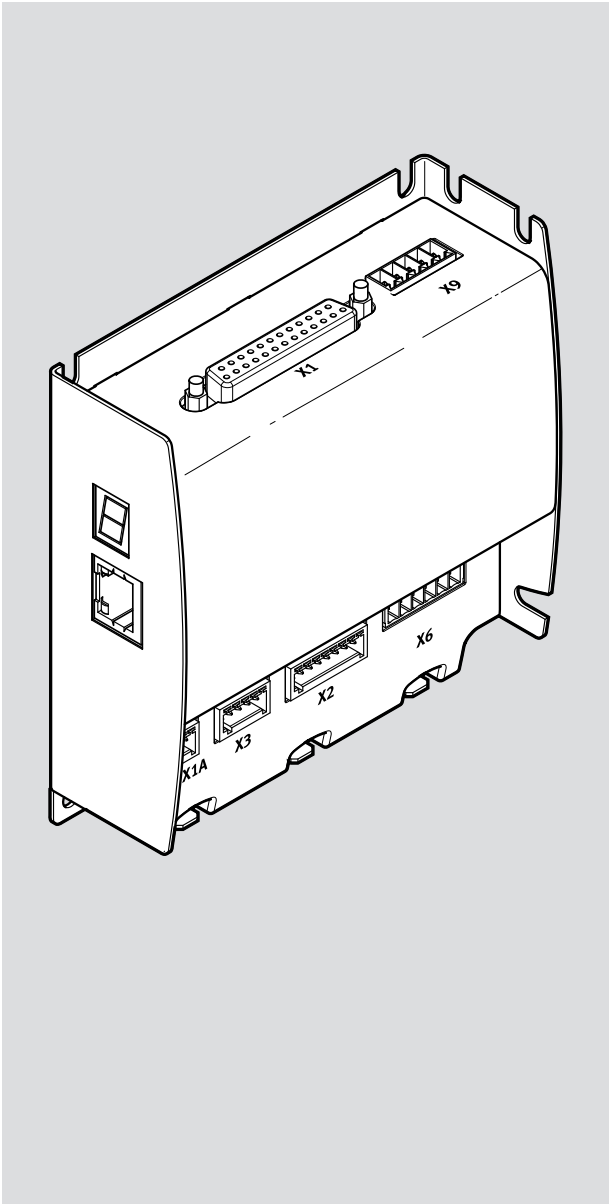
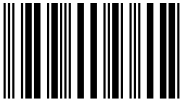


CMMO-ST-C5-1-DIOP/DION
Motor controller



FESTO

Manual | Safety
function STO



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Translation of the original instructions

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1 About this document

1.1 Applicable documents

This document only describes the use of the safety function STO – "Safe Torque Off" in accordance with EN 61800-5-2, as implemented in the motor controller CMMO-ST-C5-1-DIOP/DION. The full description of the motor controller includes the following documents:

Name, type	Contents
Brief instructions CMMO-ST-... ¹⁾	Brief product and functional description of the motor controller for initial information
Manual GDCP-CMMO-ST-EA-SY-...	Equipment and functional description of the motor controller for all product variants – Mounting – Commissioning via web server/Festo Configuration Tool (FCT) – Communication via I/O interface – Technical data
Help system for the FCT software	Descriptions of the Festo Configuration Tool (FCT) for commissioning and parameterisation of: – configurable axis/motor combinations – positioning systems in the Festo Optimised Motion Series (OMS)
Manual GDCP-CMMO-ST-EA-S1-...	Use of the STO safety function ("Safe Torque Off")
Parameter lists	List with standard settings of the parameter files for positioning systems in Festo's Optimised Motion Series (OMS)
Special documentation CMMO-ST_SPUL ¹⁾	Requirements for operating the product in the USA and Canada in accordance with certification by Underwriters Laboratories Inc. (UL)

1) The documentation is enclosed in printed format

Tab. 1: Documentation on the CMMO-ST

Additional information about the product:

- Brief documentation (quick start guide) for initial start-up and diagnostics of positioning systems in Festo's Optimised Motion Series (OMS) with the web server of the CMMO-ST
- Overview of accessories (catalogue) → www.festo.com/catalogue
- Operating manuals for the Festo configured drives and positioning systems (e.g. EPCO) → www.festo.com/sp
- Function blocks for CODESYS → www.festo.com/sp
- Certificates, declaration of conformity → www.festo.com/sp

1.2 Target group

This documentation is intended exclusively for technicians trained in control and automation technology who have experience in installation, commissioning, programming and diagnostics of positioning systems.

1.3 Versions

This documentation refers to the following version of the motor controller:

- Firmware: V 1.2.x and above
- FCT plug-in: CMMO-ST V 1.2.x and above

Firmware	What is new?	Which FCT plug-in?
V 1.0.x and above	The motor controller supports – the positioning system for EPCO electric cylinders – Festo drives with stepper motor EMMS-ST – custom drive	CMMO-ST V 1.0.0 and above
V 1.1.2 and above	Advanced parameter settings for positioning systems via web browser	CMMO-ST V 1.1.0 and above
V 1.2.1 and above	The motor controller supports additional positioning systems, such as: – Toothed belt axis ELGR – Electric semi-rotary drive ERMO	CMMO-ST V 1.2.0 and above

Tab. 2: Software versions



The hardware version, firmware version and serial number are displayed with an active online connection:

- ➔ FCT configuration software ("Controller" screen and "Online/Output" window)
- ➔ "Diagnostics" screen of the integrated web server

If an online connection is currently unavailable, information relating to the last connection will be displayed.

Additional product data, e.g. revision ➔ product labelling of the motor controller.

NOTICE

Before using a newer firmware version:

- Check whether a newer corresponding version of the FCT plug-in or user documentation is available
➔ www.festo.com/sp.

1.4 Additional information

- Contact the regional Festo contact if you have technical problems ➔ www.festo.com.
- Accessories ➔ www.festo.com/catalogue.

2 Safety and requirements for product use

2.1 Safety

When commissioning electric drives:

- Always observe the safety instructions and warnings in the documentation of the motor controller (→ 1.1 Applicable documents) and the documentation of the components used.
- Before mounting and installation work: switch off the supply voltage. Lock to prevent accidental reactivation. Only switch on the supply voltages again when mounting and installation work is complete.
- Never remove or insert a plug when the motor controller is powered.
- Observe the handling specifications for electrostatically sensitive devices.
- Do not enable the closed-loop controller until the drive has been professionally installed and fully parameterised.
- Do not perform any repairs on the motor controller. In the event of a defect: replace the complete motor controller.

2.1.1 Safety instructions for using the STO (Safe torque off) safety function

NOTICE

To achieve the safety characteristic values in accordance with EN ISO 13849-1:

- Carry out a risk assessment of the application.
- Select the components and their wiring corresponding to the required category according to EN ISO 13849-1.

CAUTION

Loss of the safety function may result in serious, irreversible injury, e.g. by unexpected movements of the actuator technology.

- Do not bypass the connections for safety equipment.
- Observe the input voltage ranges of the motor controller → 5 Technical data.
- Only use the STO function when all of the necessary protective measure have been set up and are functional.
- Validate the STO function to complete commissioning

CAUTION

Serious injuries as a result of uncontrolled movement of the driveless actuator technology when switching off the power output stage. The STO function is not sufficient as the only safety function for drives subject to a continuous torque (e.g. by suspended loads).

- Shut down the passive actuator technology mechanically if required, e.g. with a brake. This especially applies to vertical axes without automatic locking mechanisms, clamping units or counterbalancing.
- Prevent movement of the motor by suspended loads or other external forces, e.g. with a mechanical holding brake.

2.1.2 Intended use of the STO function

The motor controller supports the "safe torque off" safety function (STO, Safe Torque Off) in accordance with EN 61800-5-2. The STO function is intended to disconnect the torque from a motor that is connected to the CMMO-ST, thereby preventing an unexpected restart of the motor. The STO function should only be used for applications for which the stated safety characteristics are sufficient.

2.1.3 Safety characteristics

The STO function of the CMMO-ST satisfies the requirements for the following safety characteristics:

- PL e/Cat. 3 in accordance with EN ISO 13849-1
- SIL 3 in accordance with EN 61800-5-2
- SIL CL 3 in accordance with EN 62061

The achievable safety level depends on the other components that are used to implement the safety function. To protect against unintended start-up, the motor controller must be activated via the connection [X3] with the category required for the application according to EN ISO 13849-1, e.g. via an external safety relay unit.

2.1.4 Foreseeable misuse of the STO function

The following incorrect applications are classified as non-intended use:

- bypassing the safety function
- use in applications where switching off can result in hazardous movements or conditions.

The STO function does not provide protection against electric shock, only against dangerous movements!

2.1.5 Diagnostic coverage (DC) of the motor controller

Diagnostic coverage (➔ 5 Technical data) is influenced by the interconnection of the motor controller in the control chain as well as the measures implemented for diagnostic purposes. In order to achieve the diagnostic coverage, the status of the acknowledgment contact must be evaluated by the control system with each request of the STO function. If the signal does not correspond to the expected value, a potentially dangerous malfunction may be pending, e.g. cable break. In this case, appropriate measures must be implemented to maintain the safety level.

NOTICE

The motor controller cannot detect a cross circuit in the input circuit by itself.

- Find out if detection of shorts across contacts is required for the input circuit and wiring in your application.
- If required, use a safety relay unit with detection of shorts across contacts.

2.2 Requirements for product use

For correct and safe use of the product in a machine or system:

- Provide the complete product documentation to the following specialists
 - the design engineer and installer of the machine or system
 - the personnel responsible for commissioning
- Keep the documentation available throughout the entire product lifecycle.
- Ensure compliance with all of the specifications in the documentation for the motor controller ➔ 1.1 Applicable documents
- Also take into consideration the documentation for the other components (e.g. motor, cables etc.)

- Observe all of the legal regulations applicable for the installation site and the following documents:
 - Regulations and standards
 - Regulations of the testing organisations and insurers
 - National specifications

For correct and safe use of the STO function:

- Carry out a risk assessment for your machine or system.
- Comply with the specified safety characteristics → 5 Technical data.
- Comply with the connection and environmental conditions - in particular the voltage ranges of the product and all connected components. Only compliance with the limit values and load limits will enable operation of the product in compliance with the specified safety regulations.

2.2.1 Training of qualified personnel

The function should only be integrated into the machine by a qualified electrical technician of the machine manufacturer. The qualified technician must be familiar with:

- installation and operation of electrical control systems
- the applicable instructions for operating safety engineering systems
- the applicable instructions for accident prevention and occupational safety
- the documentation for the product

2.2.2 Product conformity

The motor controller with integrated STO safety function is a safety-related part of the control systems. Certain configurations of the product have been certified by Underwriters Laboratories Inc. (UL). The product-relevant directives are listed in the declaration of conformity → www.festo.com/sp.

Product conformity	
	in accordance with EU EMC Directive in accordance with EU Machinery Directive in accordance with EU RoHS Directive
	to UK EMC Regulations to UK Supply of Machinery Regulations to UK RoHS Regulations

Tab. 3: Product conformity

2.2.3 Specified standards

Specified standards

Version	
EN ISO 13849-1:2015-12	EN 62061:2005-04 + AC:2010-02 + A1:2013-02+A2:2015-08
EN 61800-5-2:2017-04	

Tab. 4: Standards specified in the document

3 Function and application

The STO function "Safe Torque Off" ("Safe Torque Off") enables 2-channel, secure disconnection of the power supply for the motor that is connected to the motor controller. The safety function is requested solely via the control inputs of the STO connection [X3] on the motor controller. Safety-oriented circuitry for additional interfaces of the motor controller is not required.

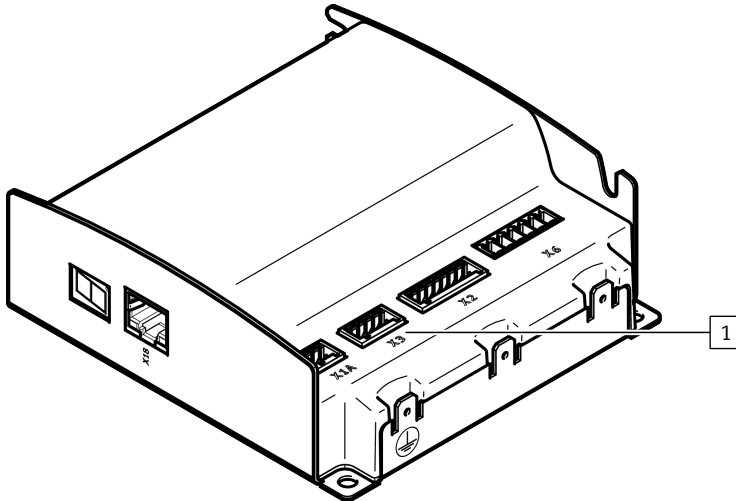


Fig. 1: "Safe Torque off" (STO) connection

1 [X3] STO

3.1 Circuitry of the control inputs



To protect against unintended start-up, the motor controller must be activated via the connection [X3] with the category required for the application according to EN ISO 13849-1. Achievable safety level of the STO function → 2.1.3 Safety characteristics.

The following components for requesting the STO function can be connected to the control inputs (→ 4.1 Installation):

- safe semiconductor outputs (electronic safety relay units, active safety sensors, e.g. light curtains with OSSD signals) (OSSD = Output Signal Switching Device)
- Switch contacts (safety relay units with relay outputs, passive safety sensors, e.g. forced position switches)

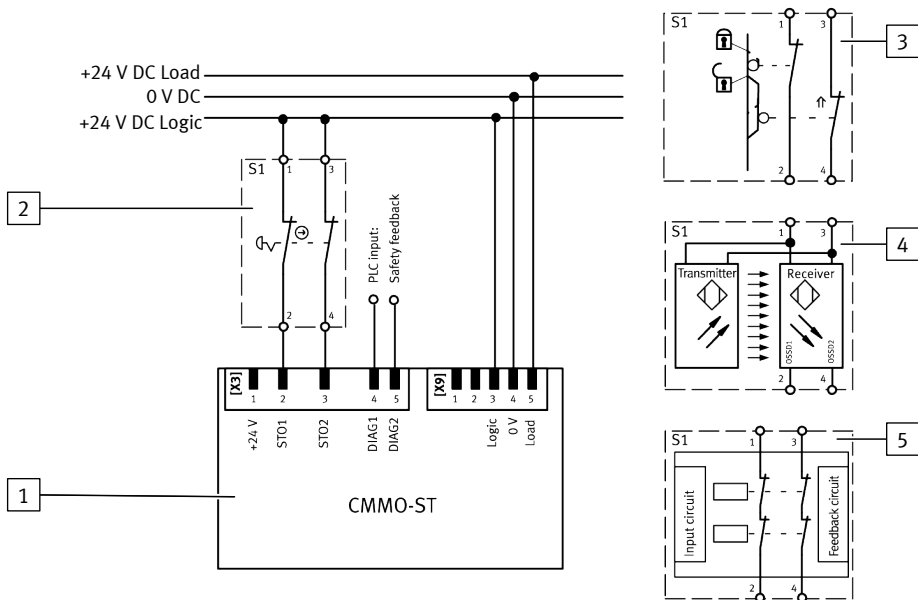


Fig. 2: Sample circuit (without detection of shorts across contacts)

- | | |
|---|--|
| 1 Motor controller with safety module (only relevant connections shown) | 4 Light curtain (alternative to [2]) |
| 2 Emergency stop switch | 5 Safety relay unit (alternative to [2]) |
| 3 Safety door (alternative to [2]) | |

NOTICE

The motor controller cannot detect a cross circuit in the input circuit by itself.

- Find out if detection of shorts across contacts is required for the input circuit and wiring in your application.
- If required, use a safety relay unit with detection of shorts across contacts.

3.2 Functional description

The STO function is requested over 2 channels with switch S1, with which the control voltage (+24 V DC, logic → Fig. 3) is switched off at both STO1 and STO2 control inputs. The control inputs are of equal value, i.e. it makes no difference in which sequence they are connected. The motor controller monitors the status of the control inputs and switches off the driver supply of the power stage as soon as logic 0 (0 V) is present at one of the control inputs. The power supply for the motor via the power stage is interrupted:

- Behaviour of the drive with a running motor: the movement of the drive is not decelerated via a braking ramp of the motor controller. The drive continues to move uncontrolled due to inertia or external forces until it comes to a standstill by itself.
- Behaviour of the drive with a stopped motor: the drive is uncontrolled and can be moved by external forces.

The 2-channel switch-off of the power stage is indicated by the DIAG acknowledgment contact (semiconductor relay). The status of the STO function can be sent for diagnostics, e.g., to an external safety relay unit by the acknowledgment contact. The diagnostics contact is not evaluated in terms of safety engineering.

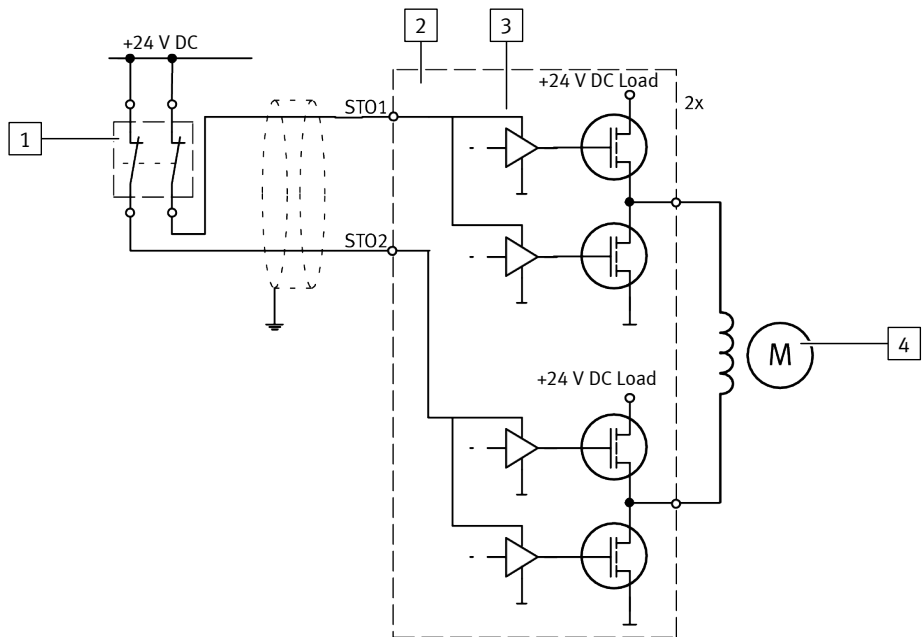


Fig. 3: "Safe torque off" – operational principle

- | | |
|---|---------------------------------------|
| 1 Input circuit (e.g. safety relay unit) | 3 Driver power supply |
| 2 Power output stage in CMMO-ST (only one phase shown) | 4 Motor (only one phase shown) |

CAUTION

Serious injuries as a result of automatic movement of the passive actuator technology after switching off the power output stage. The STO function is not sufficient as the only safety function for drives subject to a continuous torque (e.g. by suspended loads).

- Shut down the passive actuator technology mechanically if required, e.g. with a brake. This especially applies to vertical axes without automatic locking mechanisms, clamping units or counterbalancing.
- Safely prevent movements of actuator technology with suspended loads or other external forces, e.g. with a mechanical holding brake.

NOTICE

Controlling motors with an integrated holding brake.

The holding brake is actuated by the non-safety-relevant firmware of the motor controller. When the power stage is switched off, the drive is not slowed down via a braking ramp. The holding brake is closed immediately.

- Check whether the integrated holding brake can stop the actuator technology.
- Note the mechanical inertia of the holding brake.
- Take into consideration the higher wear of the holding brake in comparison to automatic brake control in normal operation.

NOTICE

Failure of the power stage.

If the power stage of the motor controller fails when an STO function is active, it may result in the drive jerking through a limited detent movement of the rotor. The rotation angle/travel corresponds to the pole pitch of the motor used.

Example of a power stage failure: simultaneous short circuit of 2 power semiconductors in different phases.

3.3 [X3] STO interface

3.3.1 Switching statuses

STO control inputs:

As long as a logic 1 (+24 V DC) is present at both control inputs, the motor can be operated. As soon as logic 0 (0 V DC) is pending at one or both control inputs, the power supply to the motor is disconnected. If both STO inputs receive logic 1 again, the controller enable must be reset.

Acknowledgment contact DIAG:

The acknowledgment contact is closed when the STO function is active.

The acknowledgment contact is open:

- in the event of a failure of the logic voltage or supply voltage
- if the STO function is inactive

STO1	STO2	DIAG1/DIAG2	Status
1	1	High resistance (open)	Normal operation – Power stage is switched on. – STO function is inactive.
1	0	High resistance (open)	The STO function has been requested on a single channel, e.g. on failure of a channel: – Power stage is switched off on 1 channel. – The motor can no longer be operated. – STO function is inactive.
0	1		
0	0	Low resistance (closed)	The STO function has been requested on two channels. – Power stage is switched off on 2 channels. – The motor can no longer be operated. – The STO function is active.

Tab. 5: Switching logic of the STO1/STO2 control inputs

Switching statuses [X3.1]		
STO1/STO2 control inputs ¹⁾		
Logic 1	[V DC]	> 18
Logic 0	[V DC]	< 5
Acknowledgment contact DIAG		
Closed: max. internal resistance	[Ω]	≤ 40
Open: off-state current	[μA]	≤ 2

1) Intermediate range is undefined

Tab. 6: Electrical data of switching statuses [X3]



The control inputs are also protected against polarity reversal, but are not equipped with voltage monitoring. If required, voltage must be monitored by other measures.

3.3.2 Switching times

The amount of energy stored in the components of the STO function (e.g. capacitors) depends on the input voltage. These amounts of energy must be charged or discharged depending on the switching operation. Depending on the input voltage, this results in different values for the transition to the safe status (STO) and the tolerance time (buffer time) regarding OSSD signals.

Signal	Switching time	
STO1/STO2	Activate STO [ms]	≤ 2
	Deactivate STO [ms]	> 6
DIAG	Close acknowledgment contact [ms]	≤ 10
	Open acknowledgment contact [ms]	≤ 20

Tab. 7: Switching times

Additional electrical data ➔ 5.2 Electrical data

3.3.3 Reaction to test pulses

Short test pulses from a safety control are tolerated and thus do not trigger the STO function. The permissible pulse width is dependent on the control voltage level at inputs STO1 and STO2.

Control inputs STO1/STO2 [X3]		
Maximum permissible pulse width		
For 0 V test pulse with 24 V signal [ms]		0.5
For 24 V test pulse with 0 V signal [ms]		5
Minimum time between test pulses		
For 0 V test pulse with 24 V signal [ms]		25
For 24 V test pulse with 0 V signal [ms]		25

Tab. 8: Test pulses of inputs STO1 and STO2

Additional electrical data ➔ 5.2 Electrical data

3.3.4 Logic supply +24 V LOGIC OUT

A 24 V auxiliary supply is available at [X3.1]. Reference potential (0 V) is pin 4 at voltage supply connection [X9].

The logic supply can be optionally used to supply external, active sensors.

Additional electrical data ➔ 5.2 Electrical data

4 Installation and commissioning

 WARNING

- Electric shock from voltage sources without protective measures.
- Use only PELV circuits in accordance with IEC 60204-1 (protective extra-low voltage (PELV)) for the electrical power supply.
 - Observe the general requirements of IEC 60204-1 for PELV circuits.
 - Use only voltage sources that guarantee reliable electrical isolation of the operating and load voltage in accordance with IEC 60204-1.

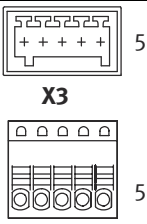
4.1 Installation

 CAUTION

- Unexpected and unintended movement of the drive during mounting, installation and maintenance work.
- Before starting work: switch off power supplies. Cancelling the enable signal on the controller is not sufficient.
 - Lock the power supplies to prevent accidental reactivation.

Installation instructions:

- Observe all of the information regarding electrical installation of the motor controller → 1.1 Applicable documents.
- Comply with the handling specifications for electrostatically sensitive components.
- Use the plug connector [X3] included in the scope of delivery of the motor controller.
- Connect the control inputs in two channels with parallel wiring.

Connection [X3]	Pin	Function	
 X3	1	+ 24 V LOGIC OUT	Logic voltage output [X9] Reference potential (0 V) is pin [X9.4] Not overload-proof! Max. 100 mA permissible.
	2	STO1	Control input for STO function: channel 1
	3	STO2	Control input for STO function: channel 2
	4	DIAG1	Acknowledgement contact: – potential-free – Low impedance if the STO function has been requested and activated via two channels.
	5	DIAG2	

Tab. 9: Connection [X3] STO with plug

NOTICE

Damage to the device in the event of overload.
Pin [X3.1] (+24 V Out) is not overload-proof! Max. 100 mA permissible.

NOTICE

The STO function must never be bridged.

- Make sure that no bridges etc. can be used parallel to the safety wiring, e.g. by using the maximum cable cross section of 0.5 mm².

4.2 Notes on commissioning



The complete commissioning of the motor controller by the machine manufacturer is described in the GDCP-CMMO-ST-EA-SY... manual and in the Online Help for the CMMO-ST plug-in of the FCT software.

Recommendation for initial commissioning without complete safety engineering:

- Minimum circuitry with emergency stop switching device and two-channel shut-down via control inputs STO1 [X3.2] and STO2 [X3.3]
- Design the circuitry in such a way that it must be removed when the final safety circuitry is installed.

NOTICE

Incorrect wiring or the use of unsuitable components will result in loss of the STO function or non-compliance with the requirements of EN ISO 13849-1 (category).

Prior to commissioning:

- Make sure that the components and their wiring comply with the category required in accordance with EN ISO 13849-1.
- Check the electrical installation (connecting cable, contact assignment).
- Validate the STO function after the installation process and after every modification to the installation.
- Only use the STO function when all of the necessary protective measures have been set up and are functional.

For a function test of the STO function:

1. Switch off each channel individually and check the reaction of the motor and the acknowledgment contact.
2. Switch off both channels and check the reactions.

4.3 Diagnostics

Diagnostics	Description
Acknowledgement contact ¹⁾	The acknowledgment contact of the STO function (DIAG1/DIAG2) can be evaluated by a higher-order controller. The closed acknowledgment contact indicates that the STO function is active.
Display 'H' ¹⁾	The 'H' in the 7-segment display of the motor controller indicates that the STO function has been requested. 'H' is always displayed if a fault message is not displayed. The status of the STO function (active/inactive) is thereby not displayed.
Fault message 0x34 ¹⁾	When the STO function is requested, the "Safe torque off" (0x34) fault message is generated. The message can be configured as an error, warning or information and is then displayed correspondingly on the 7-segment display of the motor controller. An entry in the diagnostic memory is optional. The status of the STO function (active/inactive) is thereby not displayed.

1) The diagnostics are not evaluated for safety engineering.

Tab. 10: Diagnostics options of the STO function

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For additional information on the 7-segment display and complete error lists → Manual GDCP-CMMO-ST-EA-SY...

4.4 Obligations of the machine operator

The implemented safety function must be subjected to a regular and documented performance test by a specialist during the period of use of the machine. The frequency of these tests must be determined by the machine operator based on the specifications of the machine manufacturer. An inspection of the motor controller is recommended at least once a year.

5 Technical data



The general technical data, operating and ambient conditions and additional connection data can be found in the description of the motor controller → Manual GDCP-CMMO-ST-EA-SY...

You can find the technical data of the motor/encoder in the operating manual of the Festo motor or axis-motor combination → www.festo.com/sp

5.1 Safety engineering

Safety reference data and safety specifications		
Safety function	STO	Safe torque off (safe torque off)
Category	3	In accordance with EN ISO 13849-1
Performance Level	PL e	In accordance with EN ISO 13849-1
Safety Integrity Level	SIL 3	In accordance with EN 61800-5-2 (Safety Integrity Level)
SIL Claim Limit	SIL CL 3	in accordance with EN 62061 (SIL Claim Limit)
DC _{avg} [%]	90	Average Diagnostic Coverage (average diagnostic coverage)
MTTF _d [years]	4500	Mean Time To dangerous Failure (mean time until a dangerous failure)
HFT	1	Hardware Failure Tolerance (hardware fault tolerance)
PFH [1/h]	1.3 x 10 ⁻¹⁰	Probability of dangerous Failure per Hour (probability of dangerous failure per hour)
T Proof Test Interval [years]	20	Test interval
T duration of use [years]	20	In accordance with EN ISO 13849-1
Component/function	Suitable for use in category-1 systems and above in accordance with EN ISO 13849-1	

Tab. 11: Safety reference data and safety specifications

5.2 Electrical data

Control inputs STO1/STO2 [X3]		
Nominal voltage [V DC]	24	(relative to 0 V at [X9])
Voltage range [V DC]	21.6 ... 28.8	
Permissible residual ripple [%]	5	(based on nominal voltage 24 V)
Nominal current [mA]	15	

Control inputs ST01/ST02 [X3]		
Starting current	[mA]	200
Input voltage thresholds (intermediate range is undefined)		
Logic 1	[V DC]	> 18
Logic 0	[V DC]	< 5
Activate STO function switching time	[ms]	≤ 2
Deactivate STO function switching time	[ms]	> 6
Maximum permissible pulse width		
For 0 V test pulse with 24 V signal	[ms]	0.5
For 24 V test pulse with 0 V signal	[ms]	5
Minimum time between test pulses		
For 0 V test pulse with 24 V signal	[ms]	25
For 24 V test pulse with 0 V signal	[ms]	25
Protective function		
Protection against polarity reversal		Yes
Overvoltage-proof up to 60 V DC (tested)		Yes

Tab. 12: Technical data: electrical data of the ST01 and ST02 inputs

Acknowledgment contact DIAG [X3]		
Design		Semiconductor relay
Max. voltage	[V DC]	≤ 30
Nominal current	[mA]	100
Max. internal resistance (contact closed)	[Ω]	≤ 40
Off-state current (contact open)	[μA]	≤ 2
Switching time for closing	[ms]	≤ 10
Switching time for opening	[ms]	≤ 20

Acknowledgment contact DIAG [X3]	
Galvanic isolation	Via optocoupler
Protective function	
Overvoltage resistant to 60 V DC (checked)	Yes

Tab. 13: Technical data: electrical data of the acknowledgment contact

Auxiliary supply +24 V DC, LOGIC OUT [X3.1]	
Nominal voltage [V DC] – Supply via [X9] – Not additionally filtered or stabilised	24
Nominal current [mA]	100 (max.)
Overload protection	Not overload-proof

Tab. 14: Technical data: electrical data of the auxiliary supply output

Signal lines	
Max. cable length [m]	30
Cable cross section [mm ²]	0.14 ... 0.5

Tab. 15: Technical data: cabling at [X3]

5.3 Product conformity and approvals

Approval information, safety engineering	
CE	
Type-examination	The functional safety engineering of the product has been certified by an independent testing body, see EC-type examination certificate → www.festo.com/sp
Certificate issuing authority	TÜV Rheinland, Certification Body of Machinery, NB 0035
Certificate no.	01/205/5252.02/20
UKCA	
Type-examination	The functional safety engineering of the product has been certified by an independent body, see UK-type examination certificate → www.festo.com/sp
Certificate issuing authority	TUV Rheinland UK Ltd, Approved Body for Machinery, No. 2571
Certificate no.	01/205U/5252.00/22

Tab. 16: Approval information, safety engineering

Additional approvals
c UL us - Listed (OL)
RCM (Regulatory Compliance Mark)

Tab. 17: Additional approvals

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Requirements for observing the UL certified conditions if the product is operated in the USA or Canada can be found in the separate special UL documentation.

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