 1-1: Record of revisions

Means of representation in this documentation

To facilitate reading of this documentation, the table below contains the means of representation and notations of recurring terms.

What?	How?	For example...
Important facts to be highlighted in the body text	Boldface	With the safety function "Safe parking axis", the following monitoring functions are **deactivated**: ...
Parameter names, diagnostic message names, function designations	Quotation marks	The missing speed information can be replaced via the control bit "defined safety with parked axis" in "P-0-3210, Safety technology configuration".

Tab. 1-2: Conventions of notation

Helpful information and tips are highlighted in the text. A symbol tells you what kind of information is used in the text:

This box contains important information that should be taken into consideration.

This symbol highlights useful tips and tricks.

Signal words in accordance with ANSI Z535.6-2011 draw the reader's attention to hazards (see "Explanation of signal words and the safety alert symbol").

Structure of documentation

Concerning integrated safety technology, the descriptions of the ctrlX DRIVE systems have the following structure:

- **Application Manual** of the "Safe Torque Off" ("T0") safety option (this documentation)
  - familiarizes the user with the subject of "Safe Torque Off".
  - contains information on mounting and maintenance, on proper and safe operation and on the decommissioning of the "Safe Torque Off" safety option of ctrlX DRIVE.
  - is addressed to individuals who mount, operate and maintain ctrlX DRIVE with the "Safe Torque Off" safety option.

- **Project Planning Manuals**

  Assist with electrical design and installation of the drive system, as well as its components
- **Parameter description** for ctrlX DRIVE with the AXS firmware

  Apart from the specific safety technology parameters, all other drive parameters are documented in the Parameter description
- **Description of diagnostic messages** for ctrlX DRIVE with the AXS firmware

  Apart from the specific diagnostic messages of safety technology, all other diagnostic messages are documented in the Description of diagnostic messages (also called "Troubleshooting guide").

☞ For an overview of reference documentations, please refer to: "Documentations"

Your Feedback

Your experience is important for our improvement processes of products and documentations.

If you discover mistakes in this documentation or suggest changes, you can send your feedback to the following e-mail address:

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We need the following information to handle your feedback:

- The number indicated under "Internal File Reference".
- The page number.

2 Important directions for use

2.1 Intended use

2.1.1 Introduction

Rexroth products are developed and manufactured to the state-of-the-art. The products are tested prior to delivery to ensure operational safety and reliability.

⚠ WARNING **Personal injury and property damage by using products incorrectly!**

The products have been designed for use in an industrial environment and may only be used as intended. Failure to use them in the intended way may cause situations resulting in property damage and personal injury.

☞ Rexroth as the manufacturer shall not honor any warranty, liability or compensatory claims for damages resulting from unintended use of the products. The user alone shall bear the risks of unintended use of the products.

Before using Rexroth products, make sure that all the prerequisites for an intended use of the products are satisfied:

- Personnel that in any way, shape or form uses our products must first read and understand the relevant safety instructions and be familiar with their intended use.
- Leave hardware products in their original state, i.e., do not make any structural modifications. It is not permitted to decompile software products or alter their source codes.
- Do not install damaged or faulty products or put them into operation.
- Make sure that the products have been installed as described in the relevant documentation.

2.1.2 Areas of use and application

Drive controllers by Rexroth are designed to control electric motors and monitor their operation.

Controlling and monitoring the Drive controllers may require additional sensors and actuators.

☞ The drive controllers may only be used with the accessories and attachments specified in this documentation. Components that are not expressly mentioned may neither be attached nor connected. The same applies to cables and lines.

Operation is only allowed in the specified configurations and combinations of the components using the software and firmware as specified in the relevant functional descriptions.

Drive controllers have to be programmed before commissioning to ensure that the motor executes the functions specific to the application.

Drive controllers of the ctrlX DRIVE series have been developed for use in single- and multi-axis drive and control tasks.

Device types with different drive power and interfaces are available for using the Drive controllers in specific applications.

Typical applications include, for example:

- Handling and mounting systems
- Packaging and food machines
- Printing and paper converting machines
- Machine tools

Drive controllers may only be operated under the assembly and installation conditions specified in this documentation, in the specified position of normal use and under the specified ambient conditions (temperature, degree of protection, humidity, EMC, etc.).

☞ Note regarding the **RoHS Directive 2011/65/EU**:

The CSB01, CSH01 and CDB01 control sections do not meet the requirements of the RoHS Directive 2011/65/EU.

However, the CSB01, CSH01 and CDB01 control sections may still be placed on the market within the EU if they are exclusively used in applications that are so-called "large-scale stationary industrial tools" or so-called "large-scale fixed installations".

This is stated by the derogation contemplated by Article 2, paragraph 4 of the RoHS Directive 2011/65/EU. Article 3 of this Directive specifies the definitions.

2.2 Unintended use

"Unintended use" refers to using the Drive controllers outside of the operating conditions, technical data and specifications described in this documentation.

Drive controllers must not be used, if …

- they are exposed to operating conditions that do not meet the specified ambient conditions. This includes, for example, operation under water, under extreme temperature fluctuations or extreme maximum temperatures.
- Furthermore, Drive controllers may not be used in applications that have not been expressly authorized by Rexroth. Therefore, please carefully follow the specifications outlined in the general safety instructions!

☞ Components of the ctrlX DRIVE system are **products of Category C3** (with restricted distribution) in accordance with IEC 61800-3. This Category comprises EMC limit values for line-based and radiated noise emission. Compliance with this Category (limit values) requires the appropriate measures of interference suppression to be used in the drive system (e.g., mains filters, shielding measures).

These components are not provided for use in a public low-voltage mains supplying residential areas. If these components are used in such a mains, high-frequency interference is to be expected. This can require additional measures of interference suppression.

3 Safety instructions for electric drives and controls

3.1 Definitions of terms

Application documentation Application documentation comprises the entire documentation used to inform the user of the product about the use and safety-relevant features for configuring, integrating, installing, mounting, commissioning, operating, maintaining, repairing and decommissioning the product. The following terms are also used for this kind of documentation: Operating Instructions, Commissioning Manual, Instruction Manual, Project Planning Manual, Application Description, etc.

Component A component is a combination of elements with a specified function, which are part of a piece of equipment, device or system. Components of the electric drive and control system are, for example, supply units, drive controllers, mains choke, mains filter, motors, cables, etc.

Control system A control system comprises several interconnected control components placed on the market as a single functional unit.

Device A device is a finished product with a defined function, intended for users and placed on the market as an individual piece of merchandise.

Electrical equipment Electrical equipment encompasses all devices used to generate, convert, transmit, distribute or apply electrical energy, such as electric motors, transformers, switching devices, cables, lines, power-consuming devices, circuit board assemblies, plug-in units, control cabinets, etc.

Electric drive system An electric drive system comprises all components from mains supply to motor shaft; this includes, for example, electric motor(s), motor encoder(s), supply units and drive controllers, as well as auxiliary and additional components, such as mains filter, mains choke and the corresponding lines and cables.

Installation An installation consists of several devices or systems interconnected for a defined purpose and on a defined site which, however, are not intended to be placed on the market as a single functional unit.

Machine A machine is the entirety of interconnected parts or units at least one of which is movable. Thus, a machine consists of the appropriate machine drive elements, as well as control and power circuits, which have been assembled for a specific application. A machine is, for example, intended for processing, treatment, movement or packaging of a material. The term "machine" also covers a combination of machines which are arranged and controlled in such a way that they function as a unified whole.

Manufacturer The manufacturer is an individual or legal entity bearing responsibility for the design and manufacture of a product which is placed on the market in the individual's or legal entity's name. The manufacturer can use finished products, finished parts or finished elements, or contract out work to subcontractors. However, the manufacturer must always have overall control and possess the required authority to take responsibility for the product.

Product Examples of a product: Device, component, part, system, software, firmware, among other things.

Project Planning Manual A Project Planning Manual is part of the application documentation used to support the sizing and planning of systems, machines or installations.

Qualified persons In terms of this application documentation, qualified persons are those persons who are familiar with the installation, mounting, commissioning and operation of the components of the electric drive and control system, as well as with the hazards this implies, and who possess the qualifications their

work requires. To comply with these qualifications, it is necessary, among other things,

- to be trained, instructed or authorized to switch electric circuits and devices safely on and off, to ground them and to mark them.
- to be trained or instructed to maintain and use adequate safety equipment.
- to attend a course of instruction in first aid.

Qualified personnel for handling functionally safe products

Individuals configuring, commissioning and operating functionally safe products must have the knowledge specified under "Qualified persons". Additionally, these individuals must be familiar with technical safety concepts as well as prevailing standards and regulations in the field of functional safety.

User

A user is a person installing, commissioning or using a product which has been placed on the market.

3.2 General information

3.2.1 Using the Safety instructions and passing them on to others

Do not attempt to install and operate the components of the electric drive and control system without first reading all documentation provided with the product. Read and understand these safety instructions and all user documentation prior to working with these components. If you do not have the user documentation for the components, contact your responsible Rexroth sales partner. Ask for these documents to be sent immediately to the person or persons responsible for the safe operation of the components.

If the component is resold, rented and/or passed on to others in any other form, these safety instructions must be delivered with the component in the official language of the user's country.

Improper use of these components, failure to follow the safety instructions in this document or tampering with the product, including disabling of safety devices, could result in property damage, injury, electric shock or even death.

3.2.2 Requirements for safe use

Read the following instructions before initial commissioning of the components of the electric drive and control system in order to eliminate the risk of injury and/or property damage. You must follow these safety instructions.

- Rexroth is not liable for damages resulting from failure to observe the safety instructions.
- Read the operating, maintenance and safety instructions in your language before commissioning. If you find that you cannot completely understand the application documentation in the available language, please ask your supplier to clarify.
- Proper and correct transport, storage, mounting and installation, as well as care in operation and maintenance, are prerequisites for optimal and safe operation of the component.
- Only qualified persons may work with components of the electric drive and control system or within its proximity.
- Only use accessories and spare parts approved by Rexroth.

- Follow the safety regulations and requirements of the country in which the components of the electric drive and control system are operated.
- Only use the components of the electric drive and control system in the manner that is defined as appropriate. See chapter "Appropriate Use".
- The ambient and operating conditions given in the available application documentation must be observed.
- Applications for functional safety are only allowed if clearly and explicitly specified in the application documentation "Integrated Safety Technology". If this is not the case, they are excluded. Functional safety is a safety concept in which measures of risk reduction for personal safety depend on electrical, electronic or programmable control systems.
- The information given in the application documentation with regard to the use of the delivered components contains only examples of applications and suggestions.

  The machine and installation manufacturers must

  – make sure that the delivered components are suited for their individual application and check the information given in this application documentation with regard to the use of the components,
  – make sure that their individual application complies with the applicable safety regulations and standards and carry out the required measures, modifications and complements.
- Commissioning of the delivered components is only allowed once it is sure that the machine or installation in which the components are installed complies with the national regulations, safety specifications and standards of the application.
- Operation is only allowed if the national EMC regulations for the application are met.
- The instructions for installation in accordance with EMC requirements can be found in the section on EMC in the respective application documentation.

  The machine or installation manufacturer is responsible for compliance with the limit values as prescribed in the national regulations.
- The technical data, connection and installation conditions of the components are specified in the respective application documentations and must be followed at all times.

National regulations which the user has to comply with

- European countries: In accordance with European EN standards
- United States of America (USA):
  – National Electrical Code (NEC)
  – National Electrical Manufacturers Association (NEMA), as well as local engineering regulations
  – Regulations of the National Fire Protection Association (NFPA)
- Canada: Canadian Standards Association (CSA)
- Other countries:
  – International Organization for Standardization (ISO)
  – International Electrotechnical Commission (IEC)

3.2.3 Hazards by improper use

- High electrical voltage and high working current! Danger to life or serious injury by electric shock!
- High electrical voltage by incorrect connection! Danger to life or injury by electric shock!
- Dangerous movements! Danger to life, serious injury or property damage by unintended motor movements!
- Health hazard for persons with heart pacemakers, metal implants and hearing aids in proximity to electric drive systems!
- Risk of burns by hot housing surfaces!
- Risk of injury by improper handling! Injury by crushing, shearing, cutting, hitting!
- Risk of injury by improper handling of batteries!
- Risk of injury by improper handling of pressurized lines!

3.3 Instructions with regard to specific dangers

3.3.1 Protection against contact with electrical parts and housings

☞ This section concerns components of the electric drive and control system with voltages of **more than 50 volts**.

Contact with parts conducting voltages above 50 volts can cause personal danger and electric shock. When operating components of the electric drive and control system, it is unavoidable that some parts of these components conduct dangerous voltage.

High electrical voltage! Danger to life, risk of injury by electric shock or serious injury!

- Only qualified persons are allowed to operate, maintain and/or repair the components of the electric drive and control system.
- Follow the general installation and safety regulations when working on power installations.
- Before switching on, the equipment grounding conductor must have been permanently connected to all electric components in accordance with the connection diagram.
- Even for brief measurements or tests, operation is only allowed if the equipment grounding conductor has been permanently connected to the points of the components provided for this purpose.
- Before accessing electrical parts with voltage potentials higher than 50 V, you must disconnect electric components from the mains or from the power supply unit. Secure the electric component from reconnection.
- With electric components, observe the following aspects:

  Always wait **30 minutes** after switching off power to allow live capacitors to discharge before accessing an electric component. Measure the electrical voltage of live parts before beginning to work to make sure that the equipment is safe to touch.

- Install the covers and guards provided for this purpose before switching on.
- Never touch any electrical connection points of the components while power is turned on.
- Do not remove or plug in connectors when the component has been powered.
- Under specific conditions, electric drive systems can be operated at mains protected by residual-current-operated circuit-breakers sensitive to universal current (RCDs/RCMs).
- Secure built-in devices from penetrating foreign objects and water, as well as from direct contact, by providing an external housing, for example a control cabinet.

High housing voltage and high leakage current! Danger to life, risk of injury by electric shock!

- Before switching on and before commissioning, ground or connect the components of the electric drive and control system to the equipment grounding conductor at the grounding points.
- Connect the equipment grounding conductor of the components of the electric drive and control system permanently to the main power supply at all times. The leakage current is greater than 3.5 mA.
- Establish an equipment grounding connection with a minimum cross section according to the table below. With an outer conductor cross section smaller than 10 mm^2 (8 AWG), the alternative connection of two equipment grounding conductors is allowed, each having the same cross section as the outer conductors.

Cross section outer conductor	Minimum cross section equipment grounding conductor Leakage current ≥ 3.5 mA	
	1 equipment grounding conductor	2 equipment grounding conductors
1.5 mm^2 (16 AWG)	10 mm^2 (8 AWG)	2 × 1.5 mm^2 (16 AWG)
2.5 mm^2 (14 AWG)		2 × 2.5 mm^2 (14 AWG)
4 mm^2 (12 AWG)		2 × 4 mm^2 (12 AWG)
6 mm^2 (10 AWG)		2 × 6 mm^2 (10 AWG)
10 mm^2 (8 AWG)		-
16 mm^2 (6 AWG)	16 mm^2 (6 AWG)	-
25 mm^2 (4 AWG)		-
35 mm^2 (2 AWG)		-
50 mm^2 (1/0 AWG)	25 mm^2 (4 AWG)	-
70 mm^2 (2/0 AWG)	35 mm^2 (2 AWG)	-
...	...	...

Tab. 3-1: Minimum cross section of the equipment grounding connection

3.3.2 Protective extra-low voltage as protection against electric shock

Protective extra-low voltage is used to allow connecting devices with basic insulation to extra-low voltage circuits.

On components of an electric drive and control system provided by Rexroth, all connections and terminals with voltages up to 50 volts are PELV ("Protective Extra-Low Voltage") systems. It is allowed to connect devices equipped with basic insulation (such as programming devices, PCs, notebooks, display units) to these connections.

Danger to life, risk of injury by electric shock! High electrical voltage by incorrect connection!

If extra-low voltage circuits of devices containing voltages and circuits of more than 50 volts (e.g., the mains connection) are connected to Rexroth products, the connected extra-low voltage circuits must comply with the requirements for PELV ("Protective Extra-Low Voltage").

3.3.3 Protection against dangerous movements

Dangerous movements can be caused by faulty control of connected motors. Some common examples are:

- Improper or wrong wiring or cable connection
- Operator errors
- Wrong input of parameters before commissioning
- Malfunction of sensors and encoders
- Defective components
- Software or firmware errors

These errors can occur immediately after equipment is switched on or even after an unspecified time of trouble-free operation.

The monitoring functions in the components of the electric drive and control system will normally be sufficient to avoid malfunction in the connected drives. Regarding personal safety, especially the danger of injury and/or property damage, this alone cannot be relied upon to ensure complete safety. Until the integrated monitoring functions become effective, it must be assumed in any case that faulty drive movements will occur. The extent of faulty drive movements depends upon the type of control and the state of operation.

Dangerous movements! Danger to life, risk of injury, serious injury or property damage!

A **risk assessment** must be prepared for the installation or machine, with its specific conditions, in which the components of the electric drive and control system are installed.

As a result of the risk assessment, the user must provide for monitoring functions and higher-level measures on the installation side for personal safety. The safety regulations applicable to the installation or machine must be taken into consideration. Unintended machine movements or other malfunctions are possible if safety devices are disabled, bypassed or not activated.

To avoid accidents, injury and/or property damage:

- Keep free and clear of the machine's range of motion and moving machine parts. Prevent personnel from accidentally entering the machine's range of motion by using, for example:
  - Safety fences
  - Safety guards
  - Protective coverings
  - Light barriers
- Make sure the safety fences and protective coverings are strong enough to resist maximum possible kinetic energy.
- Mount emergency stopping switches in the immediate reach of the operator. Before commissioning, verify that the emergency stopping equipment works. Do not operate the machine if the emergency stopping switch is not working.
- Prevent unintended start-up. Isolate the drive power connection by means of OFF switches/OFF buttons or use a safe starting lockout.
- Make sure that the drives are brought to safe standstill before accessing or entering the danger zone.
- Additionally secure vertical axes against falling or dropping after switching off the motor power by, for example,
  - mechanically securing the vertical axes,
  - adding an external braking/arrester/clamping mechanism or
  - ensuring sufficient counterbalancing of the vertical axes.
- The standard equipment **motor holding brake** or an external holding brake controlled by the drive controller is **not sufficient to guarantee personal safety**!
- Disconnect electrical power to the components of the electric drive and control system using the master switch and secure them from reconnection ("lock out") for:
  - Maintenance and repair work
  - Cleaning of equipment
  - Long periods of discontinued equipment use
- Prevent the operation of high-frequency, remote control and radio equipment near components of the electric drive and control system and their supply leads. If the use of these devices cannot be avoided, check the machine or installation, at initial commissioning of the electric drive and control system, for possible malfunctions when operating such high-frequency, remote control and radio equipment in its possible positions of normal use. It might possibly be necessary to perform a special electromagnetic compatibility (EMC) test.

3.3.4 Protection against electromagnetic and magnetic fields during operation and mounting

Electromagnetic and magnetic fields!

Health hazard for persons with active implantable medical devices (AIMD) such as pacemakers or passive metallic implants.

- Hazards for the above-mentioned groups of persons by electromagnetic and magnetic fields in the immediate vicinity of drive controllers and the associated current-carrying conductors.

- Entering these areas can pose an increased risk to the above-mentioned groups of persons. They should seek advice from their physician.
- If overcome by possible effects on above-mentioned persons during operation of drive controllers and accessories, remove the exposed persons from the vicinity of conductors and devices.

3.3.5 Protection against contact with hot parts

Hot surfaces of components of the electric drive and control system. Risk of burns!

- Do not touch hot surfaces of, for example, braking resistors, heat sinks, supply units and drive controllers, motors, windings and laminated cores!
- According to the operating conditions, temperatures of the surfaces can be **higher than 60 °C** (140 °F) during or after operation.
- Before touching motors after having switched them off, let them cool down for a sufficient period of time. Cooling down can require **up to 140 minutes**! The time required for cooling down is approximately five times the thermal time constant specified in the technical data.
- After switching chokes, supply units and drive controllers off, wait **15 minutes** to allow them to cool down before touching them.
- Wear safety gloves or do not work at hot surfaces.
- For certain applications, and in accordance with the respective safety regulations, the manufacturer of the machine or installation must take measures to avoid injuries caused by burns in the final application. These measures can be, for example: Warnings at the machine or installation, guards (shieldings or barriers) or safety instructions in the application documentation.

3.3.6 Protection during handling and mounting

Risk of injury by improper handling! Injury by crushing, shearing, cutting, hitting!

- Observe the relevant statutory regulations of accident prevention.
- Use suitable equipment for mounting and transport.
- Avoid jamming and crushing by appropriate measures.
- Always use suitable tools. Use special tools if specified.
- Use lifting equipment and tools in the correct manner.
- Use suitable protective equipment (hard hat, safety goggles, safety shoes, safety gloves, for example).
- Do not stand under hanging loads.
- Immediately clean up any spilled liquids from the floor due to the risk of falling!

3.3.7 Battery safety

Batteries consist of active chemicals in a solid housing. Therefore, improper handling can cause injury or property damage.

Risk of injury by improper handling!

- Do not attempt to reactivate low batteries by heating or other methods (risk of explosion and cauterization).
- Do not attempt to recharge the batteries as this may cause leakage or explosion.
- Do not throw batteries into open flames.
- Do not dismantle batteries.
- When replacing the battery/batteries, do not damage the electrical parts installed in the devices.
- Only use the battery types specified for the product.

☞ Environmental protection and disposal! The batteries contained in the product are considered dangerous goods during land, air, and sea transport (risk of explosion) in the sense of the legal regulations. Dispose of used batteries separately from other waste. Observe the national regulations of your country.

3.3.8 Protection against pressurized systems

According to the information given in the Project Planning Manuals, motors and components cooled with liquids and compressed air can be partially supplied with externally fed, pressurized media, such as compressed air, hydraulics oil, cooling liquids and cooling lubricants. Improper handling of the connected supply systems, supply lines or connections can cause injuries or property damage.

Risk of injury by improper handling of pressurized lines!

- Do not attempt to disconnect, open or cut pressurized lines (risk of explosion).
- Observe the respective manufacturer's operating instructions.
- Before dismounting lines, relieve pressure and empty medium.
- Use suitable protective equipment (safety goggles, safety shoes, safety gloves, for example).
- Immediately clean up any spilled liquids from the floor due to the risk of falling!

☞ Environmental protection and disposal! The agents (e.g., fluids) used to operate the product might not be environmentally friendly. Dispose of agents harmful to the environment separately from other waste. Observe the national regulations of your country.

3.4 Explanation of signal words and the Safety alert symbol

The Safety Instructions in the available application documentation contain specific signal words (DANGER, WARNING, CAUTION or NOTICE) and, where required, a safety alert symbol (in accordance with ANSI Z535.6-2011).

The signal word is meant to draw the reader's attention to the safety instruction and identifies the hazard severity.

The safety alert symbol (a triangle with an exclamation point), which precedes the signal words DANGER, WARNING and CAUTION, is used to alert the reader to personal injury hazards.

⚠ DANGER

In case of non-compliance with this safety instruction, death or serious injury **will** occur.

⚠ WARNING

In case of non-compliance with this safety instruction, death or serious injury **could** occur.

⚠ CAUTION

In case of non-compliance with this safety instruction, minor or moderate injury could occur.

NOTICE

In case of non-compliance with this safety instruction, property damage could occur.

4 System overview

4.1 Introduction

4.1.1 Motivation and objectives

Overview

The operational safety of machines and installations depends largely upon the extent of dangerous movements generated by the machine.

In **normal operation** (also called productive operation or automatic operation), protective equipment prevents individuals from accessing danger zones and keeps parts / materials from being thrown outwards.

In the **special mode** (also called manual mode or setting-up mode), it is often necessary for individuals to access danger zones when the entire installation has not been de-energized. In these situations, machine operators must be protected by internal mechanisms in the drive and the control unit.

The integrated Rexroth safety technology provides the user with the requirements, on the control unit and drive side, for implementing functions of personal and machine protection with a minimum of planning and installation work. Compared to conventional safety technology, the integrated safety technology considerably increases the functionality and availability of machines. Integrated safety technology is characterized by the following features:

- Complies with valid standards
- More system performance
- Less system costs
- Easy understanding of complex subjects
- Improved diagnostics
- Simplified certification
- Easy commissioning
- Independent of control units

Comparison with conventional safety technology

A drive and control system with integrated safety technology differs from systems with conventional safety technology by the fact that the safety functions are directly integrated in the intelligent drives in the form hardware and software. This increases the functionality in all operation modes with a maximum of safety (short reaction times).

The power contactor between controller and motor required for the conventional safety technology is not included in drive and control systems with the integrated safety technology "Safe Torque Off".

The integrated safety technology is **not** intended to replace conventional safety technology, such as EMERGENCY STOP monitoring devices and safety door monitors.

Using the integrated safety technology increases the available personnel and machine safety, because the total reaction time of the system in the case of an error event, for example, is considerably reduced with regard to comparable systems with conventional safety technology. The safety signals are transmitted with conventional wiring.

4.1.2 Conceptual overview

A ctrlX DRIVE system consists of the components power section, control section (including the firmware), motor and the possibly required additional components.

The integrated safety technology is implemented based on the interaction of the hardware and firmware components.

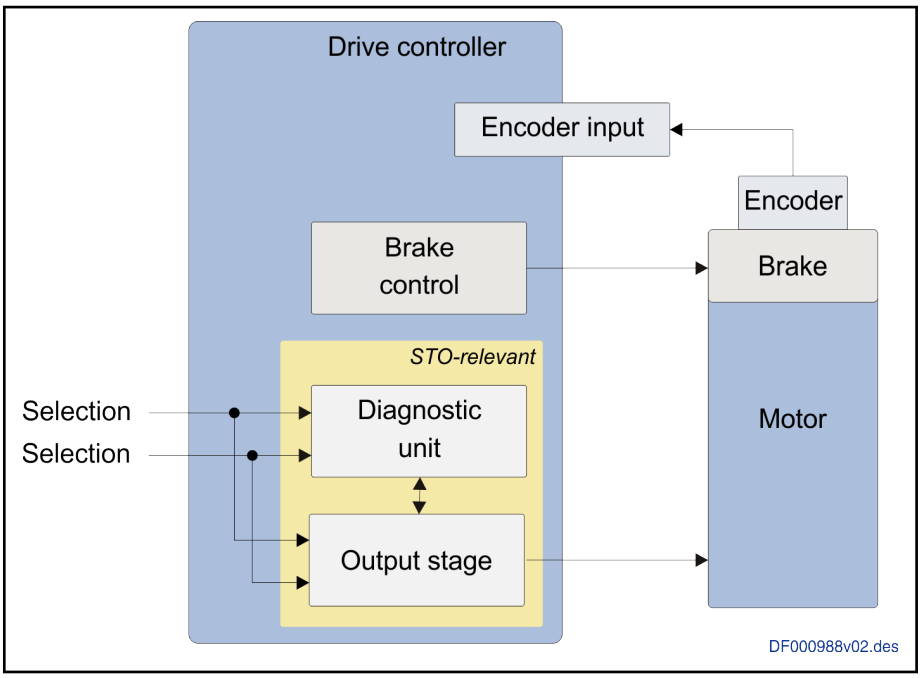


Fig. 4-1: Schematic diagram of ctrlX DRIVE with integrated safety technology "STO (Safe Torque Off)"

☞ The safety function "Safe Torque Off" does not require any measuring system.

4.1.3 Risk assessment

Before a machine can be placed on the market, the manufacturer of the machine must carry out a risk assessment in accordance with the Machinery Directive 2006/42/EC in order to determine the hazards associated with the use of the machine.

The risk assessment is a multilevel, iterative process. The procedure is described in detail in "EN ISO 12100" - "General principles for design - Risk assessment and risk reduction". This documentation can only give a very short overview on the subject of risk assessment. Users of integrated safety technology are obliged to intensively study the respective standards and legal status.

The risk assessment carried out provides the requirements for determining the category for safety-related control units according to the valid C-standard the safety-relevant parts of the machine control have to comply with.

☞ For more detailed information on the required Safety Integrity Levels (SIL) and Performance Levels (PL), please refer to the applied component- and machine-relevant standards in "Safety-relevant standards and regulations".

Procedure

To obtain the highest possible degree of safety, the machine manufacturer when choosing the solutions has to apply the following basic principles in the indicated order:

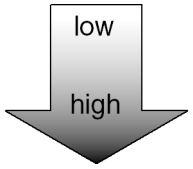
1. Eliminate or minimize the hazards by design measures.
2. Take the required protective measures against hazards that cannot be eliminated.
3. Document the remaining risks and inform the user of these risks.

Simplification by using the integrated safety technology

When using integrated safety technology, the machine manufacturer will benefit from the following simplifications:

- The safety-related device components of the **ctrlX DRIVE** product line with the **"T0"** option are suited for **applications up to SIL3 of IEC 62061 or up to Category 4, PL e of ISO 13849-1**. This means that the optional safety technology modules of the ctrlX DRIVE range allow safety functions to be implemented that comply with SIL1, SIL2 or SIL3 of IEC 62061 or PL a, PL b, PL c, PL d or PL e of ISO 13849-1.
- The safety technology functions integrated in ctrlX DRIVE were certified by TÜV Rheinland®. This guarantees the user that the solution complies with the state-of-the-art / the conformity of the components in accordance with the Machinery Directive 2006/42/EG is ensured.

Safety Integrity Level (SIL): relation between the SILs of IEC 62061 and the Performance Level (PL) of EN ISO 13849-1

Performance Level (PL)	Average probability of dangerous failure [1/h] (PFH)	Safety Integrity Level (SIL)	Risk
a	$\geq 10^{-5}...<10^{-4}$	-	
b	$\geq 3*10^{-6}...<10^{-5}$	1	
c	$\geq 10^{-6}...<3*10^{-6}$	1	
d	$\geq 10^{-7}...<10^{-6}$	2	
e	$\geq 10^{-8}...<10^{-7}$	3	

Tab. 4-1: Safety Integrity Level: failure limit values for a safety function of a PDS(SR)

4.2 Product presentation

4.2.1 What is "integrated safety technology"?

ctrlX DRIVE

The drive controllers of the ctrlX DRIVE product line can be equipped with the optional module "T0" [STO (Safe Torque Off)].

The optional module "T0" equips ctrlX DRIVE with integrated safety technology that provides the user with Safe Torque Off.

Definition

"Safe Torque Off" is an application-related safety function that safely interrupts the energy transmission from the controller to the motor (according to IEC 61800-5-2).

"Safe Torque Off" is applicable for personal protection at machines according to ISO 13849-1 Category 4, PL e and IEC 62061 SIL 3.

Selecting the function

The safety functions are selected via 24 V inputs at the drive controller.

Certification

The safety technology was certified by TÜV Rheinland ®. The NRTL listing by TÜV Rheinland of North America is available for HCS01. The other series are in preparation.

Certificates are available on "Certipedia", the certificates database of TÜV Rheinland ®.

Requirements that can be realized

The integrated safety technology is independent of the type of master communication, the higher-level control unit and the supply modules. It is available as a functionally safe characteristic of the standard drive system. The following requirements can be implemented in the machine or in the installation:

- Measures in accordance with ISO 12100-2, if accessing the danger zone is required, for example, for equipping, teaching or material withdrawal.
- Requirements for safety-related parts of control systems according to ISO 13849-1 Category 4, PL e and IEC 62061 SIL 3, as required in EN 1010-1 printing and paper converting machines), EN 12415 (turning machines) and EN 12417 (machining centres).
- Control functions in the case of an error according to IEC 60204-1 ("homogeneous redundancy").

4.2.2 Integrated safety technology in ctrlX DRIVE

Characteristics of ctrlX DRIVE

The type code shows the different characteristics of ctrlX DRIVE. The positions 20 and 21 of the type code show whether your device has been equipped with the optional module "T0".

Short type designation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Example:	X	C	S	1	-	W	0	0	5	4	A	B	N	-	0	1	N	E	T	T	0	E	C	N	N	-	S	0	1	R	S	N	2	N	N	N	2	D	N	N
	①					②	③				④	⑤	⑥		⑦		⑧	⑨		⑩		⑪		⑫			⑬	⑭		⑮		⑯	⑰	⑱				⑲	⑳	Ⓐ	
⑩	**Option 1 (safety technology):** T0 = STO																																							

Tab. 4-2: Excerpt from the type code for ctrlX DRIVE controllers

The integrated safety technology "Safe Torque Off" (T0) can be used with the firmware version FWA-XD1-AXS-V-**01**xxx-xx and above.

4.3 Safety-relevant standards and regulations

4.3.1 General information

Standard documents and sheets are subject to copyright protection and Bosch Rexroth cannot pass them on. If required, contact the authorized sales agencies; in Germany directly contact Beuth Verlag GmbH (http://www.beuth.de).

Below the user will find a short overview of the relevant standards for the use of safety-related control units. The overview does not claim completeness. Besides, only the safety-relevant standards and regulations for functional safety are taken into consideration.

4.3.2 Standards relevant to components

Product group	Standard	Title
Electric drives	IEC 61800-5-2	Adjustable speed electrical power drive systems, Part 5-2: Safety requirements - Functional
Complex controls	IEC 61508-1 to IEC 61508-7	Functional safety of electrical/electronic/programmable electronic safety-related systems

Tab. 4-3: Standards relevant to components

4.3.3 Standards relevant to machinery

Standard	Title
ISO 12100	Safety of machinery - General principles for design - Risk assessment and risk reduction
IEC 60204-1	Safety of machinery - Electrical equipment of machines
IEC 62061	Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems
ISO 13849-1 ISO 13849-2	Safety of machinery - Safety-related parts of control systems Part 1: General principles for design Part 2: Validation
ISO 13850	Safety of machinery - Emergency stop - Principles for design
EN 1037	Safety of machinery - Prevention of unexpected start-up
ISO 13855	Safety of machinery - The positioning of protective equipment in respect of approach speed of parts of the human body
ISO 14119	Safety of machinery - Interlocking devices associated with guards - Principles for design and selection
ISO 11161	Safety of machinery - Integrated manufacturing systems - Basic requirements
ISO 10218-1 ISO 10218-2	Robots for industrial environments - Safety requirements Part 1: Robots Part 2: Robot systems and integration
EN 1010-1	Safety of machinery - Safety requirements for the design and construction of printing and paper converting machines, Part 1: Common requirements
EN 848-3	Safety of woodworking machines - One side moulding machines with rotating tools, Part 3: Numerically controlled (NC) boring and routing machines
EN 415-1 to EN 415-8	Safety of packaging machines Part 1 to Part 8
EN 201	Plastics and rubber machines - Injection moulding machines - Safety requirements
EN 12415	Safety of machine tools - Small numerically controlled turning machines and turning centres
EN 12417	Machine tools - Safety - Machining centres
EN 13218	Machine tools - Safety - Stationary grinding machines

Tab. 4-4: Standards relevant to machinery

4.3.4 EC/EU directives

Description	Title
Directive 2006/42/EC	Machinery Directive
Directive 2014/35/EU	Low-Voltage Directive
Directive 2014/30/EU	EMC Directive

Tab. 4-5: EC/EU directives

4.4 Overview of functions and characteristics

4.4.1 Characteristics of integrated safety technology

Introduction

This documentation describes the "Safe Torque Off" characteristics of the integrated safety technology [pure hardware solution (optional safety technology module "T0")].

Drive system with optional safety technology module "Safe Torque Off"

With the optional safety technology module "Safe Torque Off" ("T0"), the energy supply to the motor can be safely interrupted. The drive in this case cannot generate any torque/force and, as a consequence, it cannot generate any dangerous movements, either (Safe **Torque** Off function).

The optional safety technology module "Safe Torque Off" features two 24 V inputs for dual-channel selection and two outputs for dynamization.

4.4.2 Performance

Time response and reaction times

The reaction times of integrated safety technology of the optional safety technology module "T0" are as follows:

	Selection of the STO safety functions, i.e. transition from normal operation ("bb/Ab")	Deselection of the STO safety functions, i.e. transition to normal operation ("bb/Ab")
ctrlX DRIVE with T0 option	up to 18 ms (preliminary)	up to 18 ms (preliminary)

Tab. 4-6: Reaction times of integrated safety technology

☞ The above-mentioned reaction times only apply to the safety functions. To determine the total reaction time of the system, take the following aspects, among other things, into account:

- When **selecting** the safety functions
  - Time until at least a single-channel selection greater than 1 ms exists
- When **deselecting** the safety functions
  - Time until an error-free dual-channel deselection exists
  - Reaction time of the drive system to drive enable having been set (putting motor under current, releasing the brake)

4.5 Safety characteristics of the safety system

4.5.1 Introduction

For using the optional safety technology module "T0", the ctrlX DRIVE system has been certified according to IEC 61508, IEC 61800-5-2, IEC 62061 and ISO 13849-1.

The risk assessment and risk reduction of a machine require the safety functions of the individual components to be assessed. The interaction of the components has to be taken into account, too. In addition to the systematic suitability, it is also necessary to determine the total PFH value for the machine or the machine part (e.g., a safety zone). The total PFH value allows assessing whether the required "Safety Integrity Levels" (SIL_r) or "Performance Levels" (PL_r) have been complied with. For the optional safety technology module "T0", the paragraph below shows how to determine the PFH value for a drive system and how to integrate additional external components.

The manufacturer-independent software wizard "SISTEMA" is suited for calculating the total PFH value.

You can procure SISTEMA libraries from our website.

For more information, please see the website of "Institut für Arbeitsschutz der DGUV (IFA)" [Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)]. There you can download the SISTEMA software free of charge.

Your advantages:

- Quickly calculating the Performance Level
- Easily and quickly accessing safety characteristics
- Safety characteristics for certified components

4.5.2 Optional safety technology module "T0"

Drives equipped with the optional safety technology module "T0" comply with the following "Safety Integrity Level" (SIL) or "Performance Level" (PL):

- Up to SIL3 according to IEC 62061
- Up to Category 4, PL e according to ISO 13849-1

The ctrlX DRIVE system with the optional safety technology module "T0" has the following safety characteristics:

Description	ctrlX DRIVE
PFH[1)]	<2×10^{-9} 1/h (2% SIL3) (preliminary)
Mission Time	175,200 h (20 years)
"Proof Test" interval	175,200 h (20 years)
$MTTF_{d/channel}$[1)]	> 200 years (preliminary)
DC_{avg}	> 99 % (preliminary)

1) The specified safety characteristics refer to an average ambient temperature of 40 °C (see also "Ambient and operating conditions" in the Project Planning Manuals).

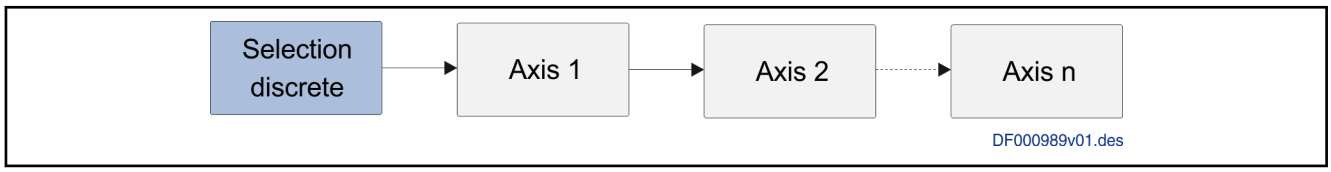
Tab. 4-7: Safety characteristics of the ctrlX DRIVE system with the optional safety technology module "T0"

"Mission Time" and "Proof Test" interval

- The "Mission Time" of all components used has to be observed and complied with. After the "Mission Time" of a component has elapsed, the component has to be discarded or replaced. It is not allowed to continue operating the component!
- After the component was discarded ("Mission Time" has elapsed), it has to be ensured that the component cannot be reused (e.g., by disabling it).
- The "Proof Test" has not been specified for the ctrlX DRIVE system. Therefore, the "Mission Time" cannot be reset by a "Proof Test".

4.5.3 Calculating the total PFH value of a safety zone

To determine the required total PFH value of an installation or a safety zone, the PFH values of the individual axes and of the required external components have to be used for calculation as follows. The exemplary figure below illustrates all the components relevant to the calculation:



1) External component

Fig. 4-2: Determining the PFH for a safety zone

To calculate the PFH value of a safety zone, a valid PFH value has to be available for all components which have an influence on the safety function (if necessary, procure the PFH value from the component manufacturer).

$PFH_{safety\ zone}=PFH_{selection\_discrete}{}^{1)}+PFH_{axis\_1}+PFH_{axis\_2}+...+PFH_{axis\_n}$

1) External component

The following conditions/restrictions apply to the general use of the formula for PFH calculation for a safety zone:

Variable	Value	Description
$PFH_{selection\_discrete}$	See manufacturer's specification	Enter the sum of the individual PFH values of the switches or safety devices involved in the selection.
PFH_{axis_x}	See "tab. 4-7 "Safety characteristics of the ctrlX DRIVE system with the optional safety technology module T0" on page 21"	This value is **independent** of the safety level to be attained.

Tab. 4-8: Variable description to calculate PFH for a safety zone

5 Functional principle of integrated safety technology

5.1 Basic functions

5.1.1 Overview

In the case of a standard drive, the axis / spindle / roll is moved according to the command values of the control unit. In this case, incorrect drive motion can be caused by operating errors, incorrect installation in the machine, defects in parts or materials, failures in the system, etc. Incorrect drive motion can endanger individuals staying in the danger zone of the drive motion, even if the errors only occur for a short time and occasionally.

It is therefore necessary to take measures that limit the effects of errors on the drive motion to a minimum. The remaining risk of danger to persons is then considerably reduced.

During operation, the safety functions are monitored by the drive system. For this purpose, measures for detecting static error states were implemented in the system:

- Dual-channel structure
- Comparison of the states of both channels
- Dynamization of static states

These measures ensure that a single error cannot cause the safety functions to be lost.

The installation or machine manufacturer has to determine in how far this is sufficient for an existing installation or machine by a risk assessment according to annex I of the Directive 2006/42/EC.

The schematic diagram of a ctrlX DRIVE device below illustrates the basic functions and functional principles explained in this section:

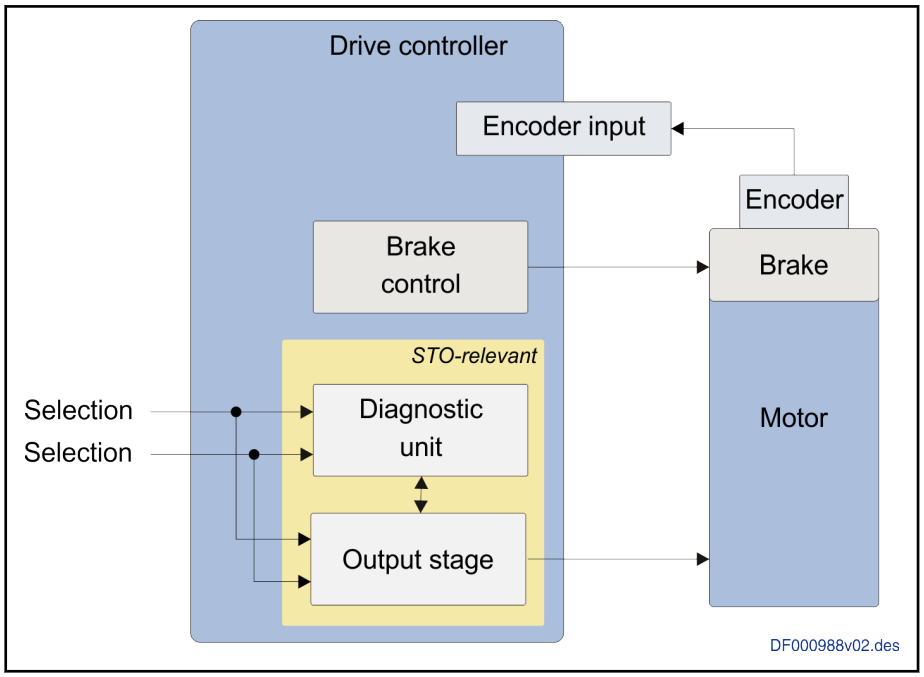


Fig. 5-1: Schematic diagram of ctrlX DRIVE with integrated safety technology

5.1.2 Dynamization

Brief description

Dynamization is to detect static error states in the safety-relevant circuits.

In the case of selection via an active or passive safety unit, dynamization takes place automatically in the background without having an effect on the safety function or the standard drive functions.

It is not necessary to configure the dynamization at the drive.

Functional principle of dynamization

A safety function is selected via an N/C-N/C combination, i.e. a "0" signal at both inputs is evaluated when the safety functions are selected. Therefore, the dynamization of the external selection channels can only take place in the deselected state (normal operation).

Dynamization in the case of selection via an active safety unit

An active safety unit is a safety switching device which selects the safe function via OSSD outputs. The active safety unit tests its outputs on its own.

The "OSSD" (Output Signal Switching Device) is that part of a safe selection unit which has been connected to the machine control and which goes to the OFF state, if the safe selection unit triggers during the intended operation.

When the safety functions are selected via an active safety unit, the dynamization pulses of the OSSD outputs of the active safety unit are evaluated and monitored. Therefore, other dynamization signals are not required.

The active safety unit must detect the following errors via its OSSD outputs:

- Short circuit of one or both selection signals with 24 V
- Short circuit between both selection signals

In order that all other relevant errors can be detected by the optional safety technology module "T0", the dynamization pulses of the OSSD outputs must comply with the following limit values:

Description	Value	Explanation
t_{PLmax}	3 ms	Maximum low time of the test pulse
t_{PLmin}	100 µs	Minimum low time of the test pulse
t_{Pmax}	1 h	Maximum periodic time of the test pulses
t_{Pmin}	1 ms	Minimum periodic time of the test pulses
t_{Vmax}	1 s	Maximum delay of the selection signals for selection or deselection
$t_{Dmin} = t_{PH} / t_P$	90 %	Minimum sampling ratio of the selection signals
t_{bounce}	400 ms	Maximum bounce time for a selection or deselection
φ	-	Phase shift of the test pulses on both channels: no requirement

Tab. 5-1: Limit values of the dynamization pulses of the OSSD outputs

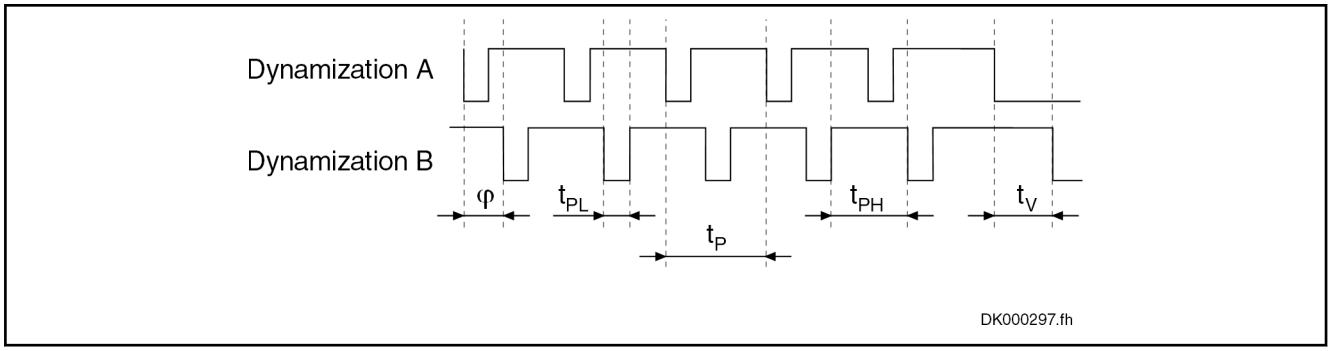


Fig. 5-2: Example of dynamized selection signals

The figure below illustrates, in schematic form, the interconnection of an active safety unit and multiple drives with a "T option":

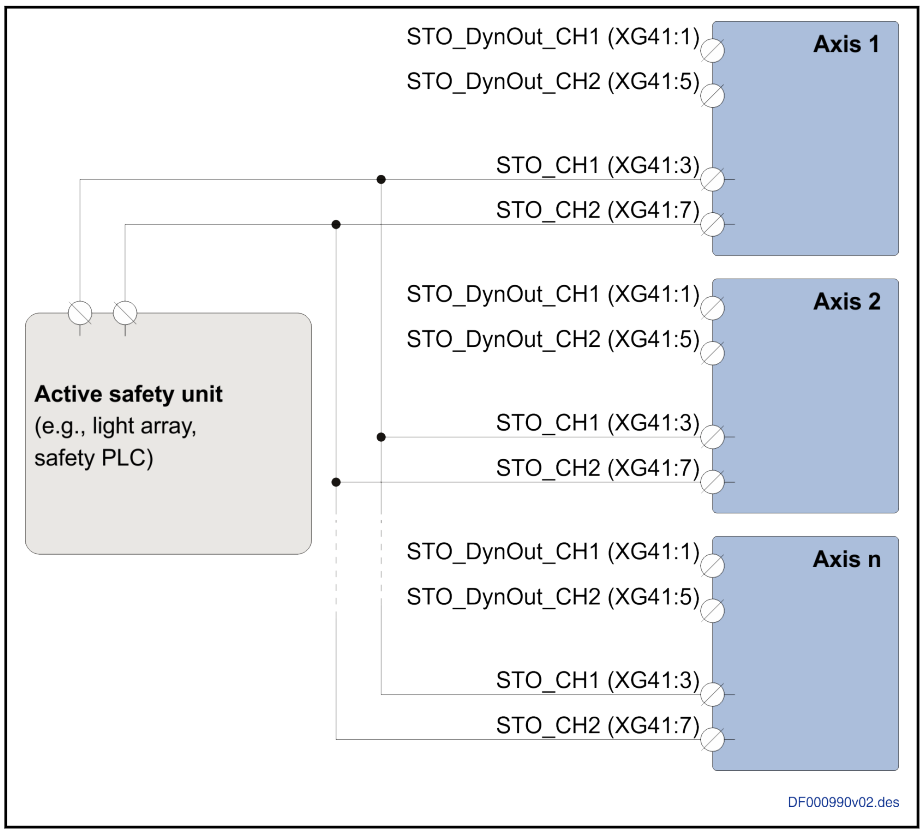


Fig. 5-3: Dynamization in the case of selection via an active safety unit

When choosing the safety unit, the maximum current consumption of the selection inputs of all drives of a safety zone has to be taken into account.

Dynamization in the case of selection via passive safety units

A passive safety unit is a safety switching device with which the safe function is selected via isolated contacts.

When the safety functions of the "T options" are selected via a passive safety unit, the drive checks the wiring of the selection.

When the safety functions are selected via a passive safety unit, the drive generates the dynamization pulses and makes them available via the "STO_DynOut_CH1" and "STO_DynOut_CH2" outputs at the XG41

connector. These two outputs allow the isolated selection contacts of the passive safety unit to be supplied.

The figure below illustrates, in schematic form, the interconnection of a passive safety unit and multiple drives with a "T option":

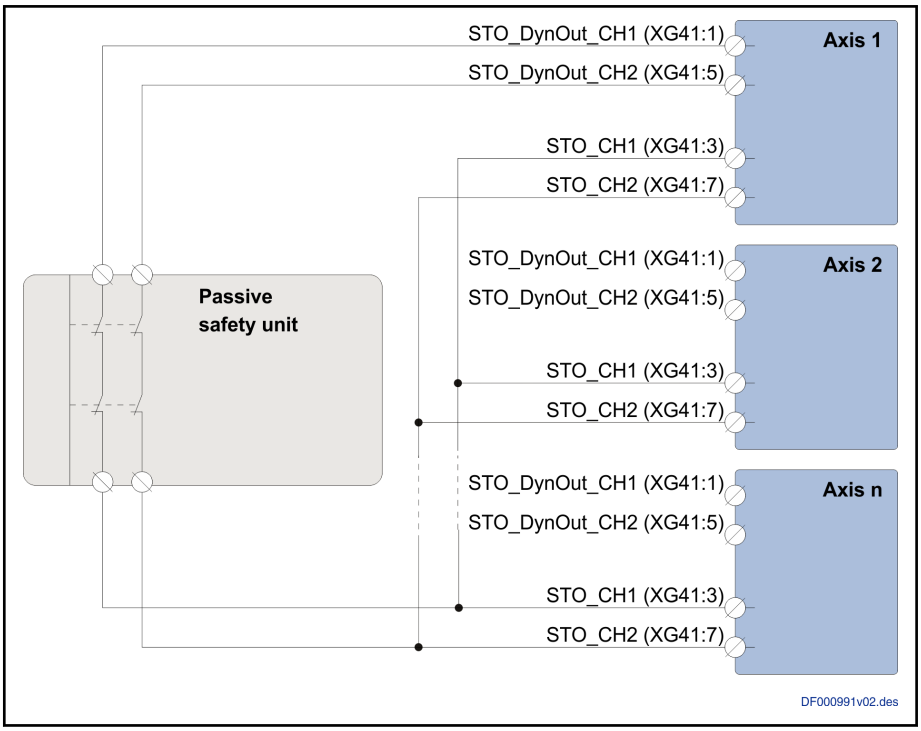


Fig. 5-4: Dynamization in the case of selection via a passive safety unit

☞ A safety zone cannot contain more than 25 drives with an optional safety technology module "T0". If more than 25 drives are to be operated at a safety unit, multiple safety zones have to be set up.

6 Integrated safety function

6.1 Overview of the safety function

6.1.1 General information

The application-related safety function "Safe Torque Off" described below has been implemented for personal protection in accordance with ISO 13849-1, Category 4, PL e and IEC 62061, SIL3.

☞ Before a safety function is selected, the drive system has to be put into the appropriate state by command value input.

6.2 Safety function in special mode "Safe standstill"

6.2.1 Safe Torque Off (STO)

Brief description

☞ Using the "Safe Torque Off" function requires the optional safety technology module "T0".

The energy supply to the motor is safely interrupted with the safety function "Safe Torque Off". The drive cannot generate any torque/force and, as a consequence, it cannot generate any dangerous motions, either.

☞ Before selecting the safety function "Safe Torque Off", the drive system has to be decelerated via the command value input; there is no drive-controlled deceleration!

⚠ WARNING **Lethal injury and/or property damage caused by unintended axis motion!**

⇒ If external force influences are to be expected with the safety function "Safe torque off", e.g. in the case of a vertical axis, this motion has to be safely prevented by additional measures, e.g. a mechanical brake or a counterweight. For such axes, Bosch Rexroth recommends using the Safe braking and holding system.

⚠ WARNING **High electrical voltage! Danger to life, risk of injury by electric shock or serious injury!**

During the time a safety function is active, power is not removed from the motor; de-energize the drive before working on the motor.

Features

The safety function "Safe Torque Off" (STO) has the following features:

- Corresponds to stop category 0 according to IEC 60204-1
- Is suited for safety-relevant applications up to SIL 3 according to IEC 62061.
- Is suited for safety-relevant applications up to Category 4, PL e according to ISO 13849-1.
- The energy supply to the motor is safely interrupted via two channels.

- The selection takes place via two channels, alternatively via
  - a passive safety unit with dual-channel, isolated conventional (non-solid-state) normally closed contacts (e.g., safety switching device for emergency stop, safety door monitor, etc.) or
  - an active safety unit with plus-switching OSSD outputs (e.g., safety controls, laser scanners, etc.).
- The dynamization of the safety function selection takes place alternatively via
  - the OSSD dynamization of the active safety unit or
  - the "O_2" and "O_3" outputs at the XG31 terminal configured as dynamization outputs, in the case of control via passive safety units.
- It is possible to set up a zone by connecting up to 25 drives in parallel.
- Online dynamization of the outputs and interrupting circuits
- Short reaction time (see "Time response and reaction times")
- The state of safety function "Safe Torque Off" is displayed via a parameter (P-0-0106).
- With the safety function "Safe Torque Off" activated, the diagnostic LED at the drive outputs the flashing pattern "blue - yellow- yellow", and the optional display of the control panel shows "STO".

Safety function

The optional safety technology module "T0" features two 24 V inputs for dual-channel selection. For operation at passive safety units, two dynamization outputs are available at the standard outputs of the drive.

For pin assignments and technical data, please refer to the chapter "Project planning".

The safety function "Safe Torque Off" includes the following topics that are described in detail below:

- Dynamization
- Requirements on the command value input
- Selecting the safety function "Safe Torque Off"

Dynamization

Dynamization is to detect static error states in the wiring and in the safety-relevant circuits. Dynamization takes place automatically in the background without having an effect on the safety function or the standard drive functions.

A safety function is selected via an N/C-N/C combination, i.e. a "0"-signal at both inputs is evaluated as the selection of the safety function. Therefore, the dynamization of the external selection channels can only take place in the deselected state (normal operation). The dynamization of the safety function selection is also used for internal dynamization.

For the dynamization of the safety function selection, we distinguish whether the safety function is selected via an active or a passive safety unit. The dynamization function is explained in the chapter on "Dynamization".

The dynamization pulses are monitored for the following aspects:

- Time interval
- Pulse width
- Sampling ratio

The "T option" monitors whether the dynamization of the selection signals is carried out in the deselected state. Monitoring takes place so that dynamization is carried out at the latest after 1 hour in the deselected state (normal operation). For this purpose, the time in the deselected state is added in the drive and only reset by dynamization. That is to say an interim selection does not cause monitoring to be reset. Monitoring takes place independently for both selection channels. If the time interval of dynamization is exceeded, an error message is generated (F3134).

☞ To increase the noise immunity, the safety technology tolerates the failure of a dynamization pulse, if the following 8 dynamization pulses occur within the time window described above.

Dynamization pulses of a duration of 100 µs and more are recognized as valid dynamization pulses.

The sampling ratio of the dynamization pulse is also monitored by the safety technology. The dynamization pause has to be at least 90% of a dynamization period. If the dynamization pause is shorter, an error message is generated (F8300).

Requirements on the command value input

☞ Before selecting the safety function "Safe Torque Off", the drive system has to be decelerated via the command value input; there is no drive-controlled deceleration!

☞ The safety function "Safe Torque Off" complies with stop category 0 according to EN 60204-1.

If the safety function "Safe Torque Off" is selected with drive enable having been set, the safety function is executed while a diagnostic message is generated at the same time, because the drive first has to be decelerated before the safety function is allowed to be activated.

Via the configuration of "Safe Torque Off" (P-0-0101) select how the drive is to react if the safety function "Safe Torque Off" is selected with drive enable having been set - with a fatal error or a fatal warning (F8027 or E8027).

The warning is automatically cleared when drive enable is removed, the error has to be cleared by the user.

Diagnostic messages are logged in the diagnostic trace for main diagnostics (S-0-1303.0.10).

⚠ DANGER **Lethal injury and/or property damage caused by coasting axes!**

⇒ If the safety function "Safe Torque Off" is selected with drive enable having been set, the drive torque, independent of the diagnostic message which was set, is immediately disabled and the drive coasts to stop. The deceleration process is relatively slow and, above all, not safe!

Selecting the safety function "Safe Torque Off"

The safety function "Safe Torque Off" always has to be selected via two channels.

The selection of the safety function is detected when a "0"-signal is detected on both selection inputs. The selection can alternatively be made via active or passive safety units.

See also "Examples of application"

The safety technology checks the selection signals for validity. In the case of dual-channel wiring and single-channel selection, the second channel also has to be selected before deselection. Otherwise, an error message is generated (F8301).

☞ The tolerance time for different selection between the two selection channels is 1 s. The parameter setting of the tolerance time cannot be changed.

For diagnostic purposes, the state of the safety function "Safe Torque Off" may be read via a parameter (P-0-0106).

Notes on commissioning

For examples of interconnection, please refer to "Examples of application"

Notes on project planning

When configuring the safety function "Safe Torque Off", it is absolutely necessary to observe the following safety instructions:

⚠ DANGER **Lethal injury and/or property damage caused by unintended axis motion!**

⇒ If external force influences are to be expected with the safety function "Safe Torque Off", e.g. in the case of a vertical axis, this motion has to be safely prevented by additional measures, e.g. a mechanical brake or a counterweight. For such axes, Bosch Rexroth recommends using the Safe braking and holding system.

⚠ WARNING **Injury and/or property damage caused by deviation from standstill position!**

⇒ Even if power section control has been safely locked, momentary axis motion, depending on the number of poles of the motor, can be triggered, when two errors are occurring simultaneously in the power section with the voltage DC bus being active:

- breakdown of a power semiconductor **and**
- breakdown of another semiconductor

In this case, two of six semiconductors are affected in such a way that the motor shaft is aligning.

Synchronous motor, for example: In the case of a synchronous motor with 6 pole pairs, the motion can be a maximum of 30 degrees. For a directly driven ball screw, e.g. 20 mm per revolution, this corresponds to a one-time maximum linear motion of 1.67 mm.

When an asynchronous motor is used, the short circuits in two separate circuits of the power section have almost no effect, because the exciter field breaks down when the inverter is shut down and has completely died down after approx. 1 s.

7 Examples of application

7.1 Examples of application for ctrlX DRIVE

The diagrams of the passive safety units show the safety function in its deselected state. The switches in the passive safety units are for exemplary purposes only. The decisive factor is that the passive safety unit complies with the safety level the application requires.

7.1.1 STO function in the case of selection via passive safety units

Dual-channel wiring

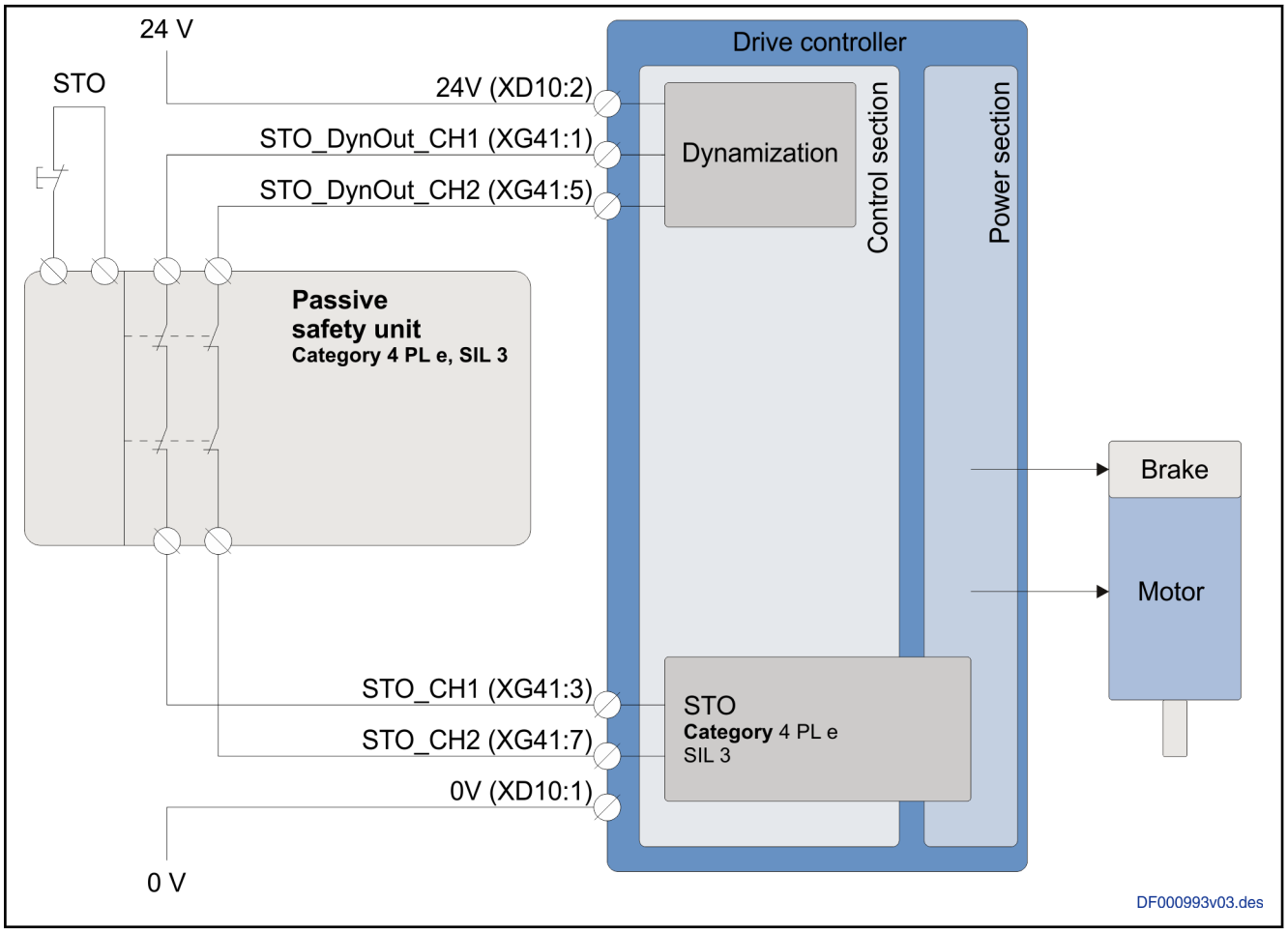


*Fig. 7-1: STO function with **dual-channel** wiring for single-axis devices and **passive** safety unit*

The assignment of the dynamization signals can be selected as desired.

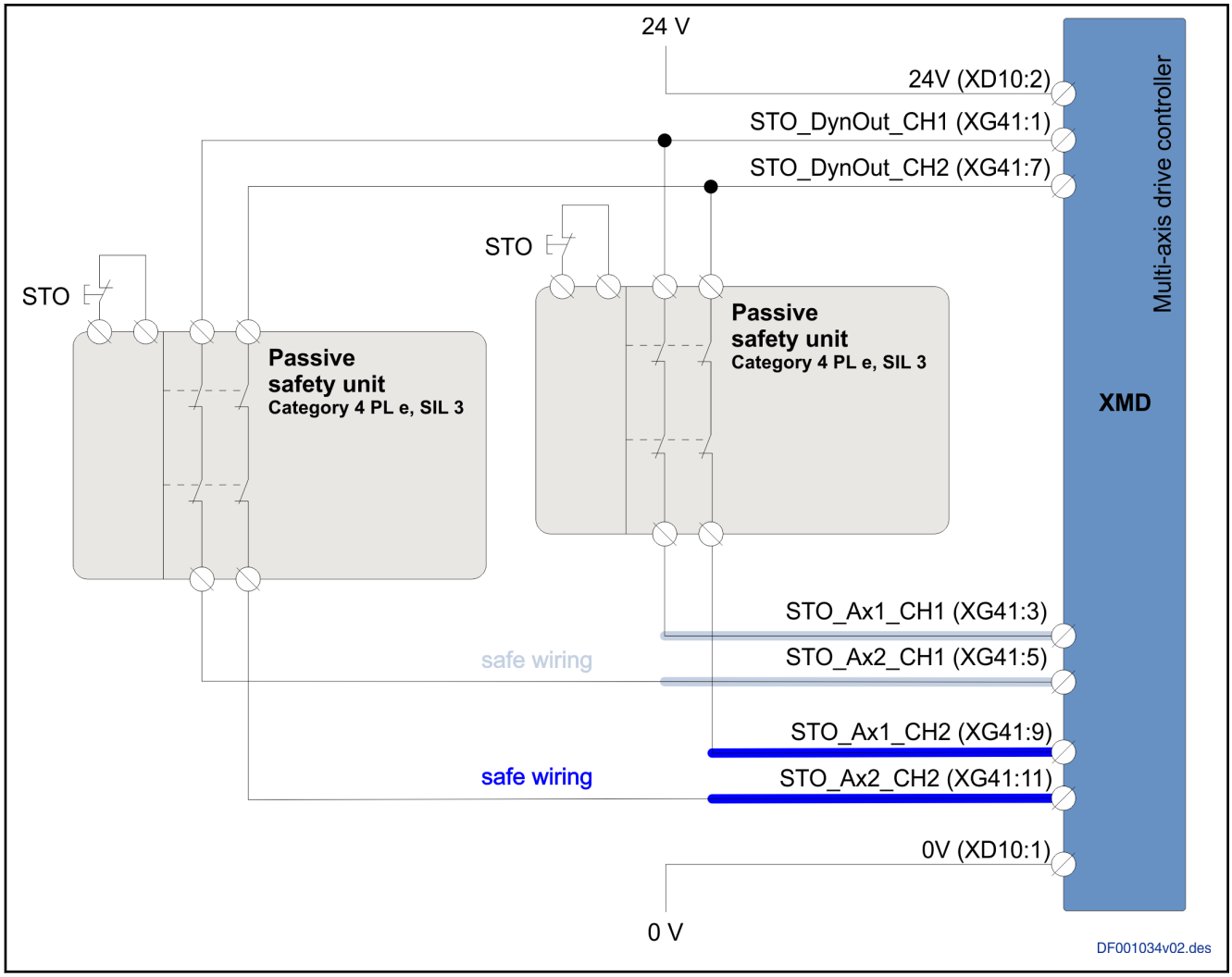


*Fig. 7-2: STO function in the case of **dual-channel** wiring for multi-axis devices (e.g., "XMD") and **passive** safety units*

In the case of **dual-channel** wiring for multi-axis devices (e.g., "XMD") and **passive** safety units, the wiring (as illustrated above) has to be implemented as a "safe wiring". This is necessary to exclude short circuit between lines supplied by the same dynamization output.

Single-channel wiring

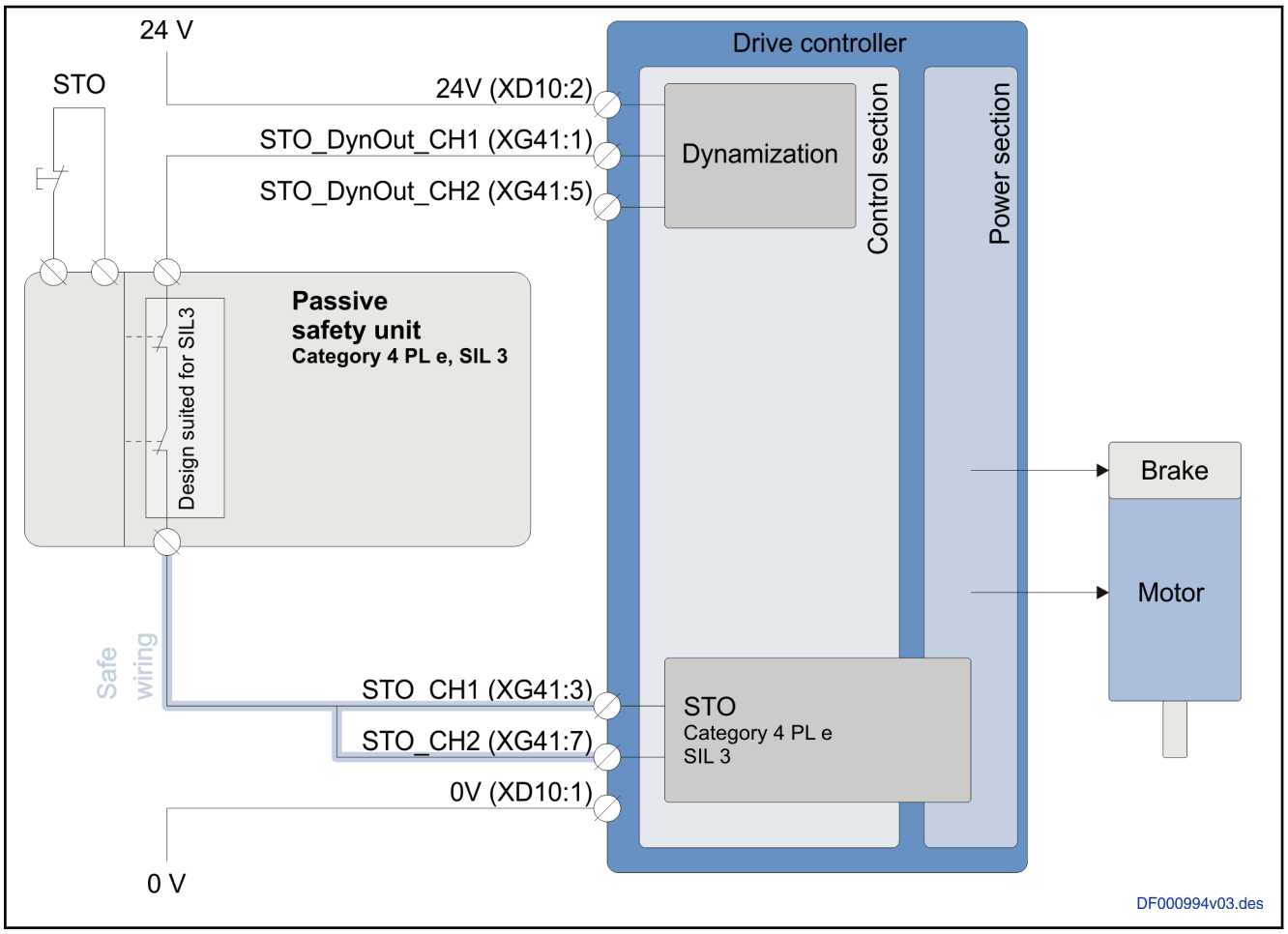


*Fig. 7-3: STO function with **single-channel** wiring and **passive** safety unit*

If the wiring (as illustrated above) between the passive safety unit and connector XG41 of the "T0 option" is to be a single-channel wiring, the wiring has to be implemented as a "safe wiring". For this purpose, the following fault exclusions have to be made:

- Short circuits with other potentials
- Short circuit with 24 V
- Short circuit with ground

 See also EN ISO 13849-2:2012, table D.4

In the case of single-channel wiring between the passive safety unit and connector XG41 of the "T0 option", the internal structure of the passive safety unit, too, has to meet the requirements of the "safe wiring".

 Application engineers are free to choose any dynamization signal.

7.1.2 STO function in the case of selection via active safety units

Dual-channel wiring

Plus-plus-switching safety unit

When the safety function is selected via a plus-plus-switching safety unit, the following errors have to be detected by the OSSD outputs:

- Short circuit of the selection signals with 24 V
- Short circuit between the two selection signals

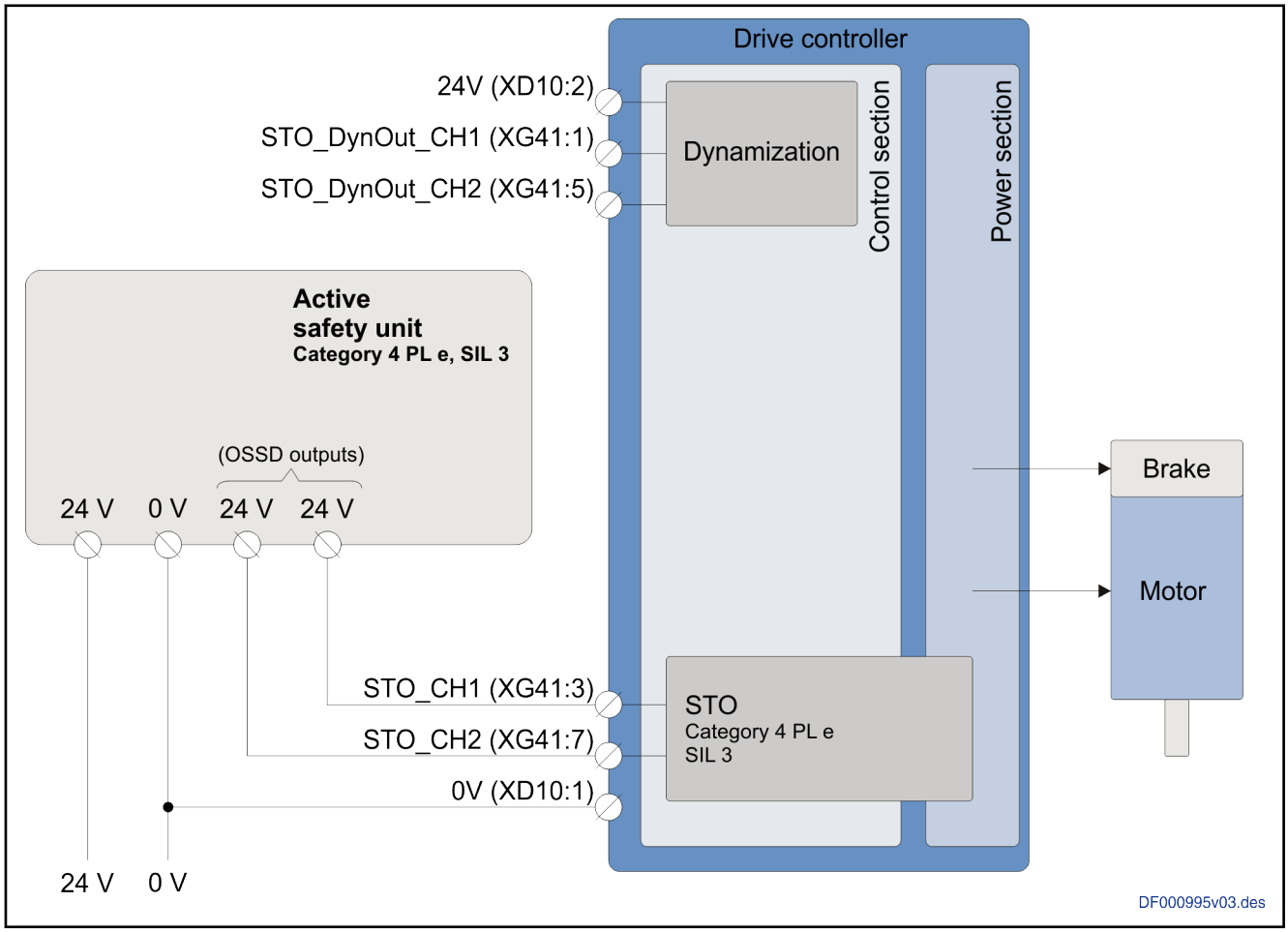


*Fig. 7-4: STO function with **active** safety unit (**plus-plus-switching** outputs)*

Single-channel wiring

When the safety function is selected via a safety unit, the short circuit with 24 V has to be detected by the OSSD output.

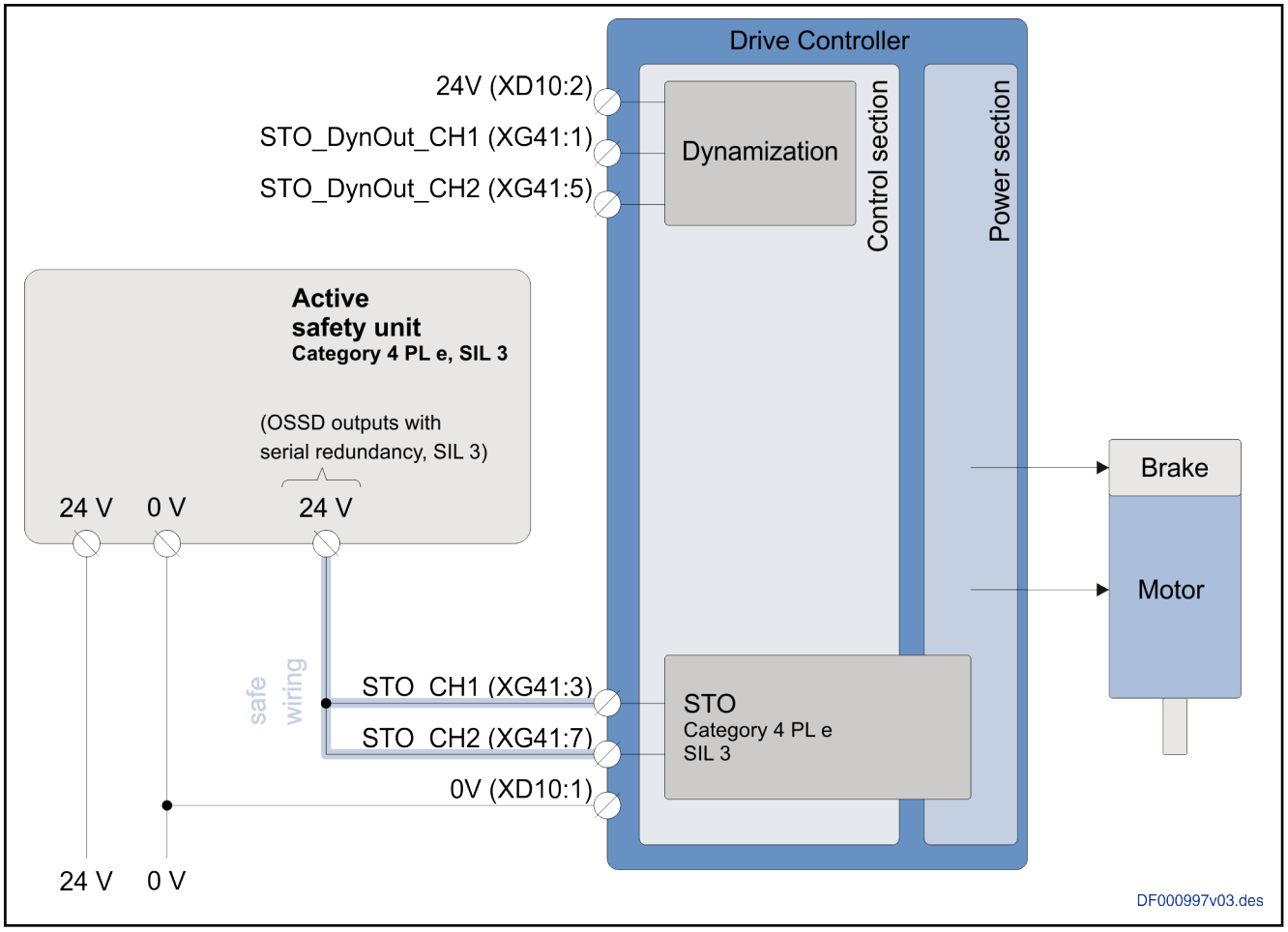


*Fig. 7-5: STO function with **single-channel wiring** and **active** safety unit*

If the wiring (as illustrated above) between the active safety unit and connector XG41 of the "T0 option" is to be a single-channel wiring, the wiring has to be implemented as a "safe wiring". For this purpose, the following fault exclusions have to be made:

- Short circuits with other potentials
- Short circuit with 24 V
- Short circuit with ground

☞ See also EN ISO 13849-2:2012, table D.4

In the case of single-channel wiring between the active safety unit and connector XG41 of the "T0 option", the OSSD output has to be designed with "serial redundancy" according to SIL3.

7.1.3 "Safe stop 1 (Emergency stop)" function with "T0" option

Using the E-Stop function of the drive (or the NC stop of the control unit), the STO function can be extended to obtain the "Safe stop 1 (Emergency stop)" function. For this purpose, the selecting safety unit (active or passive) first has to decelerate the drive via the E-Stop function (or the NC stop of the control unit) and select the STO function after a fixed time that has been set is over. The selection always has to take place after the time that has been set, independent of the axis state.

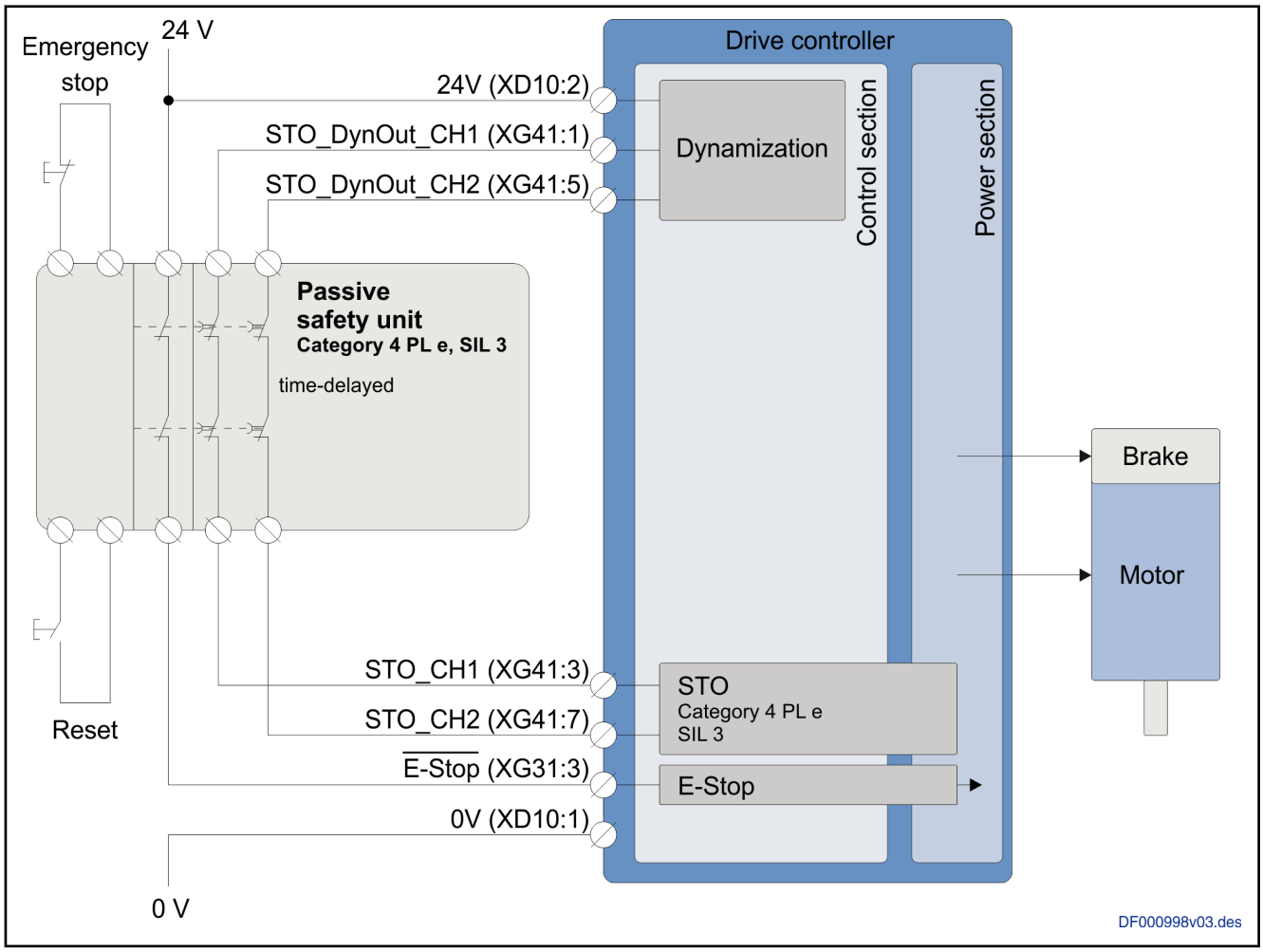


*Fig. 7-6: SS1 function with **dual-channel** wiring and **passive** safety unit*

7.1.4 Zone setup

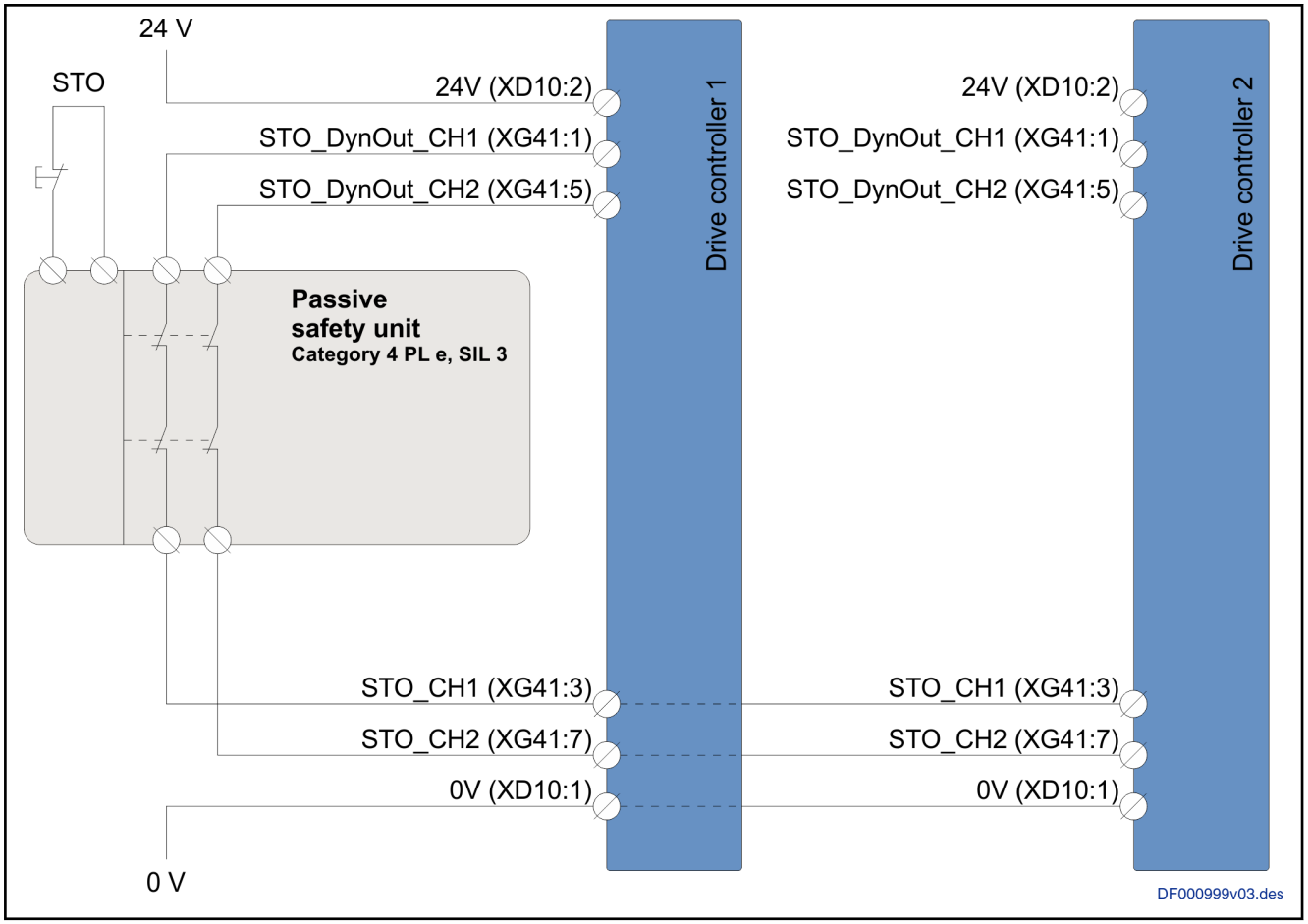


Fig. 7-7: Example of zone setup (in this case: 2 ctrlX DRIVE in a safety zone with dual-channel wiring and passive safety unit)

8 Commissioning the safety technology

8.1 Safety instruction

⚠ WARNING **Dangerous movements! Danger to life, risk of injury, serious injury or property damage!**

Do not commission the system without having it checked by a qualified individual!

Before a system with integrated safety technology is commissioned for the first time, the system must be checked and approved in documented form by a qualified individual.

Check the danger zone!

- Before commissioning, make sure that nobody is staying in the danger zone.
- Check the danger zone and secure it against access by individuals (e.g., put up warning signs, install barriers or the like).

  Observe the applicable laws and local regulations.

8.2 Prerequisites for using integrated safety technology

8.2.1 General information

The mechanical parts of power transmission, such as gearbox, motor, and those of the safety devices (brakes, fall-down protection, arresting device, ...) shall be designed to withstand the occurring static and dynamic stresses (e.g., dual load due to weight).

The safety factor and the sizing are application-specific and have to be defined by the plant or machine manufacturer.

For the maximum gearbox input torque, too, a safety factor in relation to the maximum motor torque has to be taken into account. This also applies to motor-gearbox combinations by Bosch Rexroth. (See also documentation of the respective gearbox.)

⚠ WARNING **In the case of error, injury and property damage due to inadmissibly high voltage!**

For selection and the 24 V supply of devices with integrated safety technology, use a 24 V power supply unit with protection by **SELV**[1)] in accordance with IEC 60950-1 or **PELV**[2)] in accordance with IEC 60204-1.

8.2.2 Required drive firmware

The safety technology function made available by the "T option" is a functionality only scalable using the hardware. This safety technology function does **not** require any additional **enabling of functional firmware packages**.

The integrated safety function can be used with the firmware version FWA-XD1-AXS-V-01xxx-xx and above.

1) *Safety Extra Low Voltage*

2) *Protective Extra Low Voltage*

See also Functional Description of firmware "Firmware types"

8.2.3 Required controller configuration

General information

To use the integrated safety technology of drive controllers of the ctrlX DRIVE product line, the drive controller has to be configured/equipped with the corresponding optional safety technology module.

Optional safety technology module "T0"

Using the "Safe Torque Off" function requires the optional safety technology module "T0".

The following devices have been equipped with the optional safety technology module "T0":

- Single-axis converter: XCS1-W0***A****-***T0**)
- Single-axis inverter: XMS1-W0***A****-***T0**)
- Double-axis inverter: XMD1-W****A****-***T0**)

For pin assignments and technical data of the optional safety technology module "T0", please refer to the Appendix: "XG41, safety technology Safe Torque Off".

8.2.4 Required motors and measuring systems

Rexroth motors

In conjunction with the optional safety technology module "T0" there are no specific requirements for the motor and the measuring system.

Third-party motors/optional measuring systems

In conjunction with the optional safety technology module "T0" there are no specific requirements for the motor and the measuring system.

8.2.5 Required commissioning tools

One of the following tools is required for commissioning the optional safety technology module "T0":

- Any commissioning tool for visualizing and modifying parameters
- IndraWorks commissioning software, at least IndraWorks version 14V20

8.3 Checks before initial commissioning

The checks before the initial commissioning are necessary to confirm the safety requirements stipulated in the national/international regulations (EC conformity), particularly in the Machinery Directive or the Use of Work Equipment Directive.

Check the protective equipment at the machine for effectiveness in all operation modes and functions which can be set at the machine.

Make sure that the operators - before they start working at the machine with integrated safety technology - are instructed by qualified staff of the company operating the machine. The operating company of the machine is responsible for the instruction.

8.4 Commissioning procedure

8.4.1 Overview

The "Safe Torque Off" function for the ctrlX DRIVE system is preferably commissioned using the IndraWorks commissioning software, or manually.

☞ The following commissioning steps describe the commissioning procedure on the basis of IndraWorks 14V20. For commissioning with a different commissioning tool, the corresponding parameters are listed that have to be set.

⚠ DANGER **Lethal injury and/or property damage caused by unintended axis motion!**

⇒ If external force influences, together with danger for individuals or machines, are to be expected with the safety function "Safe Torque Off", e.g. due to the load due to weight in the case of a vertical axis, this motion has to be safely prevented by additional measures, e.g. by a mechanical brake or a counterweight.

⇒ In this case, all cases of operation occurring in the application must be taken into account, including mains failure and tripped fuses.

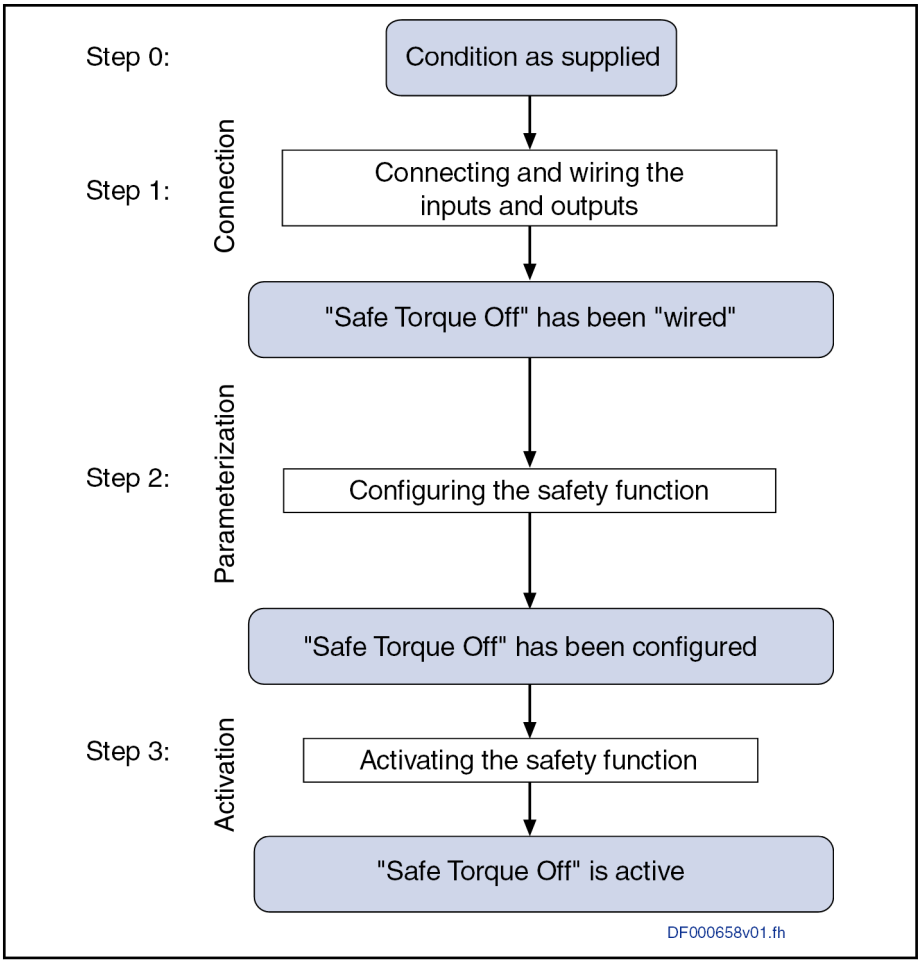


Fig. 8-1: Overview - commissioning steps of the "Safe Torque Off" function

8.4.2 Commissioning steps

Step 0: Condition as supplied and initialization

The "Safe Torque Off" function is always active and cannot be deactivated.

During the booting process, the drive system is in the "STO" operating status; i.e., the output stage has been switched off via two channels.

After the booting process, the safety function "Safe Torque Off" is active. When the drive is switched from "operating mode" to "configuration mode" / "parameterization mode", the functionality of the "Safe Torque Off" function is maintained, i.e. according to the selection, the "Safe Torque Off" function becomes active or not.

Step 1: Connecting and wiring the "Safe Torque Off" function

The connection and wiring of the "Safe Torque Off" function depends on the option used to make the selection at the drive. The "Examples of application for ctrlX DRIVE" chapter shows the different options of selection and wiring.

The inputs and outputs at the connector XG41 of the optional safety technology module have to be wired in accordance with the type of safety unit (active or passive) and the wiring type (single-channel or dual-channel):

- the STO_DynOut_CH1 (XG41:1) and STO_DynOut_CH2 (XG41:5) dynamization outputs in the case of selection via a passive safety unit
- the STO_CH1 (XG41:3) and STO_CH2 (XG41:7) selection inputs always

Step 2: Configuring the safety function

The diagnostic message output and the error reaction of the T option can be configured. Use IndraWorks for configuration. (Call the configuration dialog in IndraWorks: **Drive-integrated safety technology ▸ Configuration**.)

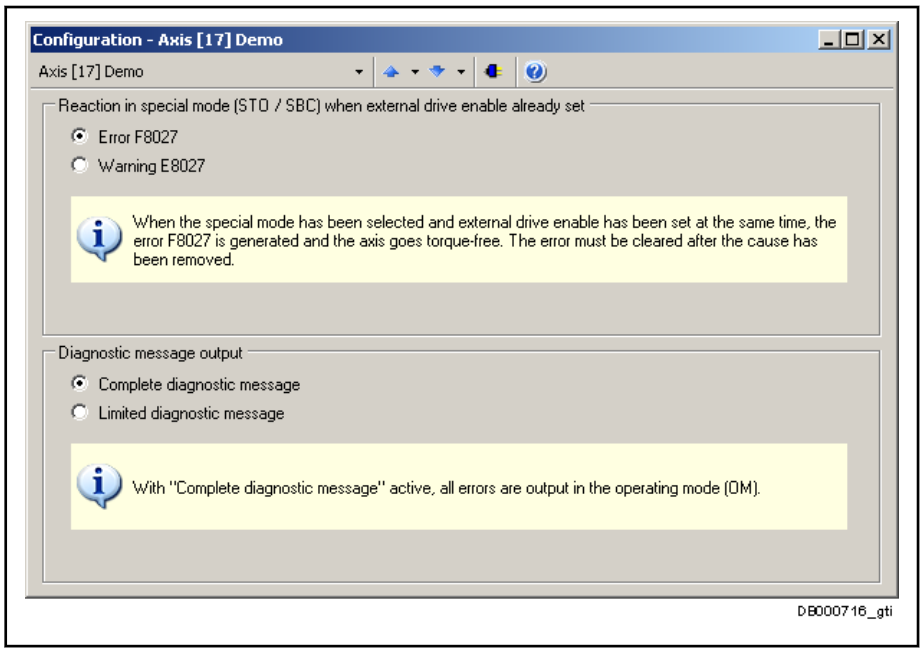


Fig. 8-2: IndraWorks "Configuration" dialog

- Switch drive to configuration mode (CM) or parameterization mode (PM).
- Use the field "Reaction in special mode (...) when external drive enable already set" to select which diagnostic message the drive is to output if drive enable had been set at the same time when the special mode was selected.

In the case of installations for which it is impossible to ensure that drive enable is removed before the special mode is selected (e.g., drive enable removed by opening the safety door), the "warning E8027" should be parameterized for "Reaction in special mode (...) when external drive enable already set".

The corresponding parameter is "P-0-0101, Configuration STO".

- The "Diagnostic message output" field is used to limit the error output in the operating mode (OM), after the initialization of the axis and before drive enable is set for the first time. For this purpose, select "Limited diagnostic message".

If the optional safety technology module "T0" is selected by external components that output invalid selection states during initialization, "Limited diagnostic message" should be parameterized.

The corresponding parameter is "P-0-0101, Configuration STO".

Step 4: Activating / deactivating the safety function

Before selecting the safety function "Safe Torque Off", decelerate the drive system using the command value input and reset drive enable. Drive-controlled deceleration is not carried out!

The safety function "Safe Torque Off" is automatically activated after the booting process. It cannot be deactivated.

8.5 Requirements for the control unit

Optional safety technology module "T0"

In conjunction with the optional safety technology module "T0" there are the following requirements for the control unit:

- Before selecting the safety function, decelerate the drive using the command value input and disable the drive torque.
- If the safety function is selected via the control unit, the selection at least has to comply with the required safety level of the application.
- If the safety function is selected via isolated selection contacts (passive safety unit), it has to be ensured that the test pulses described in chapter "Dynamization" are not inhibited.

  - or -

  The control unit features OSSD outputs (active safety unit) and has to monitor the wiring between the control unit and the safety option, as well as detect errors in the wiring.

9 Troubleshooting information

9.1 Introduction

For diagnostics (error messages, warnings and operating status messages) and servicing (firmware and hardware replacement), it is necessary to make oneself familiar with some of the functions/elements using the Functional Description of the firmware:

- Parameter handling and
- Control panel (optional)

The paragraphs below mainly explain the aspects relevant to integrated safety technology in detailed form.

The paragraphs are divided into:

- Overview of diagnostic system (e.g., diagnostic parameters and parameters containing information on the hardware configuration) ("Diagnostic system")
- Diagnostic messages of integrated safety technology

9.2 Diagnostic system

9.2.1 General information

The general diagnostic system of ctrlX DRIVE is explained in detail in the firmware Application Manual where you can read more about it, if required (see also index entry "Diagnostic system").

The following parameters are used in conjunction with the diagnostic system:

- S-0-0095, Diagnostic message
- S-0-0390, Diagnostic message number
- S-0-0390.0.136, Detailed diagnostic message
- P-0-0006, Diagnostic message configuration
- S-0-1303.0.1, Diagnostic trace configuration
- S-0-1303.0.2, Diagnostic trace control
- S-0-1303.0.3, Diagnostic trace state
- S-0-1303.0.10, Diagnostic trace main diagnostics
- S-0-1303.0.11, Diagnostic trace system time
- S-0-1303.0.12, Diagnostic trace detailed diagnostics
- S-0-1303.0.13, Diagnostic trace system time fine
- S-0-1303.0.14, Diagnostic trace system time coarse

Axis or device configuration

A drive controller consists of multiple components (power section, control section, firmware,...). Each of them has its own identifier in the form of a parameter (see also firmware Application Manual "Device configuration").

Identifiers useful for the purpose of diagnostics and service are stored in the following parameters:

- S-0-0140, Controller type
- S-0-0141, Motor type
- S-0-0142, Application type
- P-0-1516.0.x, Component type data, carrier unit

- P-0-1518.0.x, Component type data, control section unit
- P-0-1519.0.x, Component type data, output stage unit
- P-0-1520, Control section type
- S-0-0030, Manufacturer version

Electronic type plate

The (electronic) type plate of a component is represented in the following parameters:

- S-0-1300.x.1, Component Name
- S-0-1300.x.3, Vendor Code
- S-0-1300.x.4, Device Name
- S-0-1300.x.5, Vendor Device ID
- S-0-1300.x.8, Hardware version
- S-0-1300.x.9, Software version
- S-0-1300.x.11, Order Number
- S-0-1300.x.12, Serial Number

9.3 Diagnostic messages of integrated safety technology

9.3.1 Overview

For integrated safety technology, we distinguish the operating states **normal operation** and **special mode**. Triggering a monitoring function causes an error of category F3xxx or F8xxx in both operating states.

Apart from the error and warning messages, the operating states of integrated safety technology are displayed in individual parameters (status messages).

9.3.2 Status information of integrated safety technology

For diagnostic purposes, the following pieces of status information are made available for integrated safety technology (the pieces of status information are **not** allowed for the safety-relevant evaluation):

- The parameter "P-0-0106, Operating status STO" makes available binary status signals for online monitoring of the safety technology states. Via this status word, the individual status signals can be optionally programmed to existing real-time bits of the master communication or hardware I/Os or I/O extensions.
- Description of the status display dialog in IndraWorks 14:

  The "STO status" field of the IndraWorks dialog "Diagnostics" is used to diagnose the following details (calling the Diagnostics dialog in IndraWorks: **Drive-integrated safety technology ▸ Diagnostics**):

  – "STO in normal operation" is active (green), if the safety functions have not been selected or a safety technology error was detected.
  – "STO in special mode" is active (green), if the safety functions have been selected and are active.
  – "Output stage locked by STO" is active (red), if the safety technology has locked the output stage.
  – "Error" is active (red), if a safety technology error was detected.
  – "Limited diagnostic message" is active (green), unless the axis has been in control (AF) after the initialization. In this state, selection errors are not output so that external components for selection have enough time for initialization.

– "Complete diagnostic message" is active (green), if the axis has been in control after the initialization. Safety technology error messages are not suppressed.

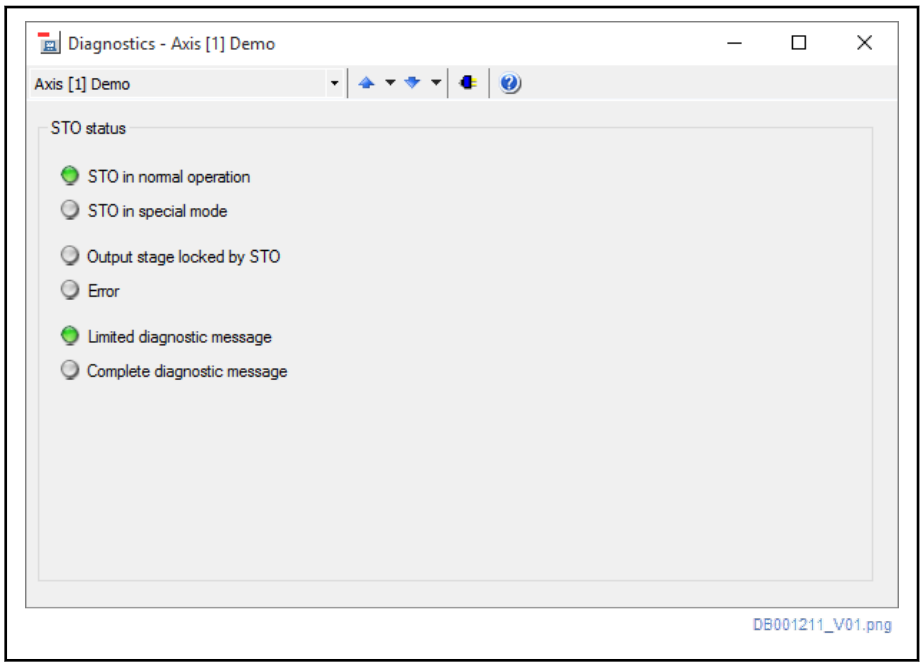


Fig. 9-1: IndraWorks "Diagnostics" dialog

9.3.3 Behavior in the case of non-fatal safety technology errors (F3xxx)

Optional safety technology module "STO" (T0)

The behavior of the drive in case non-fatal safety technology errors occur may be parameterized in drive-controlled form (P-0-0119) or carried out by the control unit (P-0-0117).

At the end of the error reaction, the drive goes torque-free.

Commissioning steps

Therefore, the drive can only be put into operation again, if:

1. The error reaction has been completed, i.e. the drive has stopped (velocity="0"!).
2. The cause of the error was removed.
3. The error message was cleared by the error clearing command [C0500 (S-0-0099)].
4. The drive is in the operating mode again and power has been switched on ("Ab").
5. Drive enable has been switched back on (positive edge).

☞ In case non-fatal safety technology errors occur repeatedly, contact our service department since operating the drive then is no longer allowed.

9.3.4 Behavior in the case of fatal errors (F8xxx)

Generally, there are 4 types of fatal errors (F8 errors):

- fatal errors during initialization (F81xx)
- fatal axis errors during operation (F80xx)
- fatal safety technology errors (F83xx)
- fatal axis and supply unit errors during operation (F88xx)

Fatal errors during initialization (initialization errors F81xx)

Fatal initialization errors (F81xx) cannot be cleared but require that the drive be restarted.

Fatal axis errors during operation (F80xx)

Axis reaction: If a fatal error occurs during operation (F80xx), closed-loop control (or open-loop V/Hz [U/f] control) of the drive is no longer ensured. Therefore, drive enable is immediately removed in the case of these errors and the holding brake - if available - is switched on. Depending on the setting in "P-0-0119, Best possible deceleration", bit 8, a motor phase short circuit can be additionally activated.

Supply unit reaction: none

☞ With the corresponding power supply configuration (P-0-0118), the power supply is disconnected in the case of all fatal errors.

Fatal axis and supply unit errors during operation (F88xx)

Axis reaction: Like for "fatal axis errors during operation (F80xx)"

Supply unit reaction: The mains supply is switched off immediately; switching off with a delay is not possible.

Fatal safety technology errors (F83xx)

If a fatal safety technology error occurs (F83xx), the safety technology immediately locks the output stage via two channels (in the case of an error in the output stage interlock, possibly via one channel only) (STO) and - if available and configured - switches on the holding brake (SBC). D.C. braking (P-0-0119, bit 8) is no longer possible.

☞ With the corresponding power supply configuration (P-0-0118), the power supply is disconnected in the case of fatal safety technology errors.

Commissioning steps

After a fatal error has occurred, the drive controller can only be put into operation again after the following steps were carried out:

1. The cause of the error has to be recognized and removed. This possibly means that an entire component (e.g., motor or drive controller) has to be replaced.
2. The error message has to be cleared by the error clearing command [C0500 (S-0-0099)] (for this purpose, it might be necessary to switch to the parameter mode or to switch off the drive controller completely).
3. The supply unit has to be switched back on.
4. The drive controller has to be in the operating mode again, and power has to be switched back on ("Ab").
5. Drive enable has to be switched back on (positive edge).

☞ In case fatal errors occur repeatedly, contact our service department since operating the drive controller then is no longer possible.

9.4 Removing malfunctions, maintenance measures, deactivating the motors

☞ When removing malfunctions, performing maintenance measures or deactivating the motors, observe the safety instructions in the chapter "Safety instructions for electric drives and controls"!

In the case of malfunctions, maintenance measures or to deactivate the motors, proceed as follows:

- Observe the instructions contained in the machine documentation.

- Use the machine-side control commands to bring the drive to a controlled standstill.
- Switch off the power voltage and control voltage of the controller.
- Only for motors with fan unit: Switch off the motor circuit breaker for the fan unit.
- Switch off the main switch of the machine.
- Secure the machine against unpredictable movements and against unauthorized operation.
- Wait to allow the electric systems to discharge and then disconnect all electrical connections.
- Before dismounting them, secure the motor and, if necessary, the fan unit against falling or moving, before unfastening the mechanical connections.

9.5 Replacing drive components

9.5.1 General information

☞ When replacing drive components, observe the safety instructions in the chapter "Safety instructions for electric drives and controls"!

The following chapters only describe the replacement of drive components which ensure safe operation. The replacement of other drive components is described in the respective Project Planning Manuals.

9.5.2 Replacing the motor

⚠ WARNING **Lethal electric shock by live parts with more than 50 V!**

The supply unit may only be replaced by qualified personnel which have been trained to perform the work on or with electrical devices.

☞ The motor should be replaced by a motor of identical type. Only by doing this is it ensured that all parameter settings can remain unchanged. Moreover, it is not required in this case to repeat the acceptance test within the scope of the "Integrated safety technology" function.

1. If necessary, write down last absolute value
2. Open main switch
3. Make sure main switch cannot be switched on again
4. Disconnect plug-in connectors

☞ When replacing the motor, cover the open mating sites of power lines with protective caps if sprinkling with cooling liquid/lubricant or pollution may occur (allowed pollution degree according to EN50178: 2).

5. Replace motor

☞ To mechanically replace the AC servo motor, observe the instructions of the machine manufacturer.

6. Connect plug-in connectors
7. **WARNING!** Risk of accident caused by unwanted axis motion! Servo axes with indirect distance measuring system via the motor encoder will lose their position data reference when the motor is replaced!

   This position data reference to the machine coordinate system must therefore be reestablished after replacement.

9.5.3 Replacing the brake

⚠ WARNING **Dangerous movements! Danger to persons from falling or dropping axes!**

While the brake is replaced, secure the axis by a blocking device or by moving the axis to a safe end position.

☞ The same type of brake must be used after replacement.

10 Decommissioning drive components

Before the drive or a component is decommissioned, an impact and hazard analysis must be prepared. The impact and hazard analysis must assess how the decommissioning affects the safety of the installation.

Furthermore, the impact and hazard analysis must contain a risk assessment of the process of decommissioning.

On the basis of this impact and hazard analysis, decommission the drive or component (see also IEC 61508-1:2010, 7.17).

11 Declaration of conformity

All converters and inverters of the "ctrlX DRIVE" product line comply with the protection goals of the Low-Voltage Directive 2014/35/EU.

We declare conformity with the Machinery Directive for the optional safety technology module "T0" [STO (Safe Torque Off)].

The declaration of conformity is also available with signatures in the English language.

If you have access to the Bosch Rexroth Intranet, please download the declaration of conformity here. Otherwise, please contact our sales representative.

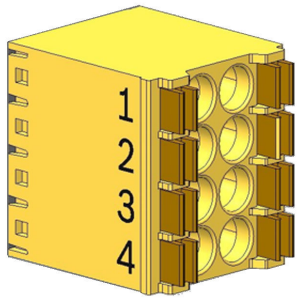
12 Project planning

This chapter describes the interfaces relevant to safety technology and the technical data of inputs and outputs.

12.1 Interfaces relevant to safety technology

12.1.1 XG41, safety technology Safe Torque Off

Single-axis; double-axis

View	Connection	Signal name	Function
	1	STO_DynOut_CH1	Channel 1 dynamization output
	2	-	n. c.
	3	STO_CH1	Input for selection of channel 1
	4	STO_CH1	Input for selection of channel 1
	5	STO_DynOut_CH2	Channel 2 dynamization output
	6	-	n. c.
	7	STO_CH2	Input for selection of channel 2
	8	STO_CH2	Input for selection of channel 2
Spring terminal (connector)	**Unit**	**min.**	**max.**
Connection cable Stranded wire	mm^2	0.2	1.5
	AWG	24	16
Stripped length	mm	-	10

Tab. 12-1: XG41, safety technology Safe Torque Off

12.2 Technical data of inputs and outputs

12.2.1 Digital inputs (safety technology)

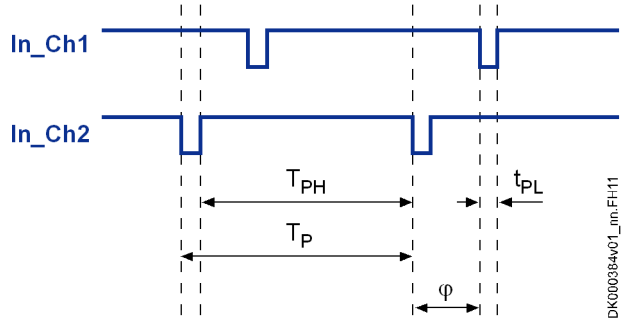
The digital inputs correspond to IEC 61131-2.

Data	Unit	min.	max.
Allowed input voltage	V	-3	30
High	V	15	30
Low	V	-3	5
Current consumption	mA	2	5

Tab. 12-2: Digital inputs (safety technology)

Time behavior

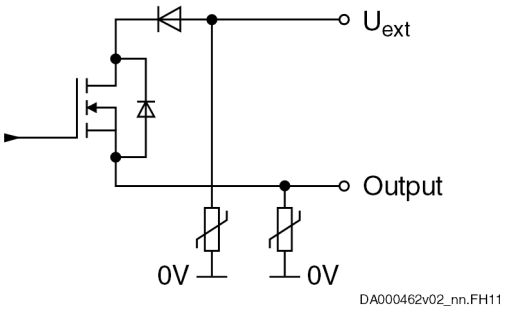
Description	Unit	min.	max.
Test pulse width (t_{PL})	µs	100	3000
Periodic time	s	0.1	3600
Phase shift between two test pulses on both channels (φ)	ms	not specified	



Tab. 12-3: Time behavior

12.2.2 Digital outputs (safety technology)

The digital outputs are compatible with digital inputs IEC 61131-2.

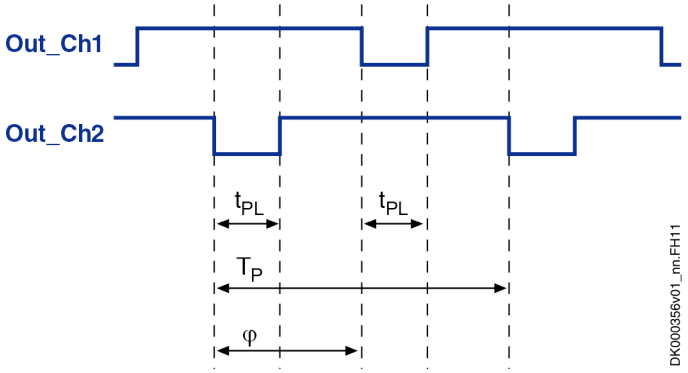
Data	Unit	min.	max.
Output voltage ON	V	U_{ext} - 1	U_{ext}
Output voltage OFF	V		5
Allowed output current per output	mA		350
Allowed energy content of connected inductive loads, e.g. relay coils	mJ		400 [1) 2)]
Capacitive load	nF		50 × n_{DI} [3)]
Short circuit protection		Present	
Overload protection		Present	
Block diagram, output:			
Error detection	The following errors are detected: • Wiring error with short circuit to high • Wiring error with short circuit to low • Wiring error with short circuit between the two channels • Internal errors In the case of an error, the control panel shows the corresponding error message: F830x, F3134		

1) At a maximum switching frequency of 1 Hz
2) In the case of inductive loads with currents > 200 mA or in the case of inductive loads with a greater energy content, an external free-wheeling arm has to be installed. The effective terminal voltage has to be < 25 V.
3) n_{DI}: Number of digital inputs that are used for a digital output

Tab. 12-4: Digital outputs

Time behavior

Description	Unit	typ.
Test pulse width (t_{PL})	µs	400
Periodic time (T_P)	ms	500
Phase shift between two test pulses on both channels (φ)	°	180



Tab. 12-5: Time behavior

13 Service and support

Our worldwide service network provides an optimized and efficient support. Our experts offer you advice and assistance should you have any queries. You can contact us **24/7**.

Service Germany

Our technology-oriented Competence Center in Lohr, Germany, is responsible for all your service-related queries for electric drive and controls.

Contact the **Service Hotline** and **Service Helpdesk** under:

Phone:	**+49 9352 40 5060**
Fax:	**+49 9352 18 4941**
E-mail:	service.svc@boschrexroth.de
Internet:	http://www.boschrexroth.com

Additional information on service, repair (e.g. delivery addresses) and training can be found on our internet sites.

Service worldwide

Outside Germany, please contact your local service office first. For hotline numbers, refer to the sales office addresses on the internet.

Preparing information

To be able to help you more quickly and efficiently, please have the following information ready:

- Detailed description of malfunction and circumstances
- Type plate specifications of the affected products, in particular type codes and serial numbers
- Your contact data (phone and fax number as well as your e-mail address)

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