ENGINEERING
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Installation Guide

VLT® Safety Option MCB 150/151

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TOMORROW

Danfoss A/S
6430 Nordborg
Denmark
CVR nr.: 20 16 57 15

Telephone: +45 7488 2222
Fax: +45 7449 0949

EU DECLARATION OF CONFORMITY

Danfoss A/S

Danfoss Drives A/S

declares under our sole responsibility that the

Product category: Frequency Converter Options
Type designation(s):

Safety Option:	Product Safety Function:
MCB150 (order no.: 130b3280)	STO, SS1, SLS
MCB151 (order no.: 130b3290)	STO, SS1, SLS
MCB152 (order no.: 130B9860)	STO (PROFIsafe)

Covered by this declaration is in conformity with the following directive(s), standard(s) or other normative document(s), provided that the product is used in accordance with our instructions.

Low Voltage Directive 2014/35/EU

EN61800-5-1 (2007)+A1:2017	Adjustable speed electrical power drive systems – Part 5-1: Safety requirements – Electrical, thermal and energy.

Machinery Directive 2006/42/EC

EN ISO 13849-1:2008	Safety of machinery – Safety related parts of control systems – Part 1: General principles for design.
EN 62061:2013	Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems
EN 61800-5-2:2008	Adjustable speed electrical power drive systems – Part 5-2: Safety requirement – Functional
EN 61508-1 to 7:2011	Functional safety of electrical/electronic/programmable electronic safety related systems – parts 1-7
EN 60204-1:2006	Safety of machinery - Electrical equipment of machines – Part 1: General requirement.

RoHS Directive 2011/65/EU including amendment 2015/863.

EN63000:2018	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances.

Date: 2020.09.15 **Place of issue:**	**Issued by**	Date: 2020.09.15 **Place of issue:**	**Approved by**
Graasten, DK	**Signature:** **Name: Gert Kjær** **Title: Senior Director, GDE**	Graasten, DK	**Signature:** **Name: Michael Termansen** **Title: VP, PD Center Denmark**

Danfoss only vouches for the correctness of the English version of this declaration. In the event of the declaration being translated into any other language, the translator concerned shall be liable for the correctness of the translation

Contents

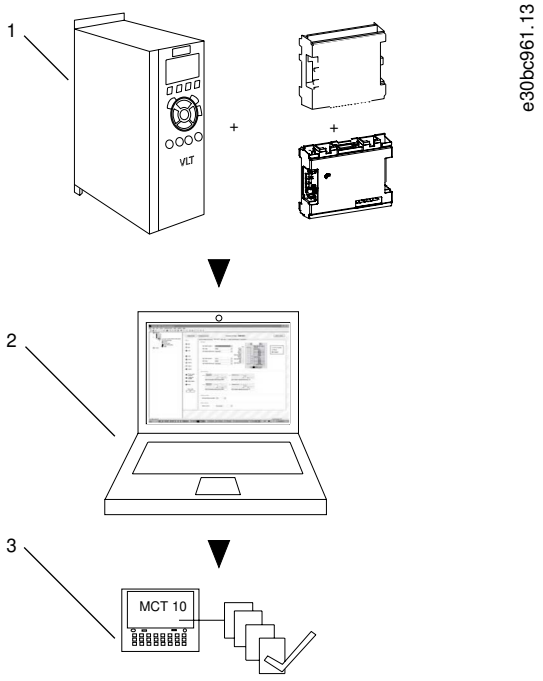
1 Introduction

1.1 Purpose of this Installation Guide

This installation guide provides information for safe installation and commissioning of the safety option. It is intended for use by qualified personnel. Read and follow the instructions to use the option safely and professionally. Pay particular attention to the safety instructions and general warnings. Always keep this installation guide available with the option.

1.2 Available Resources

Throughout this guide, there are references to other manuals that are helpful when installing the VLT® Safety Option MCB 150/151.



1 Installation phase: Use this installation guide and refer to VLT AutomationDrive FC 301/FC 302 Operating Guide.	**2** Parameterization phase: Refer to VLT® Motion Control Tool MCT 10 Set-up Software Operating Guide.
3 Test phase: Use the commissioning report generated via the MCT 10 Safe Plug-in.	

Illustration 1: System Overview

Also refer to www.danfoss.com/en/search/?filter=type%3Adocumentation%2Csegment%3Adds for more information.

1.3 Document Version

This manual is regularly reviewed and updated. All suggestions for improvement are welcome. See document version and changes applied in table 1.

Table 1: Version and Changes Applied

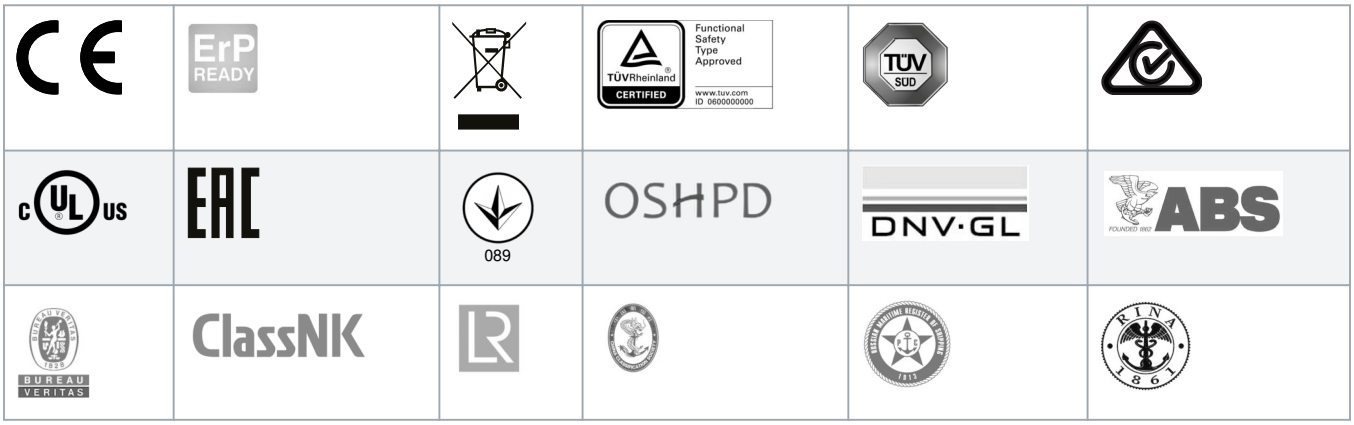
Edition	Remarks
MG34W4xx	Editorial changes. Installation of VLT® Sensorless Safety MCB 159 added.

1.4 Type Approvals and Certifications

The following list is a selection of possible type approvals and certifications for Danfoss drives:

NOTICE

Drives of enclosure size T7 (525–690 V) are not UL listed.



NOTICE

The specific approvals and certification for the drive are on the nameplate of the drive. For more information, contact the local Danfoss office or partner.

For more information on UL 508C thermal memory retention requirements, refer to the section *Motor Thermal Protection* in the product-specific *design guide*.

For more information on compliance with the European Agreement concerning International Carriage of Dangerous Goods by Inland Waterways (ADN), refer to the section *ADN-compliant Installation* in the product-specific *design guide*.

2 Legal Information and Safety

2.1 Legal Information

According to the Machinery Directive regulation, it is hereby stated that the original language of this operating guide is English US.

2.2 Warranty and Liability

All claims to warranty and liability are rendered invalid if:

- The product was used contrary to the purpose for which it was intended.
- Damage can be attributed to not having followed the guidelines in the manual.
- Operating personnel are not suitably qualified.
- Any type of modification has been made (for example, exchanging components on the PCB boards, soldering work, and more).

2.3 Safety Symbols

The following symbols are used in this manual:

⚠ DANGER ⚠

Indicates a hazardous situation which, if not avoided, will result in death or serious injury.

⚠ WARNING ⚠

Indicates a hazardous situation which, if not avoided, could result in death or serious injury.

⚠ CAUTION ⚠

Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

NOTICE

Indicates information considered important, but not hazard-related (for example messages relating to property damage).

2.4 Qualified Personnel

The products must only be assembled, installed, programmed, commissioned, maintained, and decommissioned by persons with proven skills. Persons with proven skills:

- Are qualified electrical engineers, or persons who have received training from qualified electrical engineers and are suitably experienced to operate devices, systems, plant, and machinery in accordance with the general standards and guidelines for safety technology.
- Are familiar with the basic regulations concerning health and safety/accident prevention.
- Have read and understood the safety guidelines given in this manual and also the instructions given in the operating guide of the drive.
- Have good knowledge of the generic and specialist standards applicable to the specific application.

2.5 Responsibilities of Users of PDS(SR)

Context:

In EN ISO 12100, risk assessment is defined as an overall process comprising a risk analysis and a risk evaluation.

Procedure

1. Carry out a hazard and risk analysis of the application according to EN ISO 12100.
2. Ensure that the qualified personnel has experience with working in ATEX areas according to Directive 99/92/EC (also known as the ATEX Workplace Directive).
3. Identify safety sub-functions required and allocate SIL to each of the functions.
4. Identify other subsystems and validate the signals and commands from those subsystems.
5. Design appropriate safety-related control systems (hardware, software, parameterization, and more).

2.6 Safety Precautions

⚠ WARNING ⚠

HIGH VOLTAGE

AC drives contain high voltage when connected to AC mains input , DC supply , or load sharing. Failure to perform installation, start-up, and maintenance by qualified personnel can result in death or serious injury.

- Only qualified personnel must perform installation, start-up, and maintenance.

⚠ WARNING ⚠

UNINTENDED START

When the drive is connected to the AC mains, DC supply, or load sharing, the motor may start at any time, causing risk of death, serious injury, and equipment, or property damage. The motor may start by activation of an external switch, a fieldbus command, an input reference signal from the LCP or LOP, via remote operation using MCT 10 Set-up software, or after a cleared fault condition.

- Press [Off] on the LCP before programming parameters.
- Disconnect the drive from the mains whenever personal safety considerations make it necessary to avoid unintended motor start.
- Check that the drive, motor, and any driven equipment is in operational readiness.

⚠ WARNING ⚠

DISCHARGE TIME

The drive contains DC-link capacitors, which can remain charged even when the drive is not powered. High voltage can be present even when the warning indicator lights are off.

Failure to wait the specified time after power has been removed before performing service or repair work could result in death or serious injury.

- Stop the motor.
- Disconnect AC mains, permanent magnet type motors, and remote DC-link supplies, including battery back-ups, UPS, and DC-link connections to other drives.
- Wait for the capacitors to discharge fully. The minimum waiting time is specified in the table *Discharge time* and is also visible on the nameplate on top of the drive.
- Before performing any service or repair work, use an appropriate voltage measuring device to make sure that the capacitors are fully discharged.

Table 2: Discharge Time

Voltage [V]	Minimum waiting time (minutes)					
	4	**7**	**15**	**20**	**30**	**40**
200–240	0.25–3.7 kW (0.34–5 hp)	–	5.5–37 kW (7.5–50 hp)	–	–	–
380–500	0.25–7.5 kW (0.34–10 hp)	–	11–75 kW (15–100 hp)	90–200 kW (150–350 hp)	250–500 kW (450–750 hp)	250–800 kW (450–1350 hp) 315–500 (500–750 hp)
400	–	–	–	90–315 kW (125–450 hp)	–	–
500	–	–	–	110–355 kW (150–450 hp)	–	–
525	–	–	–	55–315 kW (75–400 hp)	–	–
525–600	0.75–7.5 kW (1–10 hp)	–	11–75 kW (15–100 hp)	–	–	–
525–690	–	1.5–7.5 kW (2–10 hp)	11–75 kW (15–100 hp)	37–315 kW (50–450 hp)	355–1200 kW (450–1550 hp)	355–2000 kW (450–2050 hp) 355–710 kW (400–950 hp)
690	–	–	–	55–315 kW (75–400 hp)	–	–

⚠ WARNING ⚠

NO ELECTRICAL SAFETY

This option is suitable for performing mechanical work on the drive system or affected area of a machine only. It doesn NOT provide electrical safety. Using the option for starting or stopping the drive can cause personal injury.

- Do NOT use the option as a control for starting or stopping the drive.
- Refer to ISO 12100 for more information about the application requirements.

⚠ WARNING ⚠

LEAKAGE CURRENT HAZARD

Leakage currents exceed 3.5 mA. Failure to ground the drive properly can result in death or serious injury.

- Ensure the correct grounding of the equipment by a certified electrical installer.

NOTICE

The drive has more voltage sources than L1, L2, and L3 when load sharing (linking of DC link) or external 24 V DC are installed.

2.7 Risk Assessment

NOTICE

The safety option is intended to be part of the safety-related control system of a machine. Before installation, perform a risk assessment to determine whether the specifications of this safety option are suitable for all foreseeable operational and environmental characteristics for the system in which it will be installed.

The system user is responsible for:

- Set-up, safety rating, and validation of any actuators connected to the system.
- Completing a system-level risk assessment and reassessing the system any time a change is made.
- Providing supposition (as needed for the application) that the system fulfills the requested safety rating.
- Project management and proof testing.
- Programming the application software and the safety option configurations in accordance with the information in this manual.
- Access to the control system.
- Analyzing all configuration settings and selecting the proper setting to achieve the required safety rating.

3 Functions and Systems Overview

3.1 System Overview

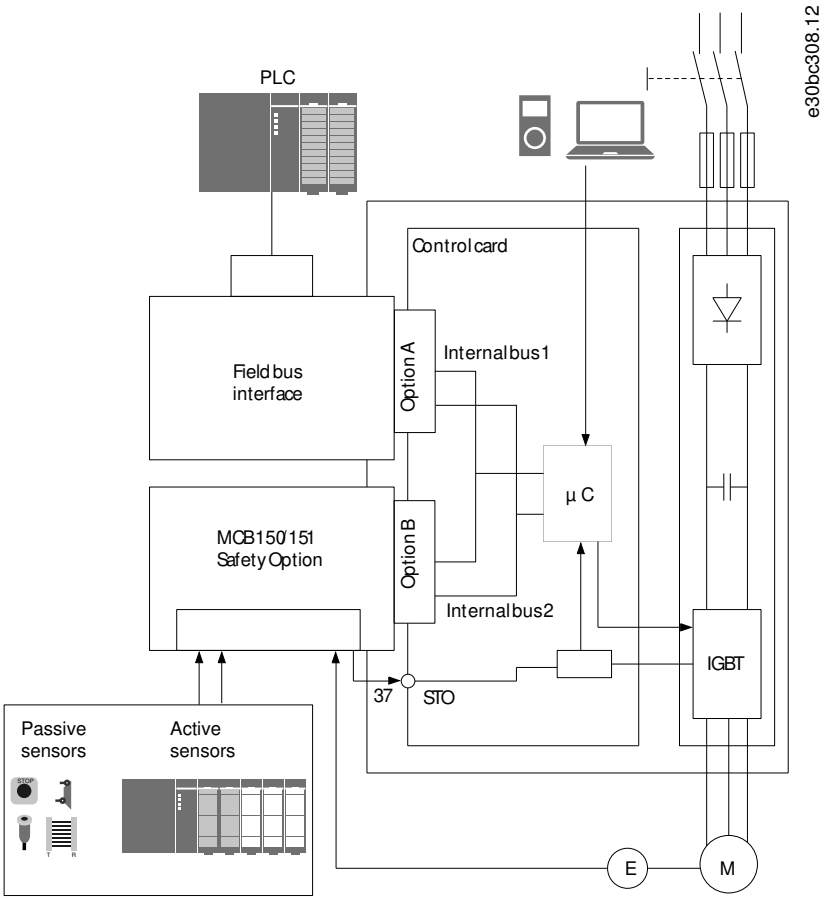


Illustration 2: Drive with Safety Option and Fieldbus Option

The safety option performs safety sub-functions in accordance with EN IEC 61800-5-2. It monitors safe motion sequences on drives, which are safely brought to a stop and shutdown if an error occurs.

The safety option:

- Activates safety sub-functions.
- Monitors safe motion sequences.
- Signals the status of the safety sub-functions to the safety control system via possible connected fieldbus.
- Activates the selected failure reaction Safe Torque Off or Safe Stop 1 if an error occurs.

There are 2 variants of the safety option:

- With HTL encoder interface (MCB 151).
- With TTL encoder interface (MCB 150).

The safety option is constructed as a standard option for the VLT AutomationDrive FC 302 and is automatically detected after mounting.

The safety option can be used to monitor the stopping, starting, or speed of a rotating or laterally moving device. As speed monitor, the option is often used with hard guarding, access doors, and safety gates with solenoid-lock or -unlock safety switches. When the speed of the monitored device drops below the set switch point (where its speed is no longer considered dangerous), the safety option sets S37 output low. This allows the operator to open the safety gate. In speed monitor applications, the safety output S37 is high for operation (when the motor speed of the monitored device is below the set switch point). When the speed exceeds the set value, indicating a too high (dangerous) speed, the safety output is low.

The drive:

- Removed the power to the motor.
- Switches the motor to torque-free if Safe Torque Off is activated.

The safe control system:

- Activates the safety sub-functions via inputs on the safety option.
- Evaluates signals from safety devices, such as:
  - E-STOP push buttons.
  - Non-contact magnetic switch.
  - Interlocking switch.
  - Light curtain devices.
- Processes the safety option status function.
- Provides safe connection between safety option and safety control system.
- Provides fault detection at activation of safety sub-functions (shorts across contact, short circuit) on signal between the safety control system and the safety option.

3.1.1 Behavior of Holding Brake

NOTICE

RISK OF HAZARD

External forces acting on the motor (vertical axis) and unwanted movements, for example caused by gravity, can cause hazards leading to death or serious injury.

- Add measures for fall protection before operating the motor.

Triggering the Safe Torque Off safety sub-function means that the delay time for motors with holding brake is not effective. The motor cannot generate holding torque to bridge the time to application of the holding brake. Check whether more measures have to be taken, for example, this may cause the load of vertical axes to lower.

3.1.2 Safety Certification

The safety option is certified for use in safety applications up to and including SIL 2 according to EN IEC 61508 and EN IEC 62061, Performance Level PL d, and Category 3 according to EN ISO 13849-1. Safety requirements are based on the standards valid at the time of certification. The IFA (Institute for Occupational Safety & Health) has approved the safety option for use in safety-related applications where the de-energized state is considered to be the safe state. All examples related to I/O included in this manual are based on achieving de-energization as the safe state.

3.1.3 Implementation in Control Systems

Often, design measures are not sufficient and protective devices are required to minimize the risk. In this context, safety sub-functions executed by SRP/CS (safety-related part of control systems) are defined. SRP/CS includes the entire safety chain with sensor (detect), logic (process), and actuator (switch).

Safety sub-functions are defined based on the application and the hazard. They are often specified in a Type C standard (a product standard), which provides precise specifications for special machines. If a C standard is not available, the machine designer defines the safety sub-functions. Typical safety sub-functions are described in more detail in EN ISO 13849-1, section 5, Specification of Safety Functions. The safety sub-functions for drive systems are described in IEC 61800-5-2.

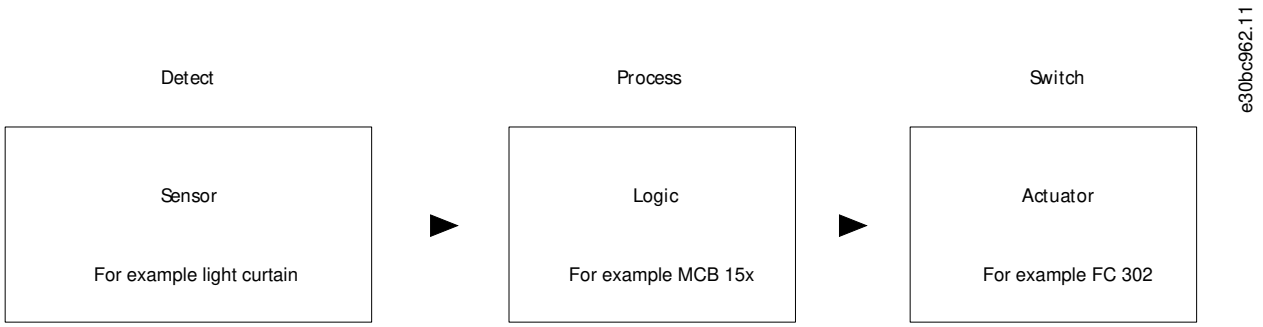


Illustration 3: Sensor-Logic-Actuator Safety Chain

3.2 Functions

3.2.1 Specification of Safety Sub-functions

The standards require a specification of functional requirements. The specification must contain details about each safety sub-function that should be executed. Also define the:

- Necessary interfaces with other control functions.
- Required error responses.
- Performance level required PLr or achievable SIL level.

3.2.1.1 Performance Level (PL) and Safety Integrity Level (SIL)

For safety-related control systems, Performance Level (PL), according to EN ISO 13849-1, and SIL levels, according to EN IEC 61508 and EN IEC 62061, include a rating of the system's ability to perform its safety sub-functions.

All the safety-related components of the control system must be included in both a risk assessment and the determination of the achieved levels. Refer to EN ISO 13849-1, EN IEC 61508, or EN IEC 62061 standards for complete information on requirements for PL and SIL determination.

3.2.2 Validation of Performance Level

Check whether the required Performance Level “PLr”, determined in the risk assessment, is achieved by the selected system for each safety sub-function used. Check the calculation using the SISTEMA SW Tool of IFA (Institute for Occupational Safety & Health). Danfoss provides a component library, which can be used for the calculation. Danfoss offers corresponding services to support the system check by calculation. The library can be downloaded from www.dguv.de/ifa/en/pra/softwa/sistema.

If using another validation method for the performance level, use the characteristic safety values specified.

3.2.3 Activation of Safety Sub-functions

- The safety sub-functions are activated using the dual-pole safe inputs on the safety option.
- These inputs operate in accordance with the fail-safe principle (on switching off). The safety control system activates the safety sub-functions via a 1/0 transition.
- Deactivate the safety sub-functions before applying any changes to them.

3.2.4 Simultaneous Activation of Safety Sub-functions

All safety sub-functions can be active at the same time. However, Safe Torque Off has priority over all other safety sub-functions. Functions already started (for example Safe Stop 1 or Safely Limited Speed) are canceled and the drive coasts.

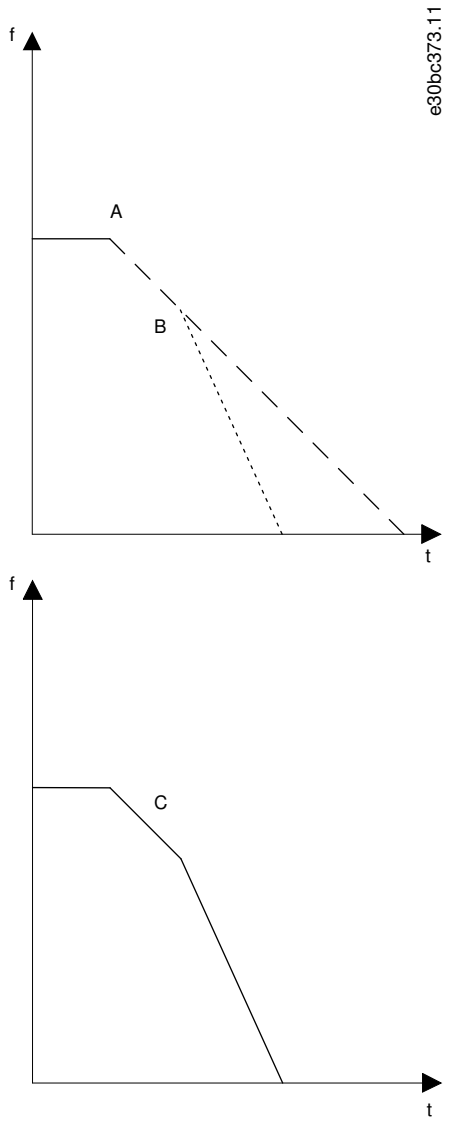
- Safe Torque Off has the highest priority. If the Safe Torque Off function is triggered, a Safe Torque Off is managed no matter what other functions are active.
- Safe Stop 1 has medium priority to the other safe functions.
- Safely Limited Speed and Safe Maximum Speed have the lowest priority.

If 2 Safe Stop 1 functions are active at the same time, the function with the steepest ramp has higher priority than the function with the less steep ramp.

If 2 Safely Limited Speed functions are active at the same time, the function with the lowest speed limit has higher priority than the function with higher speed limit.

If Safe Maximum Speed function and 1 or 2 Safely Limited Speed functions are active the same time, the function with the lowest speed limit has higher priority than the function with higher speed limit.

If 2 equal safety sub-functions have to be configured, they must be parameterized as SS1-a and SS1-b, or as SLS-a and SLS.b.



A Ramp stop function 1	**B** Ramp stop function 2
C Actual ramp stop function	

Illustration 4: Safe Stop 1 Safety Sub-functions Active

See illustration 4 for an example of first activating a Safe Stop 1 function with a given ramp and afterwards activating a 2nd Safe Stop 1 function with a steeper ramp. The lower graph shows the actual ramp function.

3.2.5 Functional Proof Tests

The functional safety standards require that functional proof tests are performed on the equipment used in the system. Proof tests are performed at user-defined intervals and depend on PFD and PFH values.

3.2.6 PFD and PFH Definitions

Safety-related systems can be classified as operating in either a low-demand mode or in a high-demand/continuous mode.

Low-demand mode

The frequency of demands for operation made on a safety-related system is maximum once per year.

High-demand/continuous mode

The SIL value for a low-demand safety-related system is directly related to order-of-magnitude ranges on its average probability of failure on demand (PFD). The SIL value for a high-demand/continuous mode safety-related system is directly related to the probability of a dangerous failure per hour (PFH).

3.2.7 Intended Use of the Safety Option

⚠ WARNING ⚠

RISK OF PERSONAL INJURY AND EQUIPMENT DAMAGE

Using the safety option for other purposes than what is intended may cause personal injury and equipment damage. The following is considered improper use:

Any component, technical, or electrical modification to the drive.

Use of the drive outside the allowed electrical and environmental conditions specified in the technical specifications and in the VLT® AutomationDrive FC 301/FC302 Operating Guide.

- Only use the safety option for its intended purpose.

The safety option is designed for use in safety-related applications. It meets the requirements for safety sub-functions in accordance with IEC 61800-5-2 regarding safe motion monitoring.

3.2.8 MCT 10 Set-up Software with Safe Plug-in

Use the MCT 10 Set-up Software to configure the safety sub-functions supported in the safety option.

- Configuration of the safety sub-functions is required for safe motion sequences. If an error or fault occurs, these functions shut down the power element of the drive in a safe and controlled way.
- Setting of limit values, braking ramps for the safety sub-functions, monitoring of motion sequences.

The software:

- Runs in full with a license key. Basic functions are available from MCT 10 Set-up Software version 3.18, all functions are available from MCT 10 Set-up Software version 4.40.
- Supports the configuration of applications with up to maximum 256 safety options per project.
- Has a simple language setting for the user interface.

A PDF file and a commissioning report can be generated for documentation of the project and all its settings.

3.3 Unit Features

The safety option has the following features:

- 2 dual-pole, digital inputs to activate the safety sub-functions in accordance with EN IEC 61800-5-2:
  - Safe Torque Off (STO).
  - Safe Stop 1 (SS1).
  - Safely Limited Speed (SLS).
- Safe speed monitoring:
  - Safe Maximum Speed (SMS) can be enabled (independent of digital inputs).
- Reset function:
  - DI2 can be used for resetting the safety option after an error or after deactivation of a safety sub-function.
- Status indicators:
  - Safe input status (LED 1 and LED 2).
  - Safe output status (LED 4).
  - LED 3 is indication for SMS.
  - By fault or warning, the LEDs indicate a failure via flash pattern, see table 26.
- Supply voltage:
  - Internally supplied by the drive.
  - 24 V DC output for safety sensors and encoder available.

3.4 Front View

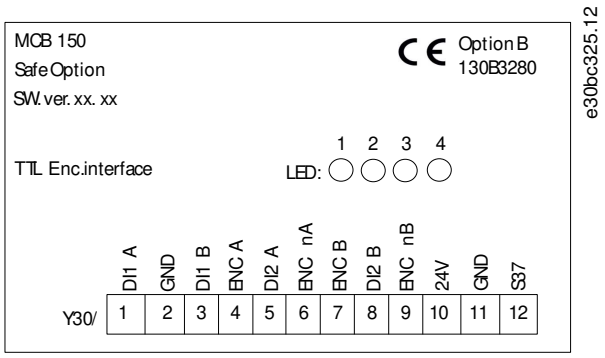


Illustration 5: VLT® Safety Option MCB 150

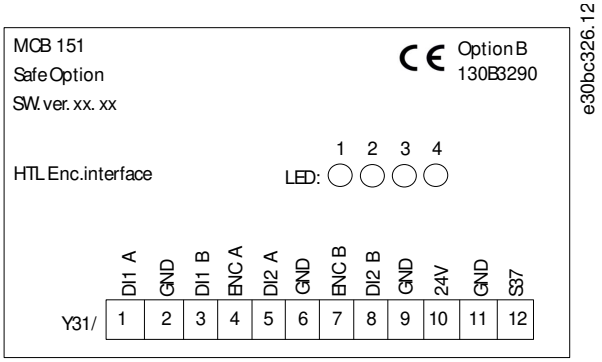


Illustration 6: VLT® Safety Option MCB 151

3.5 Categories of Safe Stop

International standard EN/ISO 13850 specifies the functional requirements and design principles of emergency stop devices.

It applies to all machines, whatever type of energy is used to control this function.

The standard allows 2 types of stop:

- Category 0 stop: Stopping by immediately cutting-off power or mechanical disconnection between the dangerous components.
- Category 1 stop: Controlled stopping with power maintained to the actuator to achieve stopping (braking for example), then cut-off of power when 0 speed is reached.

During a category 0 stop, the motor coasts down in an uncontrolled way. If access to the machine coasting down involves a hazard (results of the hazard and risk analysis), take protective measures to avoid the hazard.

Refer to EN IEC 61800-5-2:2016 (4.2.3.2) for a definition of Safe Torque Off (STO).

A category 1 stop triggers a controlled stop. The safety option monitors the controlled stop. If a power outage or an error occurs, a controlled stop is impossible. Trigger the safety sub-function Safe Torque Off after the stop to shut off the motor torque.

Refer to EN IEC 61800-5-2:2016 (4.2.3.3) for a definition of Safe Stop 1 (SS1).

An evaluation of the machine-related risks determines which of the 2 stopping methods to use.

NOTICE

When designing the machine application, consider timing and distance for a coast to stop (Stop Category 0 or Safe Torque Off). For more information regarding stop categories, refer to EN IEC 60204-1.

3.5.1 Operation and Requirements

The safety option is redundant and self-checking. It requires digital input signals from an input sensor (for example PNP proximity switch) or higher resolution TTL or HTL encoders to monitor for either safe stop or speed conditions.

3.5.2 Safety Sub-functions

Safety sub-functions maintain a safe condition or prevent hazardous conditions from arising. The safety sub-functions for drives are defined in EN IEC 61800-5-2.

The safety option implements the following safety sub-functions:

- Safe Torque Off (STO)
  - No power is being fed to the motor which can generate a rotation. Stop category 0 to EN IEC 60204-1.
- Safe Stop 1 (SS1)
  - Motor decelerates. Monitoring of deceleration ramp and Safe Torque Off following 0 speed, or Safe Torque Off at the end of a deceleration time. Stop category 1 to EN IEC 60204-1.
- Safely limited speed (SLS)
  - Prevents exceeding a defined speed value.
- Safe maximum speed (SMS)
  - Prevents continuously exceeding a defined speed value.

3.5.3 Safe Torque Off - STO

The safety sub-function Safe Torque Off disconnects power to the motor. It is implemented via the shutdown path of the drive and the safe outputs of the safety option.

Features of the safety sub-function

- The motor becomes torque-free and no longer generates any hazardous movements.
- To prevent the drive from running down in an uncontrolled manner. In normal operation, activate the safety sub-function Safe Torque Off via the safety sub-function Safe Stop 1.
- Safe Torque Off is only activated directly when:
  - There is an internal error on the safety option.
  - The Safe Stop 1 delay time is set to 0.
  - One of the inputs, DI1 or DI2, has been selected as Safe Torque Off function.
- The safety sub-function Safe Torque Off corresponds to a category 0 stop (uncontrolled stop) in accordance with EN IEC 60204-1.

Prerequisites for normal operation

- Input DI1 or DI2: "1" Signal (+24 V DC).
- S37 output: "1" Signal (+24 V DC).

Safety sub-function is activated

- By an error after limit values have been exceeded for Safe Stop 1 and Safely Limited Speed.
- By an internal error on the safety option or drive, if the drive can no longer be controlled.
- By executing the safety sub-function Safe Stop 1 (1/0 transition). In this case, the drive is monitored before it is switched to torque-free.
- By download of parameterization via MCT 10 Safe Plug-in if the current drive is running.
- By executing the safety sub-function Safe Torque Off (1/0 transition). This function ensures that no torque-generating energy can continue to affect a motor and prevents unintentional start-ups.

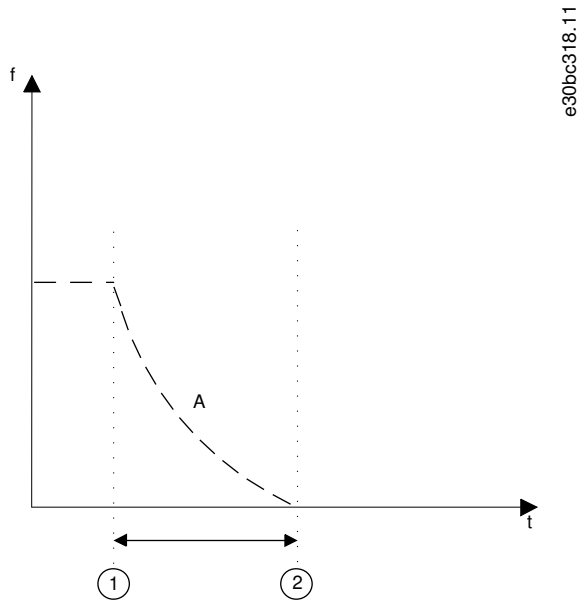
NOTICE

RISK OF HAZARD

External forces acting on the motor (vertical axis) and unwanted movements, for example caused by gravity, can cause hazards leading to death or serious injury.

- Add measures for fall protection before operating the motor.

The STO may be used where power removal is required to prevent an unintended start. The function disables the control voltage of the drive output stage. Thus, it prevents the drive from generating the voltage required to rotate the motor, see illustration 7. The function allows performing maintenance work on non-electrical parts of the machinery without switching off the power supply to the drive.



A Actual frequency	**1** Activation of STO
2 Motor standstill	

Illustration 7: Safe Torque Off

3.5.4 Safe Stop 1 - SS1

The safety sub-function Safe Stop 1 monitors the deceleration to 0 speed in a controlled manner and activates Safe Torque Off after detection of stop. The Safe Stop 1 can either be configured as SS1 Delay or SS1 Ramp.

Features of the safety sub-function

- The safety sub-function Safe Stop 1 corresponds to a category 1 stop (controlled braking) in accordance with EN IEC 60204-1.
- Monitoring the speed deceleration after which the energy supply to the motor is safely interrupted.
- The motor becomes torque-free and removes hazardous movements.

3.5.4.1 SS1 Delay

Select the SS1 Delay to activate the Safe Stop 1 function while a parameterized safety delay timer expires. STO is activated immediately when the configured stop delay has expired, regardless of speed, see 6.3 Parameter List for parameter settings.

By using SS1 Delay, the drive attempts to follow the selected ramp. After a specified delay time, STO is activated and the motor is made torque free.

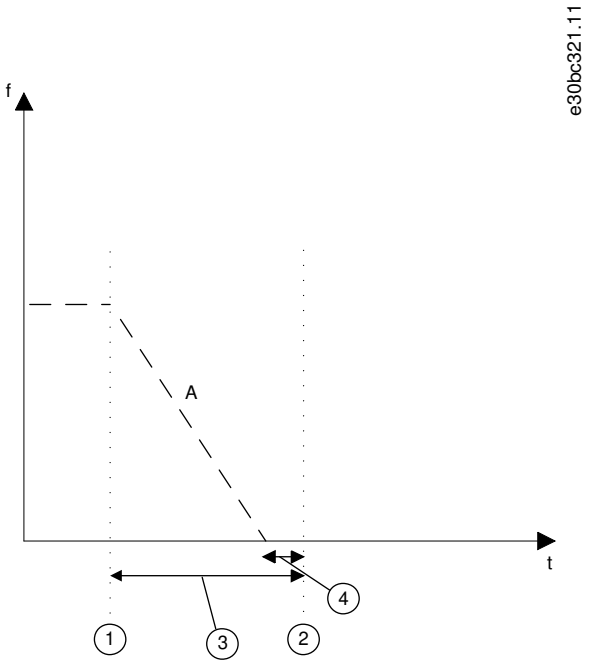
NOTICE

Using SS1 Delay may result in the motor still spinning when the Safe Torque Off is activated. The risk analysis for the machine must indicate that this behavior can be tolerated. An interlock may be required.

Default value in *parameter 42-40 Type* is *[0] Delay*. If this value is selected, the Safe Stop 1 function activates a braking ramp defined from a selected time delay in *parameter 42-42 Delay Time*. This means that the braking ramp is linear. Select the value of *parameter 42-43 Delta T* (the % of the delay time), which is a reasonable tolerance after the SS1 Delay Time has expired.

NOTICE

The SS1 Delay function does not monitor the stopping of the drive. The safety relevant time, Delta T, allows the drive to come to a stop before Safe Torque Off is activated. Thus ensuring that the system is also stopped before Safe Torque Off is activated. If a fault occurs, the drive does not come to a stop. It coasts after the time delay regardless of the speed of the drive.



A Actual frequency	**1** Activation of the SS1 Delay Timer
2 Activation of STO	**3** *Parameter 42-42 Delay Time*
4 *Parameter 42-43 Delta T*	

Illustration 8: SS1 Delay

When Safe Stop 1 function is active, the drive brings the motor to 0 speed. The Safe Torque Off function is triggered after a specified safety-relevant time. This safety sub-function corresponds to a controlled stop of the drive according to EN IEC 60204-1, stop category 1.

3.5.4.1.1 Selecting the SS1 Settings

Procedure

1. Enter *parameter 42-41 Ramp Profile*.
   Select:
   [0] Linear, if the ramp must follow a linear curve.
   [2] S-ramp Const Time, if the ramp should follow an S-ramp.

3.5.4.2 SS1 Delay with S-ramp Stop Profile

Context:

An S-ramp gives non-linear deceleration, compensating for jerks in the application.

Procedure

1. Define a speed profile by a delay (a worst-case delay from actual frequency to 0 speed) and a delay tolerance.

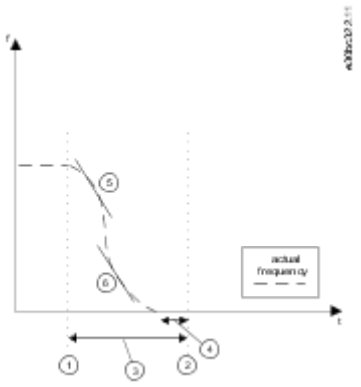
   The safety relevant time, Delta T, allows the drive to come to a stop before STO is activated. Thus ensuring that the system is also stopped before STO is activated. If a fault occurs, the drive does not come to a stop. It coasts after the time delay regardless of the drive speed.

2. Define an S-ramp configuration, which achieves 0 speed within the delay.
3. Configure the S-Ramp ratio at deceleration start in *parameter 42-48 S-ramp Ratio at Decel. Start* and set *parameter 42-49 S-ramp Ratio at Decel. End* for S-Ramp ratio at deceleration end.

Example:

Table 3: Parameters for SS1 Delay with S-ramp Stop Profile

Parameter	Unit	Range	Default
Parameter 42-42 Delay Time	s	0.1–3600.0 s	1.0 s
Parameter 42-43 Delta T	%	0–50%	5%
Parameter 42-48 S-ramp Ratio at Decel. Start	%	1–99	50
42-49 S-ramp Ratio at Decel. End	%	1–99	50



A	Actual frequency	**1**	Activation of SS1 Ramp Delay
2	Activation of STO	**3**	*Parameter 42-42 Delay Time*
4	*Parameter 42-43 Delta T*	**5**	*Parameter 42-48 S-ramp Ratio at Decel. Start*
6	*Parameter 42-49 S-ramp Ratio at Decel. End*		

Illustration 9: SS1 Delay with S-ramp Stop Profile

3.5.4.3 SS1 Ramp

NOTICE

The SS1 Ramp function can only be used when an encoder or a VLT® Sensorless Safety MCB 159 option is connected to the safety option.

This Safe Stop type allows access to the hazard area immediately after motion is detected as stopped rather than waiting until a specific time has elapsed.

The safety option monitors the following functions

- Braking ramp:
  - In the MCT 10 Set-up Software Safe Plug-in, the braking ramp is specified and monitoring is activated. The braking period depends on the speed of the motor when braking is started. The braking ramp can be monitored via a maximum speed error specified in the MCT 10 Set-up Software tolerable in *parameter 42-45 Delta V*.
- Braking ramp in normal operation:
  - The drive starts with the configured braking ramp when safety sub-function Safe Stop 1 has been activated. Once the speed is at 0 speed limit, STO is activated.
- Safety sub-function STO is activated when the configured limit value for the position error is exceeded.

A standstill threshold 0 speed (*parameter 42-46 Zero Speed*) for activating the safety sub-function STO can be specified in MCT 10 Set-up Software.

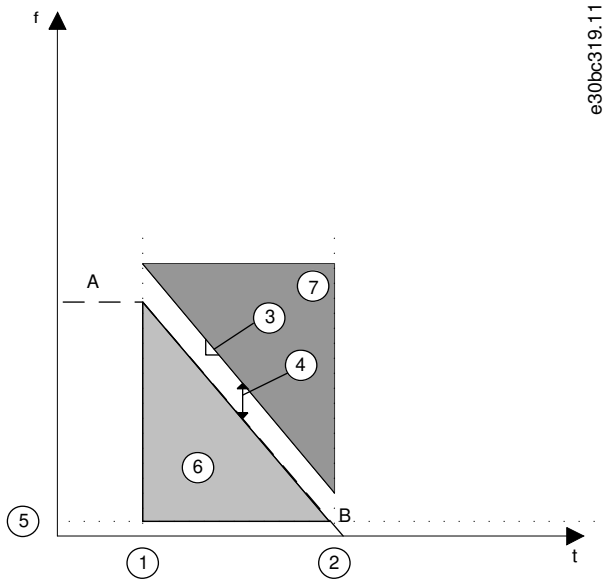
Safety sub-function STO is activated when 0 speed is achieved.

3.5.4.4 SS1 Ramp Slope

For the stopping process, the safety option initiates a stop signal to the drive and monitors the controlled braking by monitoring the braking ramp. The admissible deceleration ramp is specified in *parameter 42-44 Deceleration Rate*. If the safety option requests a Safe Stop 1, the drive must decelerate at least with the steepness of this deceleration ramp, even under heavy load. If the drive does not fulfill the admissible deceleration ramp during a Safe Stop 1 requested by the safety option, an STO is triggered immediately. The motor then performs an uncontrolled stop. This action prevents the drive from continuing to run or even accelerating if an error occurs.

Table 4: Parameters for SS1 Ramp Slope

Parameter	Unit	Range	Default
Parameter 42-44 Deceleration Rate	RPM/s	1–30000 RPM/s	1500 RPM/s
Parameter 42-45 Delta V	RPM	1–10000 RPM	120 RPM
Parameter 42-46 Zero Speed	RPM	1–600 RPM	10 RPM



A Actual frequency	**B** SS1 ramp
1 Activation of SS1 Ramp Slope	**2** Activation of STO
3 *Parameter 42-44 Deceleration Rate*	**4** *Parameter 42-45 Delta V*
5 *Parameter 42-46 Zero Speed*	**6** Safety sub-function monitors
7 Activation of failure function	

Illustration 10: SS1 Ramp Slope

When the Safe Stop 1 function is active, the drive brings the motor to 0 speed. The deceleration is monitored. If the monitored deceleration is slower than expected or at 0 speed, STO is triggered.

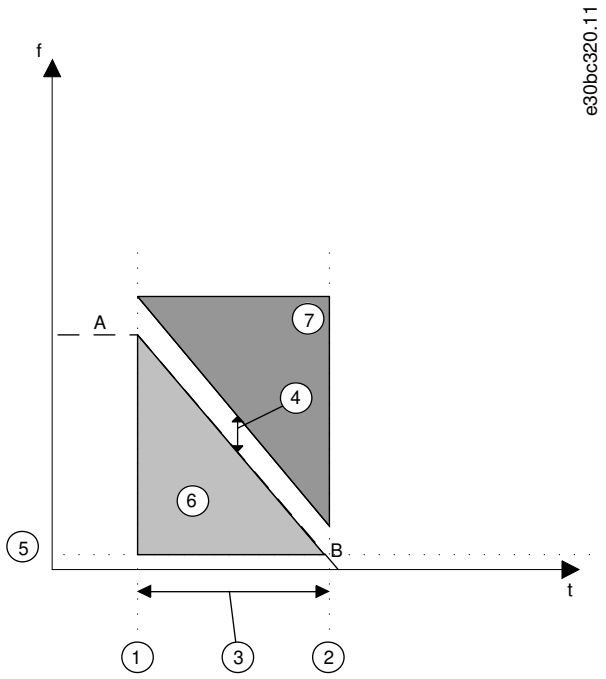
This safety sub-function corresponds to a controlled stop of the drive according to EN IEC 60204-1, stop category.

3.5.4.5 SS1 Ramp Time

Define a speed monitoring profile by a deceleration time and a tolerable speed (Delta V).

Table 5: Parameters for SS1 Ramp Time

Parameter	Unit	Range	Default
Parameter 42-47 Ramp Time	s	0.1–3600.0 s	1.0 s
Parameter 42-45 Delta V	RPM	1–10000 RPM	120 RPM
Parameter 42-46 Zero Speed	RPM	1–600 RPM	10 RPM



A Actual frequency	**B** SS1 ramp
1 Activation of SS1 Ramp Time	**2** Activation of STO
3 *Parameter 42-47 Ramp Time*	**4** *Parameter 42-45 Delta V*
5 *Parameter 42-46 Zero Speed*	**6** Safety sub-function monitors
7 Activation of failure function STO	

Illustration 11: SS1 Ramp Time

3.5.5 Safely Limited Speed

NOTICE

The Safely Limited Speed function can only be used when an encoder or a VLT® Sensorless Safety MCB 159 option is connected to the safety option.

This function is used to limit a machine speed. The main goal is to monitor the motor speed and to adjust the speed to a setpoint. There are 2 types of Safely Limited Speed:

- SLS without ramp: Monitors the motor speed and, depending on the setting of *parameter 42-52 Fail Safe Reaction*, trips in Safe Torque Off or Safe Stop 1 if an overspeed occurs.
- SLS with ramp: Limits the motor speed to a setpoint and, depending on the setting of *parameter 42-52 Fail Safe Reaction*, trips in STO or Safe Stop 1, if an overspeed occurs.

The Safely Limited Speed is given as speed limit in *parameter 42-51 Speed Limit*. The value for the cut-off speed partly depends on the motor that is being used. A suggested value from the MCT 10 Set-up Software calculates a value for which Danfoss guarantees functionality. This value is called delta speed limit and is added to the selected speed limit and suggested as value in *parameter 42-50 Cut Off Speed*.

3.5.5.1 SLS without Ramp

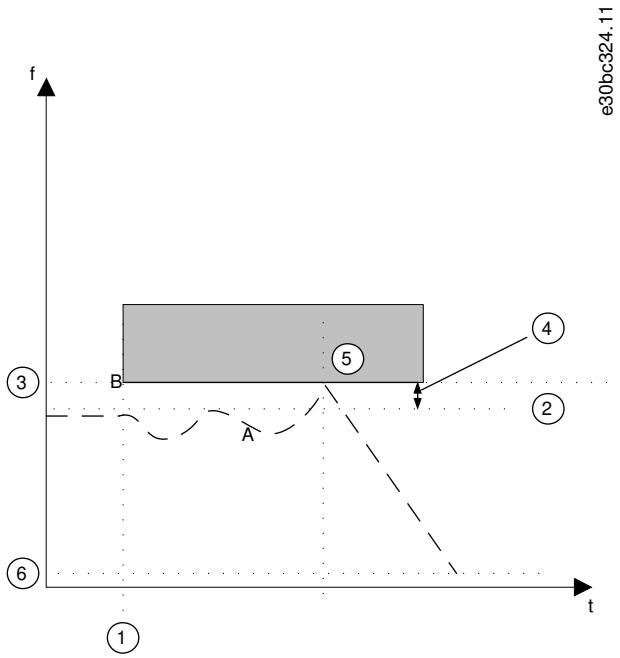
The safety sub-function Safely Limited Speed monitors whether a specified velocity value is exceeded since it was activated via DI1 or DI2. The function is active until the selected input has been put to high again.

If 2 safe-speed limits must be monitored, set 1 of the 2 Safe Digital Inputs DI1 or DI2 in *parameter 42-20 Safe Function* to SLSa or SLS-b. Then select the input type in *parameter 42-21 Type*.

The cut-off speed represents the maximum allowed frequency of the actual motor frequency. If the motor frequency accelerates above that value, the safety option enters external fault selected (STO or SS1 Ramp), and the error is given. The frequency value at which a shutdown is realized should be parameterized in *parameter 42-50 Cut Off Speed*.

Table 6: Parameters for SLS without Ramp

Parameter	Unit	Range	Default
Parameter 42-50 Cut Off Speed	RPM	120–10000 RPM	270 RPM
Parameter 42-51 Speed Limit	RPM	1–9999	150 RPM
Parameter 42-52 Fail Safe Reaction	n/a	STO/SS1	STO

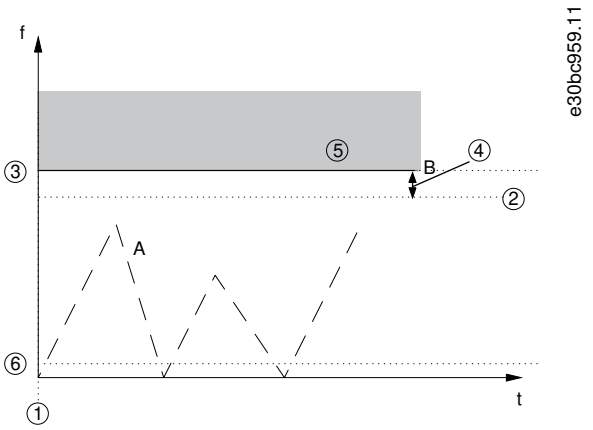


A	Actual frequency	**B**	SLS limit
1	SLS is activated	**2**	*Parameter 42-51 Speed Limit*
3	*Parameter 42-50 Cut Off Speed*	**4**	Delta speed limit
5	Activation of failure function set in *parameter 42-52 Fail Safe Reaction*	**6**	Fixed value of 120 RPM in *parameter 42-19 Zero Speed Limit*

Illustration 12: SLS without Ramp

If speed exceeds the limit, *parameter 42-52 Fail Safe Reaction* is activated. The safety sub-function can either be STO or SS1 Ramp Time. SS1 can only be triggered as error response if a Safe Stop 1 function has been set as Safe Stop 1 with ramp time function, set in *parameter 42-40 Type*.

Safe jog with SLS



A	Actual frequency	**B**	SLS limit
1	SLS is activated	**2**	*Parameter 42-51 Speed Limit*
3	*Parameter 42-50 Cut Off Speed*	**4**	Delta speed limit
5	Activation of failure function set in *parameter 42-52 Fail Safe Reaction*	**6**	Fixed value of 120 RPM in *parameter 42-19 Zero Speed Limit*

Illustration 13: Safe Jog

Access under specific conditions of reduced risk

Under specific conditions of reduced risk, safe jog allows access to areas for fault-finding, commissioning, and more. On machines where safe jog (jogging or inching) is required, this is also possible from 0 speed setpoint. By activating SLS, the motor can be moved at safe jog resulting in several cycles and with safely monitored movements. The motor can be started and stopped continuously also from 0 speed.

3.5.5.2 SLS with Ramp

If this safety sub-function is needed, configure the safety option for Safely Limited Speed (SLS). When the inputs DI1 or DI2 are selected as SLS, input is OFF, feedback velocity is monitored and compared against a configurable safe speed limit.

Select *parameter 42-53 Start Ramp* to configure an SLS Monitoring Ramp. The ramping begins when SLS monitoring is requested by the selected input for SLS transition from ON to OFF. The safety option starts monitoring for Safely Limited Speed when the ramp-down times out. If the system speed exceeds or is equal to the configured safe speed limit during Safely Limited Speed monitoring, a Safely Limited Speed fault occurs. The safety option then initiates the configured Safe Stop type selected in *parameter -52 Fail Safe Reaction*.

The ramping begins at the absolute value of the actual speed. If the actual speed is already below the Safely Limited Speed limit, the limit comes into effect immediately without ramping. When the Safely Limited Speed function is deactivated, the speed limits are ramped up back to the values defined in *parameter group 3-1* References*. The actual speed then returns to the reference value if it was limited by this function.

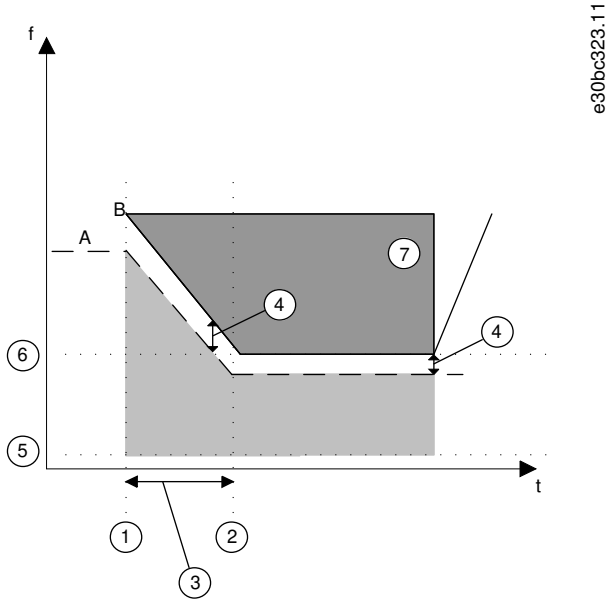
3.5.5.2.1 Configuring SLS Operation

Procedure

1. If a safe speed limit must be monitored, set 1 of the 2 safe digital inputs, DI1 or DI2, to *[1] SLS-a* or *[2] SLS-b* in *parameter 42-20 Safe Function*.
2. Select input type in *parameter 42-21 Type*.
3. Select *parameter 42-53 Start Ramp* to run Safely Limited Speed with monitored braking ramp. The default value is *[0] No* for applications without SLS Ramp control.
4. Set the time allowed to reach Safely Limited Speed in *parameter 42-54 Ramp Down Time*.

   When the safety option actively monitors Safely Limited Speed, and the motor speed is at or below the configured safe speed limit, the function monitors the speed until the function is deactivated.
5. Set the value in *parameter 42-50 Cut Off Speed*.

Example:



A	Actual frequency	**B**	SLS limit
1	SLS is activated with SS1 Ramp	**2**	SLS speed limit reached
3	Ramp-down time	**4**	Delta speed limit
5	0 speed limit, fixed value of 120 RPM	**6**	Cut-off speed
7	Activation of failure function set in *parameter 42-52 Fail Safe Reaction*		

Illustration 14: SLS with Ramp

Table 7: Parameters for SLS with Ramp

Parameter	Unit	Range	Default
Parameter 42-50 Cut Off Speed	RPM	120–10000 RPM	270 RPM

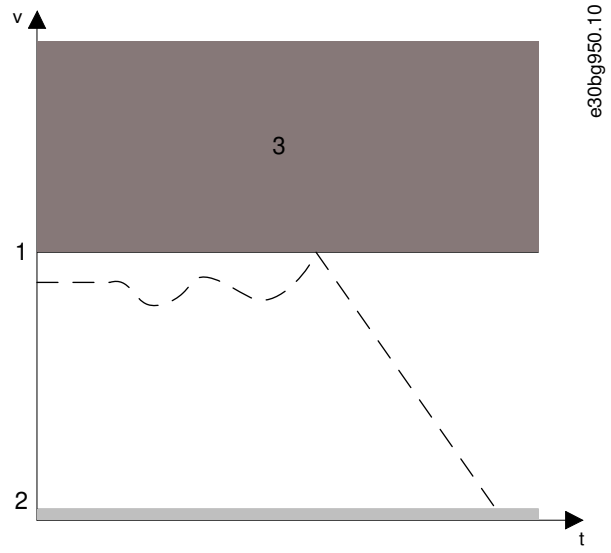
Parameter	Unit	Range	Default
Parameter 42-51 Speed Limit	RPM	1–9999 RPM	150 RPM
Parameter 42-52 Fail Safe Reaction	n/a	Safe Torque Off/Safe Stop 1	Safe Torque Off
Parameter 42-53 Start Ramp	n/a	No/Yes	No
Parameter 42-54 Ramp Down Time	s	0.1–3600.0 s	1.0 s

If the speed exceeds the limit, *parameter 42-52 Fail Safe Reaction* is activated. The safety sub-function can either be STO or SS1 Ramp Time. SS1 can only be triggered as error response if 1 digital input is selected as SS1 with ramp time function, set in *parameter 42-40 Type*.

3.5.6 Safe Maximum Speed - SMS

Use the SMS function to monitor machine speed. When maximum allowed speed is exceeded, STO is activated as fail-safe reaction.

The Safe Maximum Speed is given as *SMS Cut Off Speed Limit* in *parameter 42-71 Cut Off Speed*.



1 Cut-off speed	**2** Zero speed limit
3 Activation of STO	

Illustration 15: Safe Maximum Speed

Table 8: Parameters for SMS

Parameter	Unit	Range	Default
Parameter 42-70 Activation	n/a	Inactive/active	Inactive
Parameter 42-71 Cut Off Speed	RPM	120–20000	1500

3.6 Inputs and Output

An internal diagnostic function in the safety option cyclically tests the correct function of the output. A detected fault sets the safety option into an alarm status. At the same time, the option output S37 goes low.

Shorts between the 2 lines of a dual channel input are not detected. Therefore the cables of the channels must be routed separately to exclude short circuits.

NOTICE

Shield all proximity switch sensor/encoder cables. Connect the shielding to the chassis at both ends.

3.6.1 Inputs

The Dual-pole digital inputs are used to activate the safety sub-functions. DI 1 can be:

- STO: Safe Torque Off.
- SS1: Safe Stop 1.
- SLS: Safely Limited Speed.

Signals at DI1:

- 1/0 transition at the input: Activates the safety sub-function.
- 0 signal (0 V) at the input: Activates the safety sub-function.
- 1 signal (+24 V) at the input: Does not activate the safety sub-function.

DI2 can be:

- STO: Safe Torque Off.
- SS1: Safe Stop 1.
- SLS: Safely Limited Speed.
- Reset: Extra safe input to reset the safety option after an error, or after deactivating a safety sub-function.

Signals at DI2:

- 1/0 transition at the input: Activates the safety sub-function.
- 0 signal (0 V) at the input: Activates the safety sub-function.
- 1 signal (+24 V) at the input: Does not activate the safety sub-function.
- 0/1 transition at the DI2 input if configured to reset: Resets the safety option.

3.6.2 Reset Input (DI2)

The reset input is for resetting the safety circuit selected on DI1. Configure the reset input for automatic or manual reset types. If manual reset is configured, wire the DI2A reset input terminal to a 24 V DC via an NO switch.

3.6.3 Output

Safe, single-pole output

S37 is the output that goes to the STO input of the drive.

- STO Acknowledge
  - Internal fault on drive or safety option.
  - Limit values exceeded.
  - Activated via SS1.
  - PUST (Power-up Self-Test).
  - External failure.

3.6.4 Allowed Sensor Types on Digital Inputs

The following sensor types are applicable:

- Sensors with 2 NC switches.
- Antivalent switches (1 NO switch and 1 NC switch).
- Sensor output of type 2xPNP.

Sensors with 2 NO switches are not applicable.

The safe digital inputs are configured for both directly connecting safety sensors, for example emergency stop control devices or light curtains, and for connecting preprocessing safety relays, for example, safe controls. See examples of connecting the safe digital input, in accordance with EN ISO 13849-1 and EN IEC 62061 in 4.3.1 Connecting Safe Digital Inputs.

3.6.5 Reset

NOTICE

Both safety inputs must be off after an input fault or PUST has occurred, before a reset is accepted to branch into safe monitoring again. This reset must only be possible at the location where the safety command has been initiated.

To operate the safety option, the application must send a reset signal either via the LCP, via a dedicated digital input or via a control word. When a safety sub-function has been activated, or an external failure has caused a failure state, a reset is necessary to enable the safety option again. When the connected sensor on DI1 or DI2, or both, is enabled via a reset, the safety option can be switched on again. This deactivates active safety sub-functions or errors.

NOTICE

First, trip alarms shown on the drive must be acknowledged after which a pending safety sub-function can be acknowledged. A single reset for the alarm mode and a 2nd reset for acknowledgement of the active safety sub-function. Alarms caused by the drive must be reset before an alarm can be reset on the safety option.

3.6.6 Signal Filtering

If a sensor with 2NC or 1NC/NO is selected, the safety option checks the signals of the safe digital input for consistency. Consistent signals at both inputs always assume the same signal state (high or low). If 1NC/1NO is selected, it checks the right state of each input.

With electromechanical sensors (for example, emergency stop buttons or door switches), the 2 sensor switches never switch at the same time (discrepancy). A long-term discrepancy points towards a fault in the wiring of a safe input, for example, a wire break. An adjustable filter in the safety option prevents faults caused by temporary or short-term discrepancy. Within the filter tolerance time (*parameter 42-22 Discrepancy Time*), the safety option suppresses the discrepancy monitoring of the safe inputs.

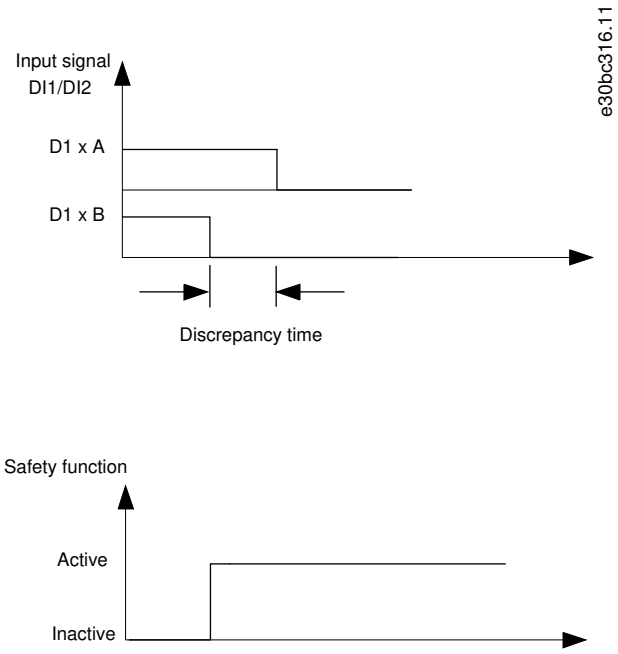


Illustration 16: Discrepancy Time

Parameterize the discrepancy time of the switching elements connected to the digital inputs. The default value is 10 ms.

NOTICE

The discrepancy time does not extend the safety option response time. The safety option activates its safety sub-function when 1 of the 2 DI signals changes from high to low.

3.6.7 Stable Signal Time from Safe Outputs

The safety option normally responds immediately to signal changes at its safe input DI1 or DI2. This response is not required in the following cases:

- When interconnecting the safe input of the option with an electromechanical sensor, contact bounce may result in signal changes occurring, to which the option could respond.
- Several control modules test their safe outputs using test pulse pattern (on/off tests), to identify faults due to either short or cross circuiting. When interconnecting the safe input of the option with a safe output of a control module, the option could respond to these test signals.

A signal change during a test pulse pattern usually lasts 1 ms.

Under stable signal time, short pulses, which could lead to safety sub-functions being incorrectly activated, can be filtered.

NOTICE

The stable signal time extends the safety option response time. The safety option only activates the safety sub-function after the response time has expired.

If the signal to the input on safety option is not stable, the option responds with a fault.

Definition of a Stable Signal

Following a change to the DI input signals, the option triggers an internal monitoring time. Use *parameter 42-23 Stable Signal Time* to select an appropriate stable signal time. A constant signal level is a high or a low state, at least for the time specified in *parameter 42-23 Stable Signal Time*.

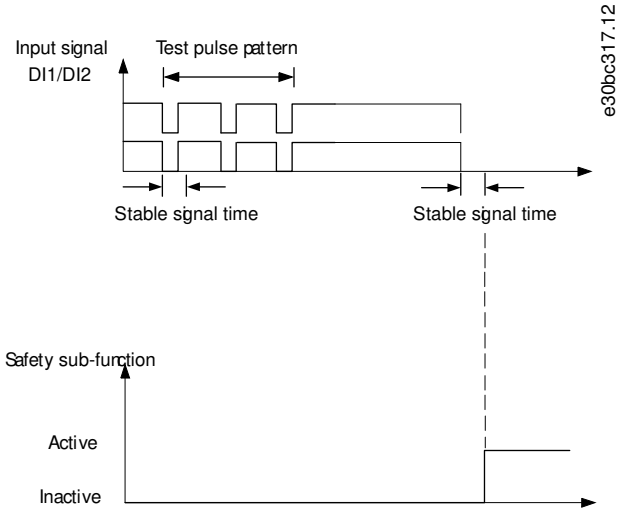


Illustration 17: Filter for Suppressing Temporary Signal Changes

3.6.8 Zero Speed Timer Error Detection

Zero Speed Timer monitors if the drive operates below 120 RPM during Safely Limited Speed.

Parameter 42-18 Zero Speed Timer contains the remaining time until the monitoring responds. The safety option signals *Alarm Ext Fail Prec Thresh Timer Elapsed* after the monitoring time expires. Define the monitoring time while commissioning the system depending on the particular application.

3.6.9 Yearly Test

According to EN ISO 13849-1, EN IEC 62061, and EN IEC 61508, the safety option must regularly test its safety-relevant circuits to ensure correct functioning. This test must be performed at least once every year. After the power supply has been connected, the safety option checks its circuits to switch off the torque each time the STO function is selected. The safety option monitors the regular test interval of its safety-relevant circuits using a time module.

After 1 year in operation, the drive shows a message that a yearly test must be performed. Power cycle the drive by disconnecting and then reconnecting the supply voltage. Activate the used inputs on the safety option and check that they function correctly.

3.6.10 Safety Parameter Settings

Factory setting for both digital inputs is Safe Torque Off, meaning that the Safe Output S37 is in low state.

At the first power-up, the option shows Blank Initial State.

Properties of safety parameters

- They are kept separate for each monitoring channel.
- During start-up, a checksum (cyclic redundancy check, CRC) over the safety parameters is generated and checked. The parameters are stored in the non-volatile memory on the option.

A reset of the safety parameters to the factory setting can be executed via the MCT 10 Set-up Software.

NOTICE

If the safety option is reinstalled in another drive, all safety parameters can be selected either from the safety option or from the drive in which the option is now installed. Always perform a commissioning test to ensure the correct functionality.

3.6.11 Encoder Interface

NOTICE

Some of the diagnostics performed on the encoder signals require motion to detect faults. Make sure that motion occurs at least once every 12 months.

To detect the standstill or the motor speed, the speed (frequency) is measured using a TTL encoder (MCB 150), an HTL encoder (MCB 151), a PNP proximity switch (MCB 151), or VLT® Sensorless Safety MCB 159 option (MCB 151). The HTL encoder uses 2 signal tracks, A and B. TTL encoders use 4 signal tracks A, B, and their inverted tracks nA, nB.

Use twisted-pair, individually shielded cable to connect encoders to the safety option.

3.7 Limitations

3.7.1 Exceeded Limit Value and Internal Errors

- Exceeding set limit values activates the stop braking ramp.
- Any internal error on the safety option or drive activates the safety sub-function STO. The drive coasts the motor.

Internal errors always result in a fault, requiring a power cycle of the drive to reset the failure. Alternatively, use *parameter 42-90 Restart Safe Option* to restart the safety option after internal failure without power cycling the drive.

3.7.2 Limitations when Using Safe Speed Monitoring Functions

Operations with pulling loads

⚠ WARNING ⚠

UNEXPECTED LOAD ACCELERATION WITH PULLING LOADS

The encoderless actual value sensing does not identify all faults and errors as in a closed-loop motor control. As a consequence, encoderless safety sub-functions cannot identify whether or not a pulling load unintendedly accelerates the motor.

- Never use safety sub-functions with encoderless speed monitoring for drives with pulling loads.
- Implement speed monitoring in machines with pulling loads by using an encoder that is mounted on the motor shaft or within the application, and connected to the VLT® Safety Option MCB 150/151.

3.7.3 Compatibility between Safety and Drive Function

The safety option is compatible with all VLT AutomationDrive FC 302 drives.

MCB 150/151 can be combined with the following A options:

- VLT® PROFIBUS DP-V1 MCA101
- VLT® DeviceNet MCA 104
- VLT® CanOpenMCA 105
- VLT® PROFINET MCA 120
- VLT® EtherNet/IP MCA 121
- VLT® Modbus TCP MCA 122
- VLT® POWERLINK MCA 123
- VLT® EtherCAT MCA 124

The MCB 151 can be combined with the following C options:

- VLT® Sensorless Safety MCB 159

The safety option is compatible with asynchronous and synchronous (PM) motors. Both motor types can be used in U/f and VVC+ in closed and open loop as well as in FLUX open-loop control. Compliance to further motor types and control modes is to come. Contact the local supplier for latest information.

The following software versions are required as a minimum for using MCB 150/151:

- LCP software version 7.0.
- VLT AutomationDrive FC 302 firmware version 6.64.

For full functionality, the following software versions are required as a minimum for using MCB 150/151:

- LCP software version 7.0.
- VLT AutomationDrive FC 302 firmware version 8.30.

All drives, options, and control mode combinations not listed above are not allowed.

4 Installation

4.1 Installing the Option

4.1.1 Safety Instructions

⚠ WARNING ⚠

RISK OF DEATH OR INJURY

The AC drive contains high voltage when connected to AC mains supply, DC supply, or load sharing. Failure to follow the instructions in this warning may result in death or serious injury.

- Before installation, disconnect the power supply voltage to the drive.
- Switch off all dangerous voltages connected from external control circuits to the inputs and outputs of the drive.
- Never install an option card into the drive during operation.
- In addition to conventional installation tools, have the VLT AutomationDrive FC 302 Operating Guide and the VLT® Motion Control Tools MCT 10 Operating Guide available as they contain important information that is not included in this manual.

⚠ WARNING ⚠

ELECTRICAL HAZARD

Activation of STO does not provide electrical safety. The safety device connected to the dual-pole input of the safety option must fulfill the required safety level for the application for interrupting the voltage/current to the safety option. This is also valid for the connections between the safety option's safe output S37 and terminal 37 on the drive.

- To connect the safety device correctly to the safety option, read and follow the instructions in this manual.

NOTICE

The safety option is exclusively intended for use in option slot B.

4.1.2 Requirements for Safe Use

⚠ CAUTION ⚠

EMC-COMPLIANT INSTALLATION

An installation that is not EMC-compliant can cause personal injury and equipment damage.

- Ensure that the installation and the wiring are EMC-compliant.

Refer to the guidelines in this manual. Also ensure compliance with:

- VLT AutomationDrive FC 301/FC 302 Operating Guide.
- Tool-Tip help for the configuration tool MCT 10 Safe Plug-in.

Only use the safety option with the following drives:

- VLT AutomationDrive FC 302 from software version 6.64.

4.1.3 Protected Cable Installation

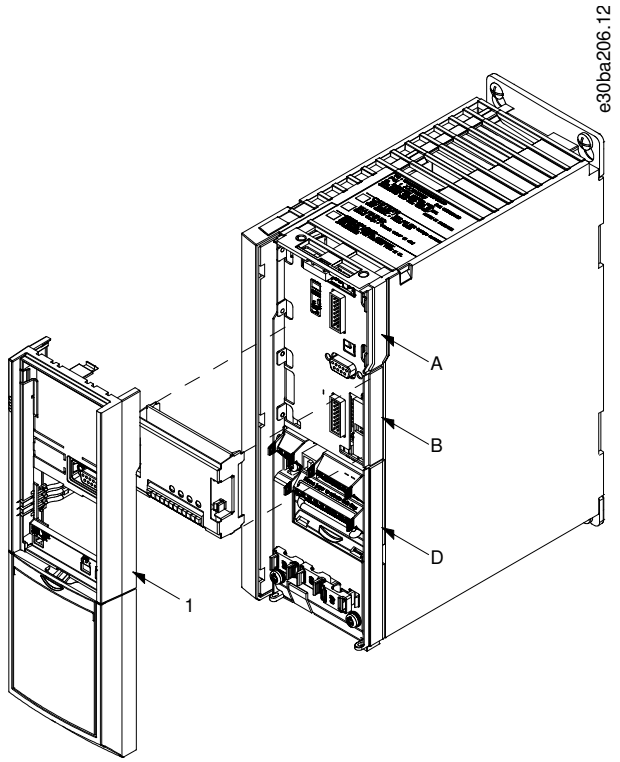
If short circuits and cross circuits can be expected with safety-related signals, and if they are not detected by upstream devices, protected cable installation is required as per EN ISO 13849-2.

4.1.4 Installing the Option

Context:

NOTICE

Place the VLT AutomationDrive FC 302 with safety option (including connection between S37 (Y30/12 or Y31/12) on VLT® Safety Option MCB 150/151 and X44/12 on the control card) in an IP54 enclosure as per IEC 60529.



A A-option slot	**B** B-option slot
D D-option slot	**1** LCP frame

Illustration 18: How to Fit the Safety Option

Procedure

1. Disconnect power from the drive.
2. Remove the LCP, the terminal cover, and the LCP frame from the drive.
3. Fit the safety option in slot B.
4. Remove the jumper wire between control terminals 31 and 12, or 13.

Cutting or breaking the jumper is not sufficient to avoid short-circuiting.

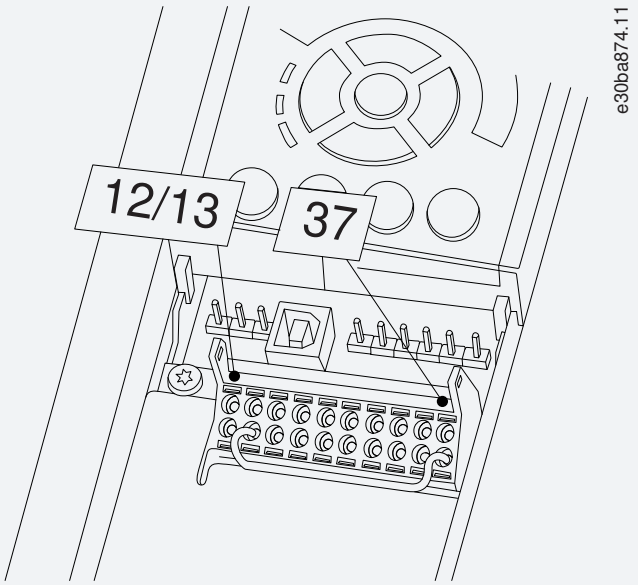


Illustration 19: Jumper between Terminals 12/13 and 37

5. Connect the safe output S37 on the safety option to terminal 37 on the control card (maximum length of this wire is 100 mm (3.9 in)).
6. Connect the control cables to the safety option and relieve the cable by the enclosed cable strips. Follow the guidelines in 4.1.5 General Wiring Guidelines.

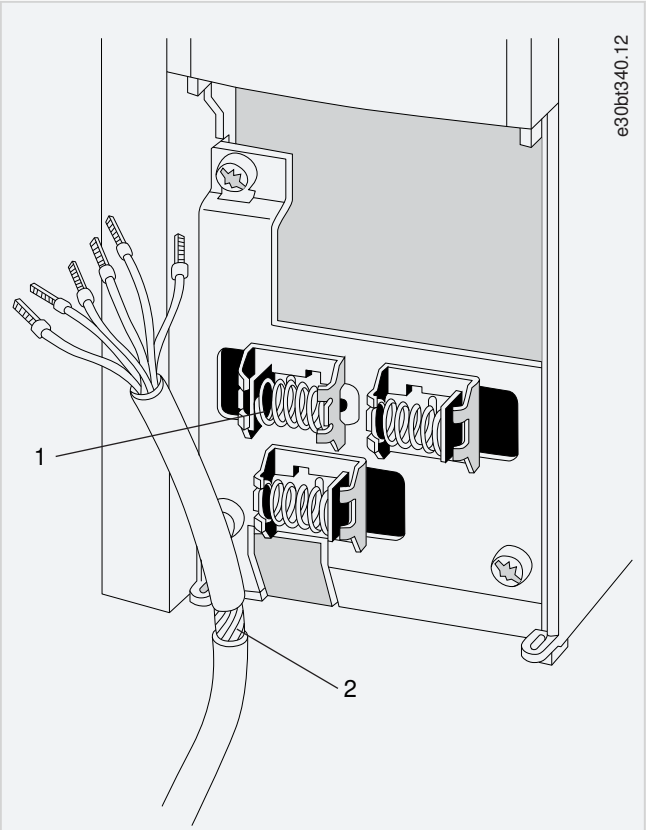


Illustration 20: Connecting the Shielded Wire

7. Remove the knock-out in the extended LCP frame so that the option fits under the frame.
8. Fit the extended LCP frame and terminal cover.

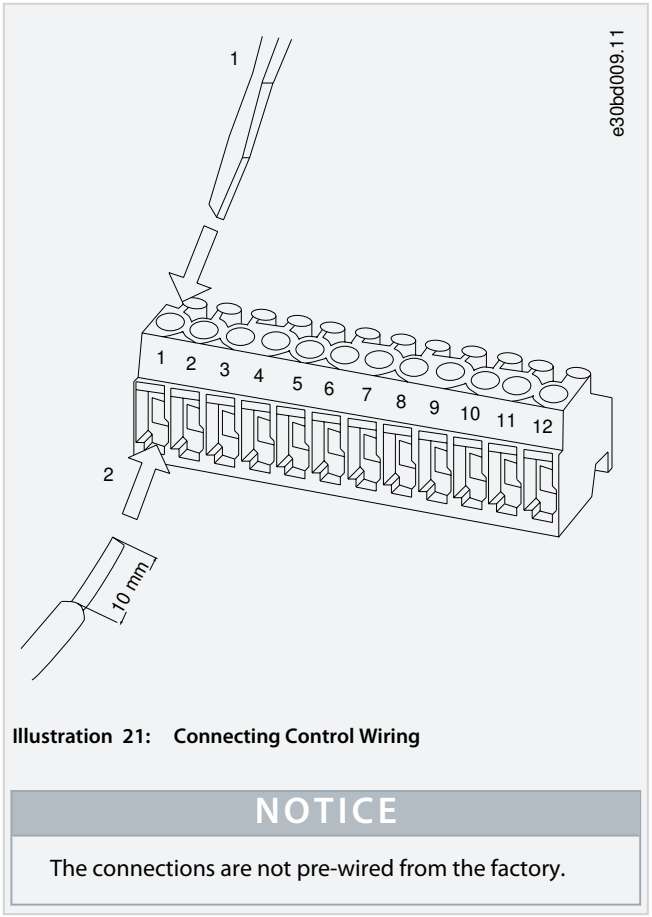


Illustration 21: Connecting Control Wiring

NOTICE

The connections are not pre-wired from the factory.

9. Fit the LCP or blind cover in the extended LCP frame.

Connect power to the drive.

Set up the input/output functions in the corresponding parameters as mentioned in the *chapter Safe Plug-in* in the VLT® Motion Control Tool MCT 10 Operating Guide.

→ The commissioning test report is automatically generated via the Safe Plug-in in MCT 10 after downloading the parameters to the safety option.

⚠ WARNING ⚠

PROPER GROUNDING

Qualified personnel, in this case the operator or electrical installer, is responsible for proper grounding and compliance with all applicable national and local safety regulations. Failure to have qualified personnel doing the wiring could result in death or serious injury.

- Only allow qualified personnel to do the wiring of the equipment.

4.1.5 General Wiring Guidelines

Inputs

Use appropriate wiring to exclude short circuits between the inputs or to a supply line.

Output

Use separate multicore cable for supply voltages to avoid short circuits between the cable from the output (S37) to the 24 V DC supply line.

NOTICE

As a result of short circuits, it is no longer possible to switch off the drive terminal 37.

NOTICE

Control cables must be shielded/armored.

See the *chapter Grounding of Shielded Control Cables* in the VLT AutomationDrive FC 302 Design Guide for detailed specifications.

Only shielded cables are suitable for connecting encoders.

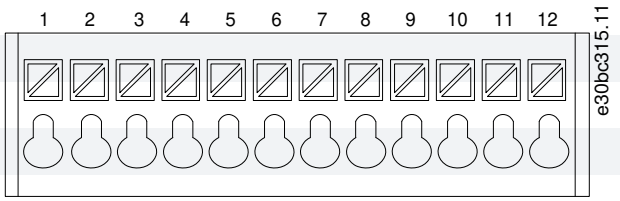
NOTICE

All signals to the safety option must be PELV supplied and comply with EN IEC 60204.

- Route sensitive control cables - such as encoder and active safety component cables - without any interruption and with optimum shield support at both ends.
- Connect shields at both ends to the grounded enclosures through a good electrical connection and through a large surface area.
- Connect cable shields as close as possible to the cabinet cable entry.
- If possible, intermediate terminals should not interrupt cable shields.
- Retain cable shields for both power cables and for signal and data cables using the appropriate EMC clamps. The shield clamps must connect the shield to the EMC shield bar of the shield support element for control cables through a low inductive connection through a large surface area.

4.1.6 Connector Pin Assignment

Table 9: Connector Pin Assignment, VLT® Safety Option MCB 150

Y30	Pin	Name	Description
	1	DI1 A	Digital input 1 A channel
	2	GND	Digital GND
	3	DI1 B	Digital input 1 B channel
	4	ENC A	Encoder channel A
	5	DI2 A	Digital input 2 A channel
	6	ENC nA	Encoder channel A inverted
	7	ENC B	Encoder channel B
	8	DI2 B	Digital input 2 B channel
	9	ENC nB	Encoder channel B inverted
	10	24 V	Power output
	11	GND	Supply GND
	12	S37	STO enable

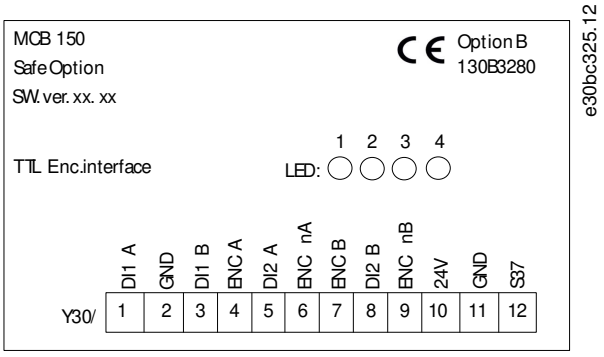
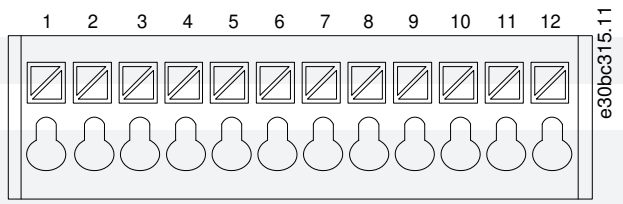


Illustration 23: Nameplate MCB 150

Table 10: Connector Pin Assignment, VLT® Safety Option MCB 151

Y31	Pin	Name	Description
	1	DI1 A	Digital input 1 A channel
	2	GND	Digital GND
	3	DI1 B	Digital input 1 B channel
	4	ENC A	Encoder channel A/VLT® Sensorless Safety MCB 159
	5	DI2 A	Digital input 2 A channel
	6	GND	Digital GND
	7	ENC B	Encoder channel B
	8	DI2 B	Digital input 2 B channel
	9	GND	Digital GND
	10	24 V	Power output
	11	GND	Supply GND
	12	S37	STO enable

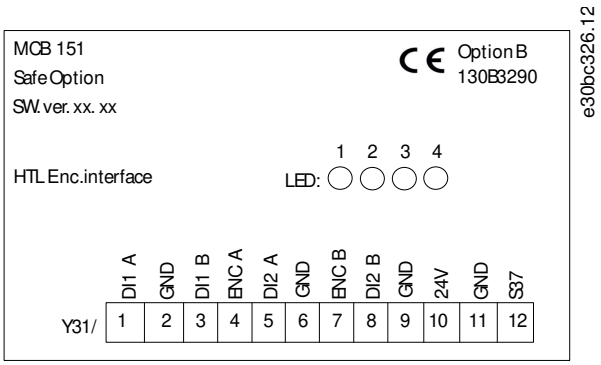


Illustration 25: Nameplate MCB 151

4.2 Encoder

4.2.1 Allowed Encoder Cable Length

The allowed cable length depends on the selected encoder. The longest cable can be achieved when using bipolar TTL encoders. Unipolar HTL encoders only allow a shorter length. In this case, the encoder power supply voltage plays a decisive role. The maximum cable length for HTL encoders used as unipolar encoder (in this case only 1 signal is evaluated) is 100 m (328 ft).

The maximum cable length for TTL encoders used as bipolar encoder (in this case both signals A/nA or B/nB) is 150 m (492 ft).

The minimum cross-section of the power supply conductor is 0.75 mm^2 (18 AWG).

NOTICE

Shield all proximity switch sensor/encoder cables. Connect the shield to the chassis at both ends. Always connect the chassis on the rotary encoder to the chassis of the drive.

NOTICE

EQUIPMENT DAMAGE

Plugging in or pulling off sensor connections during operation can damage the electrical components of the encoder.

- Always de-energize connected encoders and the safety option before plugging in or pulling off encoder connections.
- For data signals or track A and track B, use lines twisted in pairs for signal transmission according to RS485.
- Select the wire cross-section in each individual case in compliance with the current consumption of the encoder and the cable length required for the installation.

Diagnostics are performed on the encoder input signals. If the encoder diagnostic tests fail, error 99 (*Safe State Fault*) occurs.

4.2.2 Encoder Wiring Examples

See examples of how to connect encoder power and encoder signals in illustration 26 and illustration 27.

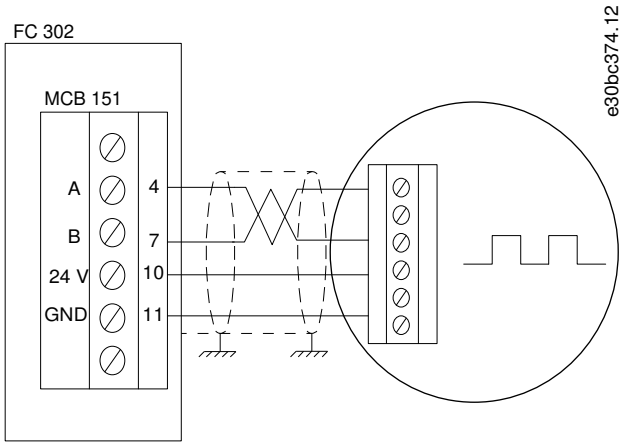


Illustration 26: Y31/Connecting Power and Encoder Signals to HTL Encoder (VLT® Safety Option MCB 151)

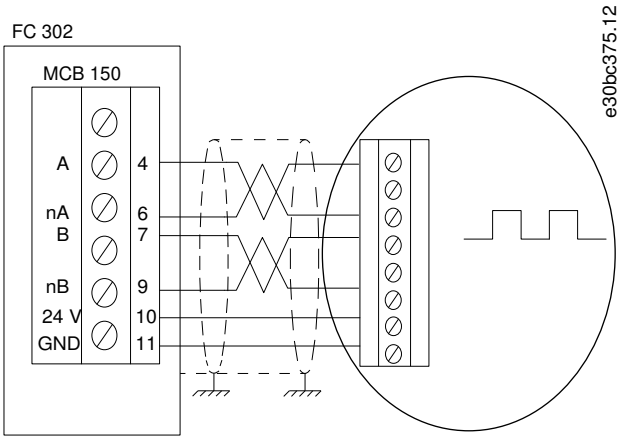


Illustration 27: Y30/Connecting Power and Differential Encoder Signals to TTL Encoder (VLT® Safety Option MCB 150)

The TTL encoder in illustration 27 is shown with 24 V supply and TTL output. If an encoder for 5 V supply must be connected, use a 5 V external supply.

4.2.3 Proximity Switch

An inductive proximity switch, detecting already present mechanical parts, for example a gear wheel, is a frequently used alternative to standard encoders. The required minimum number of pulses per revolution (PPR) is 2 on the motor shaft while considering the gear ratio.

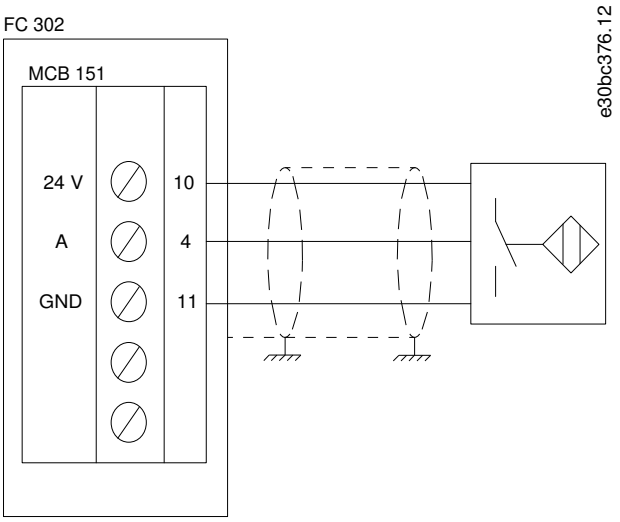
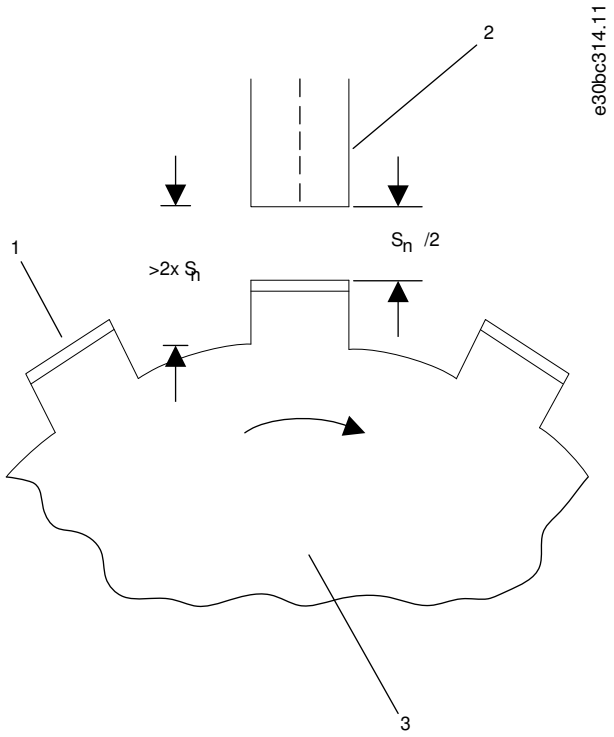


Illustration 28: Y/31 Connecting VLT® Safety Option MCB 151 to Proximity Switch (only HTL)

NOTICE

Shield and terminate the proximity switch cable to chassis at both ends (at the proximity switch side and at the option side).



1 Measuring plate	**2** Proximity switch
3 Disc (non-conducting material)	

Illustration 29: Gear Wheel for Proximity Switch

The operating distance S, set to half the nominal operating distance S_n, corresponds approximately to the optimum conditions regarding resolution and switching frequency.

NOTICE

When using PNP proximity switch as encoder feedback, set *parameter 42-14 Feedback Type* to *[1] Without direction info*.

4.2.4 VLT® Sensorless Safety MCB 159

The VLT® Sensorless Safety MCB 159 option provides safe speed monitoring functions (SLS, SMS) to a VLT® Safety Option MCB 151 without the need of an external speed signal. It can easily replace a speed sensor in applications where typically proximity switches are used as a speed feedback. Only 1 wire connects the MCB 159 option to the MCB 151.

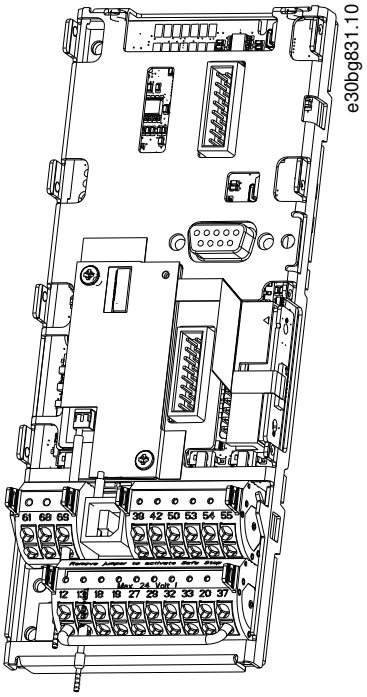
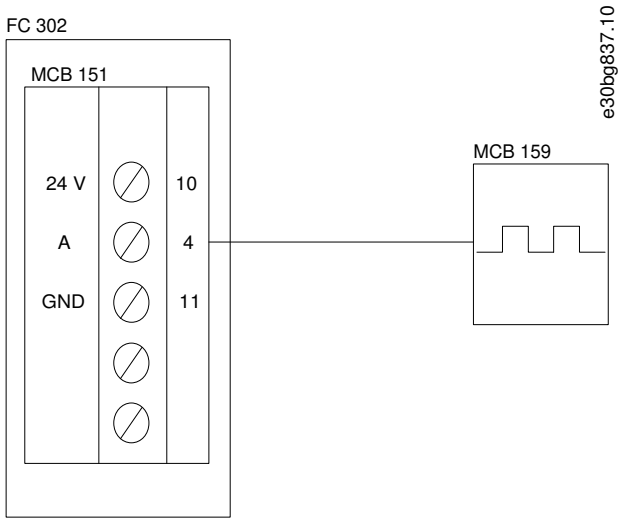


Illustration 30: The MCB 159 Installed

4.2.4.1 Connecting a VLT® Sensorless Safety MCB 159 (MCB 151 Only)

Procedure

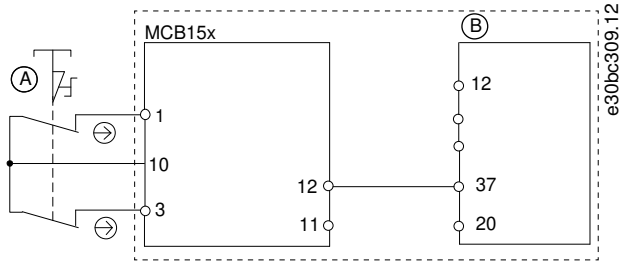
1. Connect the cable marked TER4:ENC A on the MCB 159 to terminal 4 on the MCB 151.



4.3 Application Examples

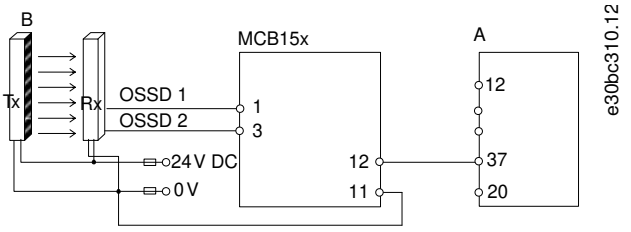
4.3.1 Connecting Safe Digital Inputs

This section contains examples of connecting the fail-safe digital input according to EN ISO 13849-1 and EN IEC 62061. The examples apply in cases where all components are installed in a control cabinet.



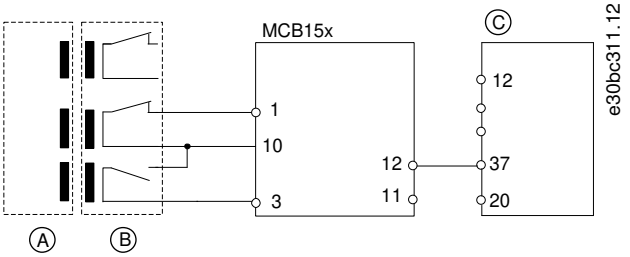
A 2-channel emergency stop switch	**B** Drive

Illustration 32: Connecting a Sensor, for Example 2-channel Emergency Stop Mushroom Push Button or Limit Switch



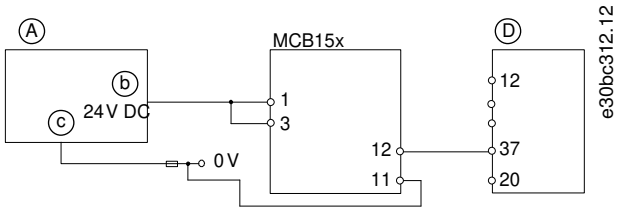
A Drive

Illustration 33: Connecting an Electronic Sensor, for Example Safety Light Curtain



A Actuator	**B** Switch
C Drive	

Illustration 34: Connecting 1 NO/1 NC Sensor, for Example Magnetic Switch



A Safety PLC	**B** Safety output
C GND	**D** Drive

Illustration 35: Connecting a Digital Output Module, for Example Safety PLC

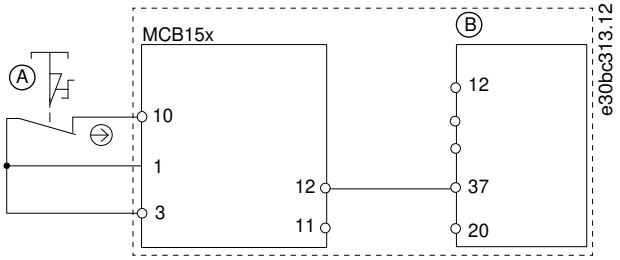


Illustration 36: Connecting a Sensor, for Example 1-channel Emergency Stop Mushroom Push Button or Limit Switch

NOTICE

All equipment used must be suitable for the selected category/PL or SIL.

NOTICE

Use of a 1-channel E-stop switch provides no input redundancy and no ability for the safety option to monitor for input short circuits. One-channel E-stop switches used with a safety option are suitable only for category 2 applications, per EN ISO 13849-1 PL c or SIL1.

When a 1-channel E-stop is used, guard against failure modes that can result in an unsafe condition. An example of an unsafe condition could be the failure of the contact to a short circuit condition. A switch with positive opening operation should be used to reduce the possibility of a failure of the switch to open. A short-circuit failure results in loss of switching function. This failure can occur from a short across the switch contacts, a short across the wires connected to the switch between the switch and the safety option, or a short to a secondary source of power. To reduce these risks, physically separate the wires from each other and from other sources of power (for example, in separate wire ways or conduit). According to the definition of European standard EN ISO 13849-1, a 1-channel E-stop could be used in applications where PL c or less (b or a) has been determined via a risk-assessment procedure.

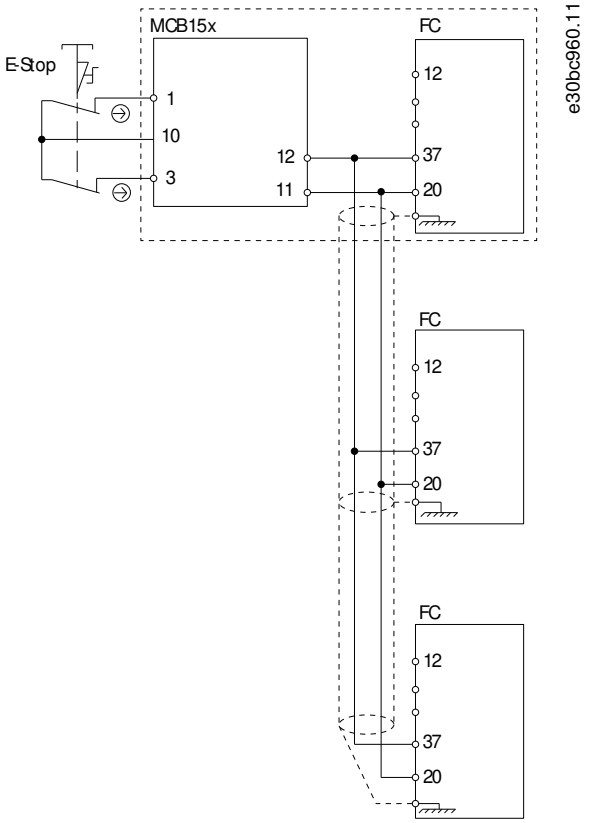


Illustration 37: Example of Multiple Drives in Daisy Chain

Up to 3 drives may be connected in a daisy chain. Total cable length must not exceed 30 m (98.4 ft).

5 Commissioning

5.1 Before Commissioning

5.1.1 Safety Guidelines

When commissioing/decommissioning:

- Secure the site in accordance with regulations (barrier, warnings, signs, and more). Only qualified personnel is allowed to commission/recommission the system.
- Refer to the guidelines, information, and specifications stated in the operating guide of the relevant programmable control system.
- Make sure that no personal injury and/or material damage can occur, even if the plant/machine moves unintentionally.

⚠ CAUTION ⚠

ELECTROSTATIC DISCHARGE

Electrostatic discharge can damage components.

- Ensure discharge before touching the safety option, for example by touching a grounded, conductive surface or by wearing a grounded armband.

⚠ WARNING ⚠

RISK OF ELECTROCUTION

Wiring the electrical connections on the drive while voltage is applied can lead to death or serious injury.

- Switch off power.
- Make sure that the control cabinet is provided with an access lock or warning signs.
- DO NOT switch on voltage until the system is commissioned.

Refer to the VLT® AutomationDrive FC 301/FC 302 Operating Guide for further information on the drive. Refer to the VLT® Motion Control Tool MCT 10 Operating Guide for further information on the Safe Plug-in.

5.1.2 Commissioning Requirements

Context:

Observe the following:

- When setting up the option for the 1st time, ensure to have a commissioning report at hand, see further information in the VLT® Motion Control Tool MCT 10 Operating Guide.

NOTICE

Only LCP SW version 7.0 or newer is supported.

Prerequisites:

The following components are required to perform the necessary steps for commissioning the safety option:

- Installation of MCT 10 Set-up Software version 4.40 or later.
- Successful connection to VLT AutomationDrive FC 302 with integrated safety option.
- USB or fieldbus connection or RS485 Interface adapter for connecting the control card of the drive with the PC.

NOTICE

If RS485 is used, set the protocol for serial communication to *[0] FC-MC* in *parameter 8-30 Protocol* (only accessible through the LCP).

Procedure

1. Configure the safety option in the MCT 10 with Safe Plug-in. Ensure only to configure safety sub-functions that are wired up to the safety option inputs.
2. Ensure that the device number (serial number and ordering number) of the safety option on the drive matches the device number of the safety option in the MCT 10 Safe Plug-in.

   Ensure that the drive is ready for commissioning (see VLT AutomationDrive FC 302 Operating Guide).

5.2 Initial Commissioning

5.2.1 Power-up/Self-test

Once the power supply has been applied to the drive, the safety option performs a self-test. During the self-test phase, all LEDs light up (lamp test) and the message *Safe Opt. initialized - SO RESET requested* or *SO in Self-test* appears. After power-up, the LEDs light up according to the device status.

NOTICE

If the supply voltage of the safety option exceeds the allowed range, the safety sub-function STO is triggered. The safety-related output S37 on the option is switched off.

5.2.2 Start Commissioning

1. Connect the configuration PC to the drive or motion control system.
   - **A** Make the interface in the MCT 10 Safe Plug-in (refer to the *chapter Functional Safety Configuration Plug-in* in the VLT® Motion Control Tool MCT 10 Operating Guide and the *Tool-Tip* for help.
2. Switch on the supply voltages.
   - **A** Switch on all the supply voltages for the drive and the safety option.
     - → The display elements on the drive and on the safety option show when they are ready for operation. The display elements on the safety option are described in 5.3 Operation.
3. Download the configuration file.
   - **A** Select *Write to drive* in the MCT 10 Safe Plug-in to establish communication between the PC and the drive.
   - **B** Make sure that no other system is accessing the interface.
   - **C** Apply password, unequal to default password.
   - **D** On multi-axis systems, the safety option can be selected individually for the download. The configuration is distributed to the safety options via the MCT 10 Set-up Software.

→ When the configuration file is downloaded, the LCP reads *SO Custom. completed*. During download, the following is checked in the configuration:

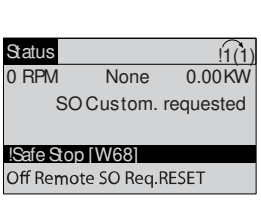
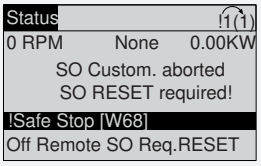
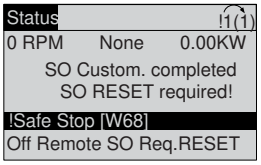
- Feasibility of the configuration data.
- Proper wiring.
- Correct device number (ordering number). If the self-test is successful, the power element of the drive is enabled.

NOTICE

Up to 10 s may elapse before the safety option is ready for operation.

5.2.3 Safety Option Customization

The following LCP messages indicate the different states of the customization process.

LCP message	Description
 e30bd125.11	MCT 10 customization of the safety option is requested.
 e30bd124.11	MCT 10 customization of the safety option is aborted.
 e30bd122.11	MCT 10 customization of the safety option is complete.

5.2.4 Setting Up the Encoder

Context:

NOTICE

If the selected encoder resolution is below 150 PPR for HTL/TTL encoder, set a feedback filter value in *parameter 42-15 Feedback Filter*. The system then calculates an allowed value. This is also the case when using a proximity switch feedback where the encoder resolution is below 600 PPR.

NOTICE

Depending on the system, a movement can imply different directions for the motor encoder.

NOTICE

Depending on the application, the motor encoder may be connected via a gearbox.

Procedure

1. Select the type of feedback device, either *[1] Safe Option* or *[0] None* in *parameter 42-10 Measured Speed Source*. For SS1 time delay functionality, no feedback source is necessary.
2. Set the feedback parameters for the safety option.

   In closed-loop applications, or if VLT® Sensorless Safety MCB 159 option is used, set *parameter 7-00 Speed PID Feedback Source* to *[11] MCB 150/151*.
3. Set mounting type to *Motor shaft mounted* or *Application mounted*.

   Select a gear ratio within 0.0001–32.0000 (default 1) in *parameter 42-13 Gear Ratio*. If the MCB 159 option is used, set the gear ratio to 1.

   For MCT 10 Set-up Software version 4.40 or higher: If MCB 159 is available and is to be used, set the mounting type to *Sensorless*. Skip steps 5 and 6 as correct values are set automatically.
4. Set the correct encoder value (1–4096 PPR) in *parameter 42-11 Encoder Resolution*.

   If the MCB 159 option is used, set the correct encoder value to half of the number of motor pole pairs.
5. Set *parameter 42-12 Encoder Direction* to *[0] Clockwise* (default) or *[1] Counter clockwise*.

   If the MCB 159 option is used, select *Clockwise*.
6. Set *parameter 42-14 Feedback Type* to *[0] With direction info* or *[1] Without direction info*.

   Select *[1] Without direction info* if a VLT® Sensorless Safety MCB 159 option or a proximity switch sensor is used for speed detection.

5.2.5 Commissioning Test

The MCT 10 Safe Plug-in creates a commissioning report based on the commissioning test result. It generates the drive safety signature. This function provides a final report when the safety option has been configured. This report is considered as a help tool for safety commissioning and validates that all the safety sub-functions are operational. The commissioning report can either be printed or converted into a PDF file.

The test objective is to verify proper implementation (forced dormant error detection measures) and to examine the response of specific monitoring functions to the explicit input of values outside tolerance limits.

⚠ WARNING ⚠

UNEXPECTED BEHAVIOR

Modifying or changing hardware and/or software components can lead to unexpected behavior of the drive. This behavior could result in death or serious injury.

- Ensure that all protective equipment is closed before system start-up and activation of the drive.
- Keep personnel out of the danger zone.
- Carry out a partial or complete commissioning test (mandatory).
- Test the steady control response by briefly moving the drive in forward and reverse direction before allowing anybody to reenter the danger zone.

EN IEC 61508, EN IEC 62061 and EN ISO 13849 require that the final assembler of the machine validates the operation of the safety sub-function with a commissioning test. The commissioning tests for the standard safety sub-functions Safe Stop of the drive are described in the drive manuals. The tests for the optional safety sub-functions are described in the commissioning report generated by the MCT 10 Safe Plug-in. The commissioning test must be performed:

- At initial start-up of the safety sub-function.
- After any changes related to the safety sub-function (wiring, components, settings, and more).
- After any maintenance work related to the safety sub-function.

5.3 Operation

⚠ WARNING ⚠

UNINTENDED BEHAVIOR

Numerous stored data or settings control the behavior of the drive system. Unsuitable settings or data may trigger unexpected movements or responses to signals and disable monitoring functions. Follow the instructions below to avoid risk of death, serious injury, or equipment damage.

- Do NOT operate the drive system with unknown settings or data.
- Verify that the stored data and settings are correct.
- When commissioning, carefully run tests for all operating states and potential error situations.
- Verify the functions after replacing the product and also after changing the settings or data.
- Only start the system if there are no persons or obstructions in the hazardous area.

Prerequisites for normal operation are:

- Commissioning is complete.
- The safety option contains the configuration data.
- The safety sub-functions have been tested.
- LED1, LED2, and LED4 are lit.

During operation:

- Any pulse edge change at the safety option safe input is monitored.
- The safety sub-functions are performed in accordance with the configuration.

6 General Parameter Set-up

6.1 Configuration

6.1.1 General Parameter Set-up

See 6.3 Parameter List to configure an operation of the safety option. The set-up is done via the MCT 10 Safe Plug-in.

Speed monitoring by the safety option

If an external encoder is connected to the safety option and selected in *parameter 42-10 Measured Speed Source*, speed monitoring is active all the time whether a safety sub-function is requested or not. However, if an STO is triggered (either directly, or as a consequence of a Safe Stop 1) it interrupts the speed monitoring.

Encoder configuration

To define the type of feedback used by the safety option, select *[1] Safe option* in *parameter 42-10 Measured Speed Source*.

6.1.2 Configuration of Safety Sub-functions

The safety sub-functions to be carried out by the safety option are defined in the MCT 10 Safe Plug-in:

- Configurations of the safety sub-functions.
- Setting of limit values, braking ramps for the safety sub-functions, monitoring of motion sequences.

NOTICE

Always perform the required commissioning test. The commissioning test report is automatically generated via the Safe Plug-in in MCT 10 after downloading the parameters to the safety option.

Downloading the configuration to the safety option:

- On single-drive systems, via the RS486/USB interface on the drive.
- On networked systems, via RS485 or fieldbus interface on the MCT 10 Safe Plug-in. The control system passes the configuration to the respective safety option.
- The feasibility of the configuration is checked when it is downloaded.

Further information on configuration and setting parameters for the safety sub-functions is available in the online help for the MCT 10 Safe Plug-in and in the VLT® Motion Control Tool MCT 10 Operating Guide.

The safety option is configured with the commissioning software MCT 10 Set-up Software via a Safe Plug-in. The Safe Plug-in in the commissioning software is available as default from version 3.18, all functions are available from MCT 10 Set-up Software version 4.40.

The commissioning software provides the following menu items for the safety option:

- General speed monitoring.
- Safe input.
- Safe Stop 1.
- Safely Limited Speed.
- Safe Maximum Speed.
- Parameters.
- Status.

The menu items are described in detail in the VLT® Motion Control Tool MCT 10 Operating Guide.

The menu item *Status* shows the following:

- Current signal states of inputs and outputs.
- Option operating mode
- Active safety sub-function.

The states of the inputs and output cannot be changed via the commissioning software.

6.1.3 Password Protection

Use a password to protect the system configuration. A password must be entered only when changing safety option parameters (writing to option).

Default password is 12345678.

It is advised to change the safety option default password before downloading the parameter values of a safety option with factory settings. Only persons knowing the password can change the safety option parameter values.

NOTICE

Any misuse of password may lead to severe safety problems.

NOTICE

No password is required to access the commissioning parameters of the safety option. The password is required when the parameters must be downloaded to the option via *Write to Drive*.

The password must be of 8 characters and is case-sensitive. Alphanumeric characters and symbols are valid for password.

The safety option checks the parameter password entered. Use the menu item *Change Password* to change the safety option parameter password. Change the safety option password if there is any indication of manipulation.

6.1.3.1 Resetting the Password

Context:

NOTICE

Resetting the password resets all option parameters to factory default.

Procedure

1. In the *Administration* menu, select *Reset*.
2. Checkmark *Yes, I want to reset Safe Option configuration in the drive*.
3. Enter the default password (12345678).
4. Click *Reset*.
5. On the prompt that appears, click *Yes*.
6. Change the safety option password.

6.2 Reset and Status over Fieldbus

6.2.1 Reset of Safety Option and Pending Safe Function

There are 2 different methods of resetting the safety option and pending safe function. The configuration of *parameter 42-31 Reset Source* is decisive for which method to use.

If *parameter 42-31 Reset Source* is set to *[0] Drive Reset*, a reset according to the selected control word profile is required.

NOTICE

The drive-specific alarms are also reset.

If *parameter 42-31 Reset Source* is set to *[1] Drive Safe Reset*, configure *[3] Safe Option Reset* in *parameter 8-14 Configurable Control Word CTW*.

NOTICE

The drive-specific alarms are not reset and the control word profile is overwritten.

6.2.2 Retrieving Safety Option Status

A subset of the safety option status can be retrieved as part of the status word. Its behavior changes based on the selected control word profile.

Configure *[91] Safe Opt. Reset. req* and *[90] Safe Function active* in *parameter 8-13 Configurable Status Word STW* to:

- Indicate that a reset of the safety option is required.
- Indicate that a safe function is active.

Parameter 42-80 Safe Option Status indicates the actual status (active safe function, any requests, and error number) of the safety option and is accessible as read-only parameter from any interface or configurable as read process data for a specific fieldbus.

NOTICE

Only active safe function is set in Safety Option Status.

Table 11: Explanation of the Status Bits for Safety Option Status

Bit	Description
0	Normal_up
1	PUST
2	STO active
3	SS1-a active
4	SS1-b active
5	SLS-a active
6	SLS-b active
7	Safe Maximum Speed active
8	Reserved for further SP
9	Reserved for further SP
10	Reserved for further SP
11	Int_fail
12	Reset required
13	Pending fail-safe state
14	Ext_fail
15	Safe function pending
16	General reset
17	Customization_confirmed
18	Customization_aborted
19	Customization_requested
20	Suspension of speed monitoring
21	PUST warning
22	DI_1_offline_warning
23	DI_2_offline_warning
24	Error code
25	Error code
26	Error code
27	Error code
28	Error code
29	Error code
30	Error code
31	Error code

Table 12: Bit Functions

Bit number	Bit name	Value	Function
00	Safety sub-function deactive/active	0	Safety sub-function, fail-safe reaction is active or pending, or warning is active.
		1	Normal operation.
01	Power up self-test	1	Safety option is in PUST state.
02	Safe Torque Off	0	Safe Torque Off is not active.
		1	Safe Torque Off is active.
03	Safe Stop 1 a	0	Safe Stop 1 a is not active.
		1	Safe Stop 1 a is active.
04	Safe Stop 1 b	0	Safe Stop 1 b is not active.
		1	Safe Stop 1 b is active.
05	Safely Limited Speed a	0	Safely Limited Speed-a is not active.
		1	Safely Limited Speed-a is active.
06	Safely Limited Speed b	0	Safely Limited Speed-b is not active.
		1	Safely Limited Speed-b is active.
07	Safe Maximum Speed	0	Safe Maximum Speed is inactive.
		1	Safe Maximum Speed is active
08–10	Reserved for future safety sub-functions.	–	–
11	Internal failure	0	No internal failure is active.
		1	Internal failure is active.
12	Reset	0	No safety option reset required.
		1	Safety option reset required.
13	Pending fail-safe state	0	No pending fail-safe state.
		1	Safety option is in this state at each power-up.
14	External failure	0	No external failure is active.
		1	External failure is active.
15	Safe function pending	0	No safe function pending.
		1	Safe function pending.
16	General reset	0	No change in state.
		1	General reset is done.
17	Customization confirmed	0	No change in state.
		1	Customization confirmed.
18	Customization aborted	0	No change in state.
		1	Customization aborted.

Bit number	Bit name	Value	Function
19	Customization requested	0	No change in state.
		1	Customization is requested.
20	Suspension of speed monitoring	0	No change in state.
		1	Suspension of speed monitoring - see error code.
21	Power Up Self-Test warning	0	No change in state.
		1	Power Up Self-Test warning is issued.
22	Digital input 1 offline test warning	0	No change in state.
		1	Digital input 1 offline test warning.
23	Digital input 2 offline test warning	0	No change in state.
		1	Digital input 2 offline test warning.
24–31	Causes for possible internal or external errors. See error code.		

NOTICE

Parameter 42-81 Safe Option Status 2 indicates which digital input of the safety option is either activated, in pending state, or in blank initial state.

Table 13: Explanation of the Status Bits for Safety Option Status 2

Bit	Description	State
0	DI1 safety status	00 - Inactive
1		01 - Active 10 - Pending
2	DI 2 safety status	00 - Inactive
3		01 - Active 10 - Pending
4	Blank initial state	0 (inactive/1 (active)
5	Unused	
31		

Table 14: Bit Functions, Status 2

But number	Bit name	Value	Function
00-01	DI1 safety status	00	Inactive.
		01	Active.
		10	Pending.

But number	Bit name	Value	Function
02-03	DI2 safety status	00	Inactive.
		01	Active.
		10	Pending.
04	Blank initial state	0	Safety option is configured.
		1	Safety option is in blank initial state.
05–31	Reserved for future use		

6.3 Parameter List

Table 15: Safety Option Parameters

Group	Group name	Parameter	Value range/ available options	Default	Description	Conversion index	Data type
42-0*	Speed Performance	42-00 Speed Deviation Timer	10–5000 ms	10 ms	Enter the time for which a speed deviation above 120 RPM between estimated and measured speed is allowed.	1	u_int16
		42-01 Fast Ramp	[0] No	[0] No	Select *[1] Yes* if fast ramping is needed with poor resolution of measured speed.	–	u_int8
			[1] Yes				

Group	Group name	Parameter	Value range/ available options	Default	Description	Conversion index	Data type
42-1*	Speed Monitoring	42-10 Measure Speed Source	[0] None [1] Safe Option	[1] Safe Option	The source of the speed feedback.	0	u_int8
		42-11 Encoder Resolution	1–4096 PPR (for option with HTL encoder) 1–10000 PPR (for option with TTL encoder)	1024 PPR	Encoder or proximity switch resolution of the encoder connected to the MCB 150 TTL and MCB 151 HTL.	0	u_int16
		42-12 Encoder Direction	[0] Clockwise [1] Counter clockwise	[0] Clockwise	Allows for changing the detected encoder rotation direction without changing the wiring to the encoder.	–	u_int8
		42-13 Gear Ratio	0.0001–32.0000	1	Ratio between motor speed and encoder speed. Remark: Only used when gear mounted.	-4	u_int32
		42-14 Feedback Type	[0] With direction info [1] Without direction info	[0] With direction info	The feedback can be with or without direction information. For TTL/HTL encoder, direction info is available. For proximity switch, select *[1] Without Direction Info*.	–	u_int8
		42-15 Feedback Filter	0.01–200.00 Hz	200 Hz	Frequency of the feedback filter. Default value is 200 Hz (off) if the encoder resolution is higher than 150 PPR. A filter value of 200 Hz is selected, meaning that the filter is off. The use of filters depends on the given encoder resolution, gear ratio, and feedback type.	-2	u_int16
		42-17 Mounting Type	[0] Motor Shaft Mounted [1] Application Mounted [2] Sensorless	[0] Motor Shaft Mounted	Location where the measured speed source is mounted.	–	u_int8
		42-18 Zero Speed Timer	0–10000 h	8760 h	Time period where the option is allowed to be below 120 RPM when SLS is active before STO is activated.	74	u_int16
		42-19 Zero Speed Limit	Fixed	120 RPM		67	u_int16

Group	Group name	Parameter	Value range/ available options	Default	Description	Conversion index	Data type
42-2*	Safe Input	42-20 Safe Function	[0] STO	[0] STO	This can be 1 of the safety sub-functions or disabled. Remark: Both Safe Inputs can NOT be disabled at the same time.	–	u_int8
			[1] SS1-a				
			[2] SS1-b				
			[3] SLS-a				
			[4] SLS-b				
			[5] disable				
		42-21 Type	[0] NCNC	[0] NCNC	NCNC, antivalent (NC/NO) or 1NC.	–	u_int8
			[1] Antivalent				
			[2] NC				
		42-22 Discrepancy Time	0–5000 ms	10 ms	An adjustable filter time prevents faults caused by temporary discrepancy.	-3	u_int16
		42-23 Stable Signal Time	0–5000 ms	10 ms	An adjustable signal filter in the safety option suppresses temporary signal changes using test pulse pattern.	-3	u_int16
		42-24 Restart Behavior	[0] Manual	[0] Manual	In case of an activated safety sub-function, the safety option can either restart automatically or wait for a RESET signal from the user.	–	u_int8
			[1] Automatic				
42-3*	General	42-30 External Failure Reaction	[0] STO	[0] STO	Safety sub-function that is executed if there is an external failure.	–	u_int8
			[1] SS1-a				
			[2] SS1-b				
		42-31 Reset Source	[0] Drive Reset	[0] Drive Reset	Source for the RESET of the safety option. Can either be executed on the option input DI2, via fieldbus or digital input on the drive or via the LCP. By selecting Drive Safe Reset, only the safety option is reset.	–	u_int8
			[1] Drive Safe Reset				
			[2] Safe Option DI1_A				
		42-33 Parameter Set Name	Visible String, length: 8	SafeSet1	Name of the safe parameter Set (must be 8 characters to avoid a bad customization data error).		

Group	Group name	Parameter	Value range/ available options	Default	Description	Conversion index	Data type
42-4*	SS1	42-40 Type	[0] Delay	[0] Delay	The type of the SS1 safety sub-function.	–	u_int8
			[1] Ramp (slope)				
			[2] Ramp (time)				
		42-41 Ramp Profile	[0] Linear	[0] Safe Option Linear	The ramp profile for an SS1 Delay can be either specified as linear or S-ramp.	–	u_int8
			[2] S-ramp Const Time				
		42-42 Delay Time	0.1–3600.0 s	1.0 s	Time until STO is activated.	-1	u_int16
		42-43 Delta T	0–99%	2%	Δ T subtracts from the time in *parameter 42-42 Delay Time* to get motor to stop before the timer expires.	0	u_int8
		42-44 Deceleration Rate	1–30000 RPM/s	1500 RPM/s	Deceleration rate for the SS1 slope-based ramp type.	0	u_int16
		42-45 Delta V	1–10000 RPM	120 RPM	Tolerance between calculated and actual speed that the safety option allows.	67	u_int16
		42-46 Zero Speed	1–600 RPM	10 RPM	When this speed is reached, the safety option activates the STO.	67	u_int16
		42-47 Ramp Time	0.1–3600.0 s	1.0 s	Time to ramp down to 0 RPM.	-1	u_int16
		42-48 S-ramp Ratio at Decel. Start	1 to (100 - 42-49 S-ramp Ratio at Decel. End)%	50%	The proportion of the total ramp-down time (*parameter 42-42 Delay Time*) where the deceleration torque increases. The larger the percentage value, the greater the jerk compensation achieved, and thus the lower the torque jerks in the application.	0	u_int8
		42-49 S-ramp Ratio at Decel. End	1 to (100 - 42-48)%	50%	The proportion of the total ramp-down time (*parameter 42-42 Delay Time*) where the deceleration torque decreases. The larger the percentage value, the greater the jerk compensation achieved, and thus the lower the torque jerks in the application.	0	u_int8

Group	Group name	Parameter	Value range/ available options	Default	Description	Conversion index	Data type
42-5*	SLS	42-50 Cut Off Speed	(42-51 + 1) to 10000 RPM	270 RPM	Speed at which the fail-safe reaction gets activated. This should be the value of *parameter 42-51 Speed Limit* plus a tolerance.	67	u_int16
		42-51 Speed Limit	0 to (42-50 - 1) RPM	150 RPM	Maximum speed allowed when the SLS function is active.	67	u_int16
		42-52 Fail Safe Reaction	[0] STO	[0] STO	Safety sub-function that is activated, if the speed exceeds the limit. Only for SLS.	–	u_int8
			[1] SS1-a				
			[2] SS1-b				
		42-53 Start Ramp	[0] No	[0] No	If the speed at activation of SLS is higher than the speed limit, it ramps down to the speed limit (yes) or activate an STO (no).	–	u_int8
			[1] Yes				
		42-54 Ramp Down Time	0.1–3600.0 s	1.0 s	Ramp-down time for start ramp.	-1	u_int16
42-7*	SMS	42-70 Activation	[0] Inactive	[0] Inactive	Activate or deactivate SMS (Safe Maximum Speed).	67	u_int8
			[1] Active				
		42-71 Cut Off Speed	120–20000 RPM	1500 RPM	Maximum allowed speed	–	u_int16

Group	Group name	Parameter	Value range/ available options	Default	Description	Conversion index	Data type
42-8*	Status	42-80 Safe Option Status	0–4294967295	0	Shows the safety option status word as a hexadecimal value.	0	u_int32
		42-81 Safe Option Status 2	0–2147483647	0	Shows the safety option status 2 as a hexadecimal value. For example, it contains DI1, DI2, and blank initial state status.	0	u_int32
		42-85 Active Safe Func.	[0] STO [1] SS1-a [2] SS1-b [3] SLS-a [4] SLS-b	None	Shows the currently active safe function. Can be used on LCP. **NOTICE** Can only be selected in *parameters 0-20 to 0-22*.	–	u_int8
		42-86 Safe Option Info	0 - None, if no safe function is active	0	Shows information about the safety option. Can be used on LCP. **NOTICE** Can only be selected in *parameter 0-23 Display Line 2 Large* and *parameter 0-24 Display Line 3 Large*.	0	
		42-89 Customization File Version	0.00–99.99	1.00	Stores the customization file version.	-2	u_int16
42-9*	Special	42-90 Restart Safe Option	[0] No [1] Yes	[0] No	Possibility to restart option after internal failure without power cycling the drive.	–	u_int8

Refer to VLT AutomationDrive FC 302 Operating Guide for a comprehensive parameter list.

7 Service and Repair

7.1 Updates, Servicing, and Modifications

NOTICE

UPDATES TO FIRMWARE

Contact Danfoss to get an update of the firmware.

⚠ CAUTION ⚠

FIRMWARE MODIFICATIONS

Unauthorized modifications made to the firmware can lead to injury and equipment damage and voids the warranty. Furthermore, Danfoss cannot be held liable for any consequences third-party changes may have on the functional safety.

- Only have Danfoss change the firmware.

⚠ CAUTION ⚠

MODIFICATIONS TO THE UNIT

Unauthorized modifications made to the unit can lead to injury and equipment damage and voids the warranty. Furthermore, Danfoss cannot be held liable for any consequences third-party changes may have on the functional safety.

- Only have Danfoss make hardware modifications of the safety option.

⚠ WARNING ⚠

YEARLY TEST

The safety option functions must be tested on a yearly basis to avoid the risk of death or injury.

- Test the safety sub-function.
- Switch off the options used in the safety chain.

7.2 Repair

⚠ WARNING ⚠

SHOCK HAZARD

Attaching or removing the safety option while the soft starter is connected to mains voltage may cause personal injury.

- Before attaching or removing the safety option, isolate the drive from mains voltage.

NOTICE

Only Danfoss is authorized to repair the safety option. A defect option must be returned to Danfoss.

7.3 Replacement of Safety Option

7.3.1 Before Removing the Safety Option

Procedure

1. Save all parameters of the safety option, see VLT® Motion Control Tool MCT 10 Operating Guide.
2. Duplicate the existing device setting.

7.3.2 Removing the Safety Option

Context:

NOTICE

The drive generates an error message after removing the safety option.

NOTICE

If the removed safety option is installed in another drive, the drive issues a warning for safety option parameter selection. Select the safety configuration from either the drive or from the safety option.

Procedure

1. Disconnect all power (power stage supply voltage and controller supply) before plugging in or removing the option.
2. Verify that no voltage is present.
3. Remove the safety option according to the instructions in the *chapter Installation* in the VLT AutomationDrive FC 302 Operating Guide.

7.3.3 Replacing the Safety Option

Context:

⚠ WARNING ⚠

SHOCK HAZARD

Attaching or removing the safety option while the soft starter is connected to mains voltage may cause personal injury.

- Before attaching or removing the safety option, isolate the drive from mains voltage.

NOTICE

Alarm 67, Option Change informs that a change of the drive hardware configuration has occurred after a power-up. This situation can occur after installing/removing an option, or if an option is defect. If the configuration changes, the drive freezes the hardware configuration, trips, and refuses to start up.

- Thus avoiding any unintended parameter changes.

When replacing the safety option, note the following:

- If the firmware version has changed, configured functions and stated parameters may no longer be supported or may have been modified. Adapt the configuration in the MCT 10 Set-up Software.
- Download the configuration to the safety option again.

Alternatively, copy the safe parameters using a graphical LCP, see 7.3.4 Copying Safe Parameter Set-up.

Prerequisites:

Reset all option parameters to factory setting to avoid trips caused by replacement of the safety option.

Order a new safety option at Danfoss.

Procedure

1. Replace the defective option, see 4.1 Installing the Option.

   At the 1st power-up, the drive recognizes different configurations between the safety option and the drive if the safety parameters are not set default values.

2. Select *Frequency converter*.
3. If configured, enter the password for the copied safety option configuration from the LCP.
4. Accept to download the safe parameters to the drive/safety option.
5. Select *OK*.
6. Restart the drive.
7. Download the configuration data again from either:

   MCT 10 Safe Plug-in to the safety option via RS485 or USB, or

   An LCP in the drive to the safety option.

→ A checksum is saved along with the file to allow for identification for the duplicated safety option parameters. Follow the guided sequence on the LCP display to transfer the safety option parameters to a safety option.

Verify that the correct safety parameter file is transferred to the safety option. Perform a commissioning test, see 5.2.5 Commissioning Test.

7.3.4 Copying Safe Parameter Set-up

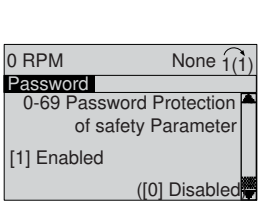
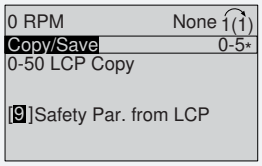
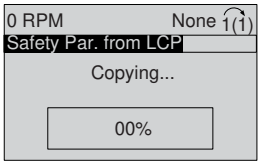
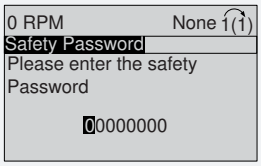
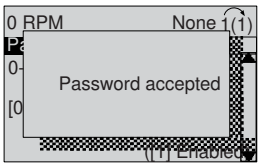
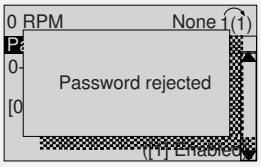
Procedure

1. Prepare a commissioning report.
2. Select *[0] All to LCP* in *parameter 0-50 LCP Copy*. Monitor the upload on the progress bar.
3. Install the LCP with all the copied parameters on the drive that has to be updated.
4. Select *[2] All from LCP* in *parameter 0-50 LCP Copy*. The normal password protection can be applied in *parameter 0-60 Main Menu Password*.
5. Enter the password for copied SO configuration (=safe parameters) from LCP.
6. Accept the download of the safe parameters to the drive, which has now a new configuration assigned to it.
7. Reset the drive to activate the new configuration.

7.3.4.1 Password Protection LCP Copy and Safe Parameter Mismatch

Optionally, a password protection can be used for the function LCP copy (see table 16) and if there is a parameter mismatch (see table 17). Password protection can be enabled/disabled in *parameter 0-69 Password Protection of Safety Parameters*. The password is set in *parameter 0-68 Safety Parameters Password*. Default password is 300.

Table 16: LCP Copy Messages

Message	Description
	The password protection of the safety parameters is enabled.
	Copying the safety parameters from the LCP into the drive is selected.
	The safety parameters get copied from the LCP into the drive.
	If password protection is enabled in *parameter 0-69 Password Protection of Safety Parameters*, enter the correct LCP-copy/parameter mismatch password (*parameter 0-68 Safety Parameters Password*).
	If the entered password is correct, this overlay message is shown for some seconds.
	If the entered password is wrong, this overlay message is shown for some seconds. Then the password can be entered again.

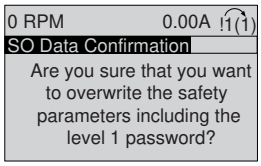
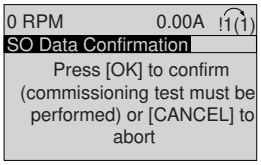
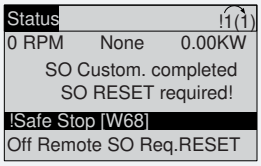
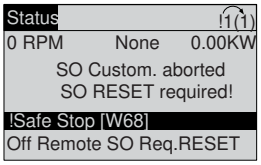
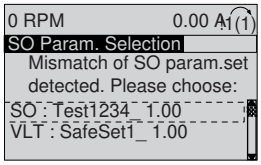
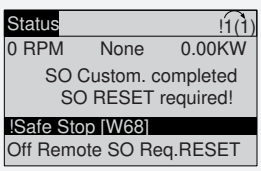
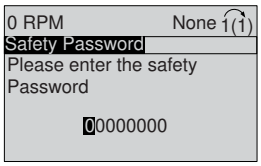
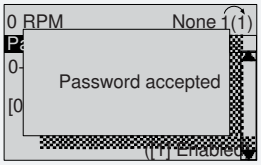
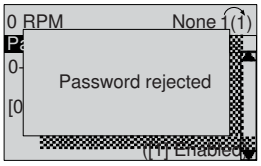
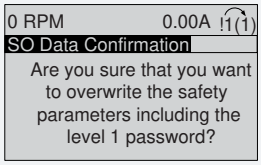
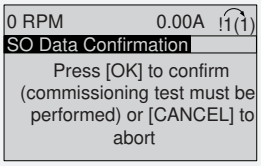
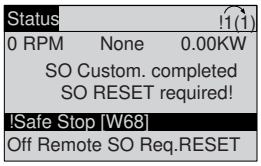
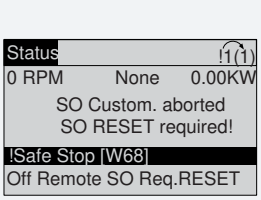
Message	Description
 e30bd120.11  e30bd121.11	Decision box for continuing overwriting the existing data or to abort the procedure.
 e30bd122.11	Press [OK] to complete the customization of the safety option. A reset is required to finalize this procedure.
 e30bd124.11	Press [Cancel] to abort the customization of the safety option. A reset is required to finalize this procedure.

Table 17: Mismatch Between Safety Parameters in the Safety Option and in the Drive

Message	Description
 e30bd115.11	Whenever there is mismatch of safety parameters within the safety option and the drive, this selection form is shown on the LCP. Select between the 'safety data on safe option' or the 'safety data on frequency converter' as valid data.
 e30bd122.11	If selecting [SO:…], the customization of the safety option is completed and a reset is required to finalize this procedure.

Message	Description
 e30bd118.11	If selecting [VLT:…] and the password protection in *parameter 0-69 Password Protection of Safety Parameters* is enabled, enter the correct LCP-copy/parameter mismatch password (*parameter 0-68 Safety Parameters Password*).
 e30bd119.11	If the entered password is correct, this overlay message is shown for some seconds.
 e30bd123.11	If the entered password is wrong, this overlay message is shown for some seconds. Then the password can be entered again.
 e30bd120.11  e30bd121.11	Decision box for continuing overwriting the existing data or to abort the procedure.
 e30bd122.11	Press [OK] to complete the customization of the safety option. A reset is required to finalize this procedure.

Message	Description
	Press [Cancel] to abort the customization of the safety option. A reset is required to finalize this procedure.

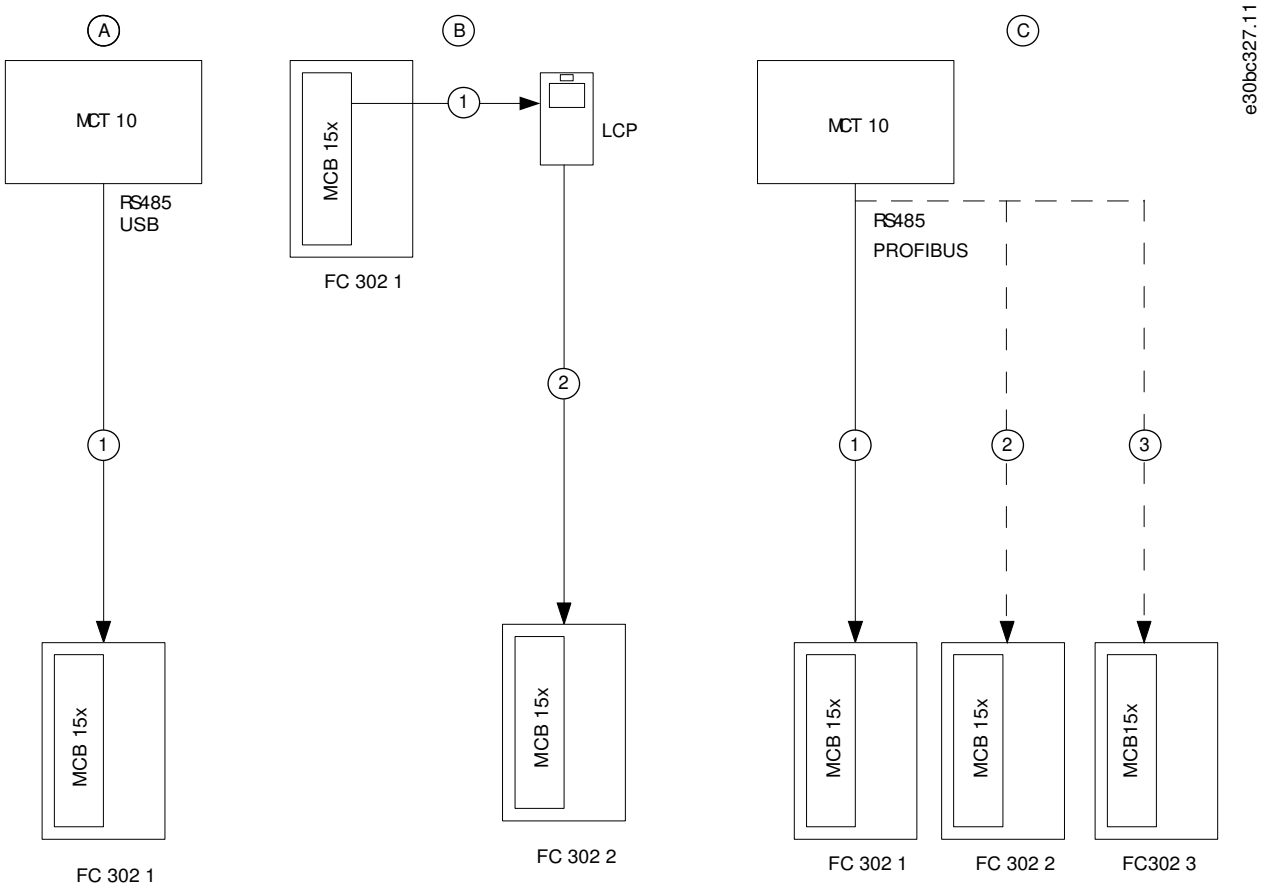


Illustration 41: Possible Parameter Set-up

7.4 Commissioning Test

The commissioning test for systems with safety sub-functions is focused on validating the functionality of safety monitoring and stop functions configured in the drive system.

The test objective is to verify proper configuration of the defined safety sub-functions and of test mechanisms and to examine the response of specific monitoring functions to the explicit input of values outside tolerance limits. Test safety-configured monitoring functions running in the final set-up.

7.4.1 Safety Guidelines

When commissioning/recommissioning, note the following:

- Secure the site in accordance with the regulations (barrier, warning signs, and more). The system may only be commissioned/ recommssioned by qualified personnel.
- Refer to the information and specifications stated in the operating guide of the relevant programmable control system.
- During commissioning/recommissioning, make sure that no personal injury and/or material damage can occur, even if the plant/ machine moves unintentionally.
- When commissioning the safety option, read the safety guidelines in the operating guide for the drive.

7.4.2 Before Running the Commissioning Test

The system integrator/machine manufacturer runs a commissioning test of the safety option to verify and document the correct selection of the safety option parameter values. The system integrator/machine manufacturer hereby proves to have tested the effectiveness of the safety sub-functions used. Run the commissioning test based on the risk analysis. All applicable standards and regulations must be adhered to.

Check that:

- The machine is properly wired.
- The effectiveness of all safety components used in the application fulfills the requirements.
- All safety equipment, such as protective door monitoring devices, light barriers, or emergency stop switches, is connected and ready for operation.
- All motor parameters and command parameters must be set correctly on the drive.

Run a commissioning test of the safety option in the following situations:

- After the configuration of each machine.
- After changing the safety option parameters.
- After making changes to the machine (as per applicable standards and regulations).

7.4.2.1 Checking Effectiveness of Safety Sub-functions

Procedure

1. Document each individual step of the test.
2. Note the checksum of the safety option parameters in the records.
3. Do NOT release the system unless it has successfully passed all individual steps of the test.
4. Restart the drive and check that the motor runs normally.

7.4.3 Safety Sub-functions in the Drive

After making, for example, an LCP copy of safe parameters, a commissioning test is required. Use these short versions of the commissioning test reports to follow and approve the test sequence.

Table 18: Commissioning Test Report, Safe Torque Off

Test procedure	Approved ✓
1. Disable the STO function: • Via DI1. • Via DI2. • Check the STO circuit connections against the circuit diagram.	
2. No safety faults and alarms.	
3. Run the drive.	
4. Ensure that the correct drive is running.	
5. Select STO while the drive is running.	
6. Check the following: • The drive coasts to 0 speed. • The motor is braked and stopped by the mechanical brake (if available and configured). • *Warning/alarm 68, Safe Stop* is shown.	
7. Deselect STO.	
8. Check the following: • Depending on the configuration, *Safety Func. Pending* is shown.	
9. Restart the drive and check that the motor runs normally.	
10. Ensure that the STO function is safe and accepted to operate.	
11. Document and sign the commissioning test report.	

Table 19: Commissioning Test Report, Safe Stop 1 Time-based

Test procedure	Approved ✓
1. Disable the Safe Stop 1 function: • Via DI1. • Via DI2. • Check the SS1 circuit connections against the circuit diagram.	
2. No safety faults and alarms.	
3. Run the drive.	
4. Ensure that the correct drive is running.	
5. Select SS1 while the drive is running.	
6. Check the following: • The drive ramps down to 0 speed. Ensure that it stops within the delay time specified. • The motor is braked and stopped by the mechanical brake (if available and configured). • The SS1 ends with an STO warning or alarm, depending on the configuration.	
7. Deselect SS1.	
8. Check the following: • *Safety Func. Pending* is shown. • SS1 is deselected and inactive.	

Test procedure	Approved ✓
9. Restart the drive and check that the motor runs normally.	
10. Ensure that the SS1 function is ready to operate.	
11. Document and sign the commissioning test report.	

Table 20: Commissioning Test Report, Safe Stop 1 Delay

Test procedure	Approved ✓
1. Disable the Safe Stop 1 function: • Via DI1. • Via DI2. • Check the SS1 circuit connections against the circuit diagram.	
2. No safety faults and alarms.	
3. Run the drive.	
4. Ensure that the correct drive is running.	
5. Select SS1 Delay while the drive is running.	
6. Check the following: • The drive ramps down to 0 speed. Ensure that it stops within the delay time specified. • The motor is braked and stopped by the mechanical brake (if available and configured). • The SS1 ends with an STO warning or alarm, depending on the configuration.	
7. Deselect SS1 Delay.	
8. Check the following: • *Safety Func. Pending* is shown. • SS1 Delay is deselected and inactive.	
9. Restart the drive and check that the motor runs normally.	
10. Ensure that the SS1 function is ready to operate.	
11. Document and sign the commissioning test report.	

Table 21: Commissioning Test Report, Safe Stop 1 Ramp-based

Test procedure	Approved ✓
1. Disable the Safe Stop 1 function: • Via DI1. • Via DI2. • Check the SS1 circuit connections against the circuit diagram.	
2. No safety faults and alarms.	
3. Run the drive.	
4. Ensure that the correct drive is running.	
5. Select SS1 while the drive is running.	

Test procedure	Approved ✓
6. Check the following: • The drive ramps down to 0 speed. • The motor is braked and stopped by the mechanical brake (if available and configured). • The SS1 ends with an STO warning or alarm, depending on the configuration.	
7. Deselect SS1.	
8. Check the following: • *Safety Func. Pending* is shown. • SS1 Delay is deselected and inactive.	
9. Restart the drive and check that the motor runs normally.	
10. Ensure that the SS1 function is ready to operate.	
11. Document and sign the commissioning test report.	

Table 22: Commissioning Test Report, Safely Limited Speed without Ramp

Test procedure	Approved ✓
1. Disable the SLS function: • Via DI1. • Via DI2. • Check the SS1 circuit connections against the circuit diagram.	
2. No safety faults and alarms.	
3. Run the drive. • Up and down ramps can be separately entered for jog operation (jog mode). This can be parameterized as part of the Quick Menu. • The motor speed must be higher than the SLS selected, if the machine allows this.	
4. Ensure that the correct drive is running.	
5. Select SLS while the drive is running.	
6. Check the following: • The drive coasts to 0 speed if STO is selected as fault reaction. • Run SS1 if that is selected as fault reaction. • The motor is braked and stopped by the mechanical brake (if available and configured). • Ensure that *error 70, Int fail speed limit SLSa: Reaction STO* is shown.	
7. Deselect SLS.	
8. Check the following: • *Safety Func. Pending* is shown. • SLS is deselected and inactive.	
9. Restart the drive and check that the motor runs normally.	

Test procedure	Approved ✓
10. Ensure that the SLS function is ready to operate: • Run motor below SLS limit. • Activate SLS. • Increase reference above SLS limit. • Make sure that the SLS limit is not exceeded.	
11. Document and sign the commissioning test report.	

Table 23: Commissioning Test Report, Safely Limited Speed with Ramp

Test procedure	Approved ✓
1. Disable the SLS function: • Via DI1. • Via DI2. • Check the SS1 circuit connections against the circuit diagram.	
2. No safety faults and alarms.	
3. Run the drive. • The motor speed must be higher than the SLS selected, if the machine allows this.	
4. Ensure that the correct drive is running.	
5. Select SLS while the drive is running.	
6. Check the following: • The speed ramps down according to the selected ramp time/slope to SLS setpoint.	
7. Deselect SLS.	
8. *Safety Func. Pending* is shown.	
9. Run the drive. • The motor speed must be higher than the SLS selected, if the machine allows this.	
10. Ensure that the correct drive is running	
11. Select SLS while the drive is running.	
12. Check the following: • The drive ramps down to the SLS.	
13. Deselect SLS.	
14. Check the following: • No safety faults. • *Safe Func. Pending* is shown.	
15. Reset the drive and check that the motor runs normally.	
16. Ensure that the SLS function is ready to operate.	
17. Document and sign the commissioning report.	

Table 24: Commissioning Test Report, Safe Maximum Speed

Test procedure	Approved ✓
1. Disable all safety sub-functions that can be activated by DI1 or DI2 and ensure that no alarms and warnings are shown.	
2. Enable SMS.	
3. Run the motor below SMS cut-off speed (~100 RPM below is recommended).	
4. Increase the motor speed until SMS cut-off speed is reached.	
5. Check that the drive coasts and *Warning 68, Safe Stop* is shown.	
6. Set the motor speed value below SMS cut-off speed.	
7. Apply reset.	
8. Ensure that the motor starts running. This might require a separate start signal from the control system.	
Document and sign the commissioning report.	

Tester/Approver

Date: _____

Signature: _____

8 Warnings and Alarms

8.1 Fault Types and Messages

This chapter provides troubleshooting tables for diagnosing fault conditions associated with the safety option.

The safety option differentiates between fatal error and alarm.

Table 25: Fault Types

Fault type	Description	Effect on the system	Reset condition
Fatal error	Severe exceptional error caused by the program run in the safety option. Cyclic program sequence is no longer possible for safety-related reasons. The last active function is shown. The system is in stop mode.	Output S37 is switched off	Reset possible by power cycling the drive or restart the safety option via *parameter 42-90 Restart Safe Option*.
Alarm	Functional fault, caused by an external process. Both systems continue to run cyclically and serve all requests from the communication interfaces. Sensing of the external process is also maintained.	Output S37 is switched off	Reset possible via parameterizable input DI2, reset on LCP/DI or via fieldbus or via *parameter 42-90 Restart Safe Option*.

Table 26: LED Status Indicators

Color	Mode	Description
Green	Flashing	System OK, configuration validated.
Green	Permanent	System OK, input or output activated.
Yellow	Flashing	System OK, configuration not yet validated.
Red	Flashing	Alarm.
Red	Permanent	Fatal error.

All external failures can be removed by giving a reset signal (via LCP, DI2a, and digital inputs on control card or via fieldbus depending on configuration). All internal failures can be removed by power cycle, *parameter 42-90 Restart Safe Option* and configuration.

8.1.1 Messages

Any errors on the safety option are indicated on the drive display with different messages.

The following options are available for detailed diagnosis and fault detection:

- LEDs on the front of the safety option provide information on operating states. The LEDs are used to indicate the status of the option, that is active safety sub-functions, failures, and warnings, if any.
- LCP text or information via bus shows the status of the safety sub-functions (for example SS1a).

The following is shown in online mode in the MCT 10 Set-up Software:

- Status of the safety option input and output errors, messages, and the corresponding remedies are shown in the expanded diagnosis system of the MCT 10 Set-up Software.

8.2 Warnings and Alarms

NOTICE

The errors are listed numerically.

Table 27: LED Indications, Errors 1–68

Error number	Description	LED indicators				
				LED1	LED2	LED4
	Internal failure	**Reason**	**Action**			Green constant
1	Diagnostic in progress			Status of LED 1 and LED2 depends on safety sub-function state assigned to DI1 and DI2.		Green constant
67	Int Fail tolerance error exceeded: Reaction STO	• Check that data for feedback (PPR., type of feedback, and gear ratio) is entered correctly. • Direction of feedback is wrong. • Due to use of feedback filter the dynamic of the system does not match with dynamic of feedback filter (*parameter 42-15 Feedback Filter*). System is ramping too fast. • Feedback signals are not received at all. • No proper shielding of feedback cables.	• Make a recustomization with correct data if needed. • Set *parameter 42-12 Encoder Direction* to the opposite value. • Decrease the ramping time on the drive. • Try to run the system at, for example, 60 RPM. If *error 99, Int Fail Feedback error* occurs, this is the reason. • Improve shielding of feedback cables and motor cables.			Red constant
68	Int fail Speed limit SS1a Ramp: Reaction STO	• The value of Delta V is too small. For closed-loop system, it must often be larger than the recommended value. • Due to use of feedback filter the dynamic of the system does not match with dynamic of feedback filter (*parameter 42-15 Feedback Filter*). • Load change takes place during ramping.	• If running in closed loop, try to adjust PID setting and if needed increase SS1 ramping time. • Try to increase *parameter 42-15 Feedback Filter*, but this might cause *error 67, Int Fail tolerance error exceeded: Reaction STO* to occur. • Otherwise increase *parameter 42-45 Delta V*.			Red constant

Table 28: LED Indications, Errors 69–72

Error number	Description	LED indicators				
				LED1	**LED2**	**LED4**
	Internal failure	**Reason**	**Action**			Green constant
69	Int fail Speed limit SS1b Ramp: Reaction STO	See 68.	See 68.	Status of LED 1 and LED 2 depends on safety sub-function state assigned to DI1 and DI2.		Red constant
70	Int fail speed limit SLSa: Reaction STO	Happens during ramping to SLS limit, see 68. Happens during speed below SLS limit: • If speed is above cut-off speed at activation point and *parameter 42-53 Start Ramp* is set to *No*, this error occurs. • Noise on the feedback signal (incl. quantization noise) is larger than expected. • Load change takes place, do as in above point.	• Change *parameter 42-53 Start Ramp* to *Yes* and set *parameter 42-54 Ramp Down Time* accordingly. • Increase *parameter 42-50 Cut Off Speed* or decrease *parameter 42-51 Speed Limit* to get a larger tolerance.			Red constant
71	Int fail speed limit SLSb: Reaction STO	See 70.	See 70.			Red constant
72	Internal failure MCB 150/151		• First, power cycle the drive or restart the safety option via *parameter 42-90 Restart Safe Option*. Second, try to make a general reset of the safety option with the *Administration* button (safety option goes back to blank initial state). • If the problem persists, contact Danfoss.			Red constant

Table 29: LED Indications, Errors 73–77

Error number	Description	LED indicators				
				LED1	LED2	LED4
	Internal failure	Reason	Action			Green constant
73	Internal failure MCB 150/151		• First, power cycle the drive or restart the safety option via *parameter 42-90 Restart Safe Option*. • If the problem persists, contact Danfoss.	Status of LED 1 and LED 2 depends on safety sub-function state assigned to DI1 and DI2.		Red constant
74	Internal failure MCB 150/151		• First, power cycle the drive or restart the safety option via *parameter 42-90 Restart Safe Option*. • If the problem persists, contact Danfoss.			Red constant
75	Int Fail DI2 in PUST: Reaction STO	• Safety input connected to DI2 has illegal signal level. • Sensor is broken.	• Check that the configuration of DI2 *parameter 42-21 Type* is set correctly or that the connected sensor is installed according to specification. • Extend discrepancy time on the safe input tab in the MCT 10 Safe Plug-in via *parameter 14-22 Operation Mode*.			Red constant
76	Int Fail DI1 in PUST: Reaction STO	• Safety input connected to DI1 has illegal signal level. • Sensor is broken.	• Check that the configuration of DI1 *parameter 42-21 Type*, sub-index [0], is set correctly or that the connected sensor is installed according to specification. • Extend discrepancy time on the safe input tab in the MCT 10 Safe Plug-in via *parameter 14-22 Operation Mode*.			Red constant
77	Int Fail fail-safe data CRC mismatch: Reaction STO	The CRC of the safety option does not match the stored CRC value on the drive.	Configure the safety option with MCT 10 Safe Plug-in or by CRC select/LCP copy.			Red constant

Table 30: LED Indications, Errors 78–85

Error number	Description	LED indicators				
				LED1	LED2	LED4
	Internal failure	Reason	Action			Green constant
78	Internal failure safety option		• First, power cycle the drive or restart the safety option via *parameter 42-90 Restart Safe Option*. • If the problem persists, contact Danfoss.	Status of LED 1 and LED 2 depends on safety sub-function state assigned to DI1 and DI2.		Red constant
79	Internal failure safety option		Contact Danfoss.			Red constant
80	Internal failure safety option		Contact Danfoss.			Red constant
81	Internal failure safety option		• First, power cycle the drive. • If the problem persists, contact Danfoss.			Red constant
82	Internal failure safety option		• First, power cycle the drive. • If the problem persists, contact Danfoss.			Red constant
83	Internal failure safety option		• First, power cycle the drive. • If the problem persists, contact Danfoss.			Red constant
84	Internal failure safety option		• First, power cycle the drive. • If the problem persists, contact Danfoss.			Red constant
85	Internal failure safety option		• First, power cycle the drive. • If the problem persists, contact Danfoss.			Red constant

Table 31: LED Indications, Errors 86–93

Error number	Description	LED indicators				
				LED1	LED2	LED4
	Internal failure	Reason	Action			Green constant
86	Internal failure safety option		• First, power cycle the drive. • If the problem persists, contact Danfoss.	Status of LED 1 and LED 2 depends on safety sub-function state assigned to DI1 and DI2.		Red constant
87	Internal failure safety option		• First, power cycle the drive. • If the problem persists, contact Danfoss.			Red constant
88	Internal failure safety option		• First, power cycle the drive. • If the problem persists, contact Danfoss.			Red constant
89	Internal failure safety option		• Perform a general reset of the safety option with the *Administration* button. • If the problem persists, contact Danfoss.			Red constant
90	Internal failure safety option		• Perform a general reset of the safety option with the *Administration* button. • If the problem persists, contact Danfoss.			Red constant
91	Internal failure safety option		• First, power cycle the drive. • If the problem persists, contact Danfoss.			Red constant
92	Internal failure safety option		• First, power cycle the drive. • If the problem persists, contact Danfoss.			Red constant
93	Internal failure safety option		• First, power cycle the drive. • If the problem persists, contact Danfoss.			Red constant

Table 32: LED Indications, Errors 94–102

Error number	Description	LED indicators				
				LED1	LED2	LED4
	Internal failure	Reason	Action			Green constant
94	Internal failure safety option		• First, power cycle the drive. • If the problem persists, contact Danfoss.	Status of LED 1 and LED 2 depends on safety sub-function state assigned to DI1 and DI2.		Red constant
95	Internal failure safety option		• First, power cycle the drive. • If the problem persists, contact Danfoss.			Red constant
96	Internal failure safety option		• First, power cycle the drive. • If the problem persists, contact Danfoss.			Red constant
97	Internal failure safety option		Contact Danfoss.			Red constant
98	Int fail invalid customer file version	Version of customization file of safety option stored in EEPROM does not match the customization file supported by the SW version of safety option.	Do a new configuration with MCT 10 Safe Plug-in, which supports the SW version of safety option.			
99	Int Fail Feedback error	The connected feedback source does not give any signal.	Check that the connection is done according to the specification or if the feedback source is broken.			Red
102	Int Fail Speed Limit SMS: Reaction STO	• Speed is above cut-off speed. • Noise on the feedback signal (incl. quantization noise) is larger than expected.	Check the value of *parameter 42-71 Cut Off Speed*.			Red constant

Table 33: LED Indications, Errors 113–135

Error number	Description	LED indicators				
				LED1	**LED2**	**LED4**
	Internal failure	**Reason**	**Action**			Green constant
113	Ext Fail DI1: Reaction STO	• Safety input connected to DI1 has illegal signal level. • Sensor is broken.	• Check that configuration of DI1 *parameter 42-21 Type* is set correctly or the connected sensor is installed according to the specification.	Red constant.	Status depends on safety sub-function state assigned to DI2.	Red flashing, cycle (on 500 ms, off 500 ms)
114	Ext Fail DI2: Reaction STO	• Safety input connected to DI2 has illegal signal level. • Sensor is broken.	• Check that configuration of DI2 *parameter 42-21 Type* is set correctly or the connected sensor is installed according to the specification. • Extend discrepancy time on safe input tab in MCT 10 Safe Plug-in *parameter 14-22 Operation Mode*.	Status depends on safety sub-function state assigned to DI1.	Red constant.	Red flashing, cycle (on 500 ms, off 500 ms)
115	Ext Fail Prec Thresh Timer Elapsed: Reaction STO	The drive has been running below 120 RPM for more than the time entered in *parameter 42-18 Zero Speed Timer* with safe function SLS active.	Increase speed to above 120 RPM.	Status of LED 1 and LED 2 depends on safety sub-function state assigned to DI1 and DI2.		Red flashing, cycle (on 500 ms, off 500 ms)
116	Ext Fail SF activation Speed Suspension: Reaction STO	The drive has been running below 120 RPM for more that 1 year and a safety sub-function that needs speed feedback is activated.	Increase speed to above 120 RPM.			Red flashing, cycle (on 500 ms, off 500 ms)
134	Int fail speed limit SLSa: Reaction SS1a	See 70.	See 70.			Red constant
135	Int fail speed limit SLSb: Reaction SS1a	See 70.	See 70.			Red constant

Table 34: LED Indications, Errors 177–252

Error number	Description	LED indicators				
				LED1	**LED2**	**LED4**
	Internal failure	**Reason**	**Action**			Green constant
177	Ext Fail DI1: Reaction SS1a	See 113.	See 113.	Red constant.	Status depends on safety sub-function state assigned to DI2.	Red flashing, cycle (on 500 ms, off 500 ms)
178	Ext Fail DI2: Reaction SS1a	See 114.	See 114.	Status depends on safety sub-function state assigned to DI1.	Red constant.	Red flashing, cycle (on 500 ms, off 500 ms)
179	Ext Fail Prec Thresh Timer Elapsed: Reaction SS1a	See 115.	See 115.	Status of LED 1 and LED 2 depends on safety sub-function state assigned to DI1 and DI2.		Red flashing, cycle (on 500 ms, off 500 ms)
180	Ext Fail SF activation Speed Suspension: Reaction SS1a	See 116.	See 116.			Red flashing, cycle (on 500 ms, off 500 ms)
198	Int fail speed limit SLSa: Reaction SS1b	See 70.	See 70.			Red constant
199	Int fail speed limit SLSb: Reaction SS1b	See 70.	See 70.			Red constant
241	Ext Fail DI1: Reaction SS1b	See 113.	See 113.	Red constant.	Status depends on safety sub-function state assigned to DI2.	Red flashing, cycle (on 500 ms, off 500 ms)
242	Ext Fail DI2: Reaction SS1b	See 114.	See 114.	Status depends on safety sub-function state assigned to DI1.	Red constant.	Red flashing, cycle (on 500 ms, off 500 ms)
243	Ext Fail Prec Thresh Timer Elapsed: Reaction SS1b	See 115.	See 115.			Red flashing, cycle (on 500 ms, off 500 ms)
244	Ext Fail SF activation Speed Suspension: Reaction SS1b	See 116.	See 116.			Red flashing, cycle (on 500 ms, off 500 ms)
252	Internal failure safety option		Power cycle the drive. If the problem persists, contact Danfoss.			

8.2.1 Safety Option Warning

A warning message notifies that an issue exists on the safety option. It is not handled as an internal or external failure. These messages are defined to indicate that a manual user action is required.

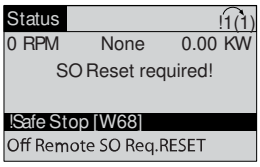
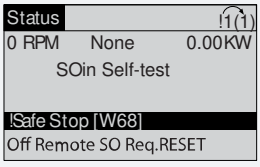
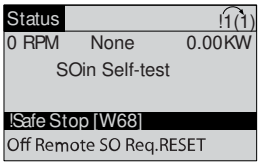
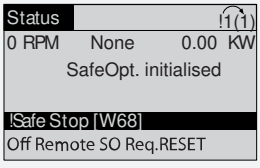
NOTICE

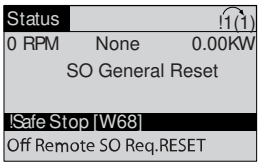
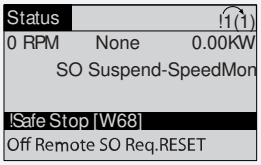
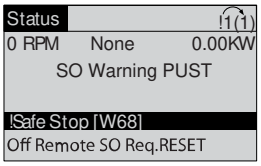
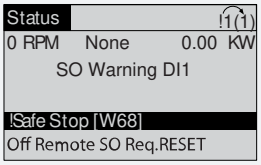
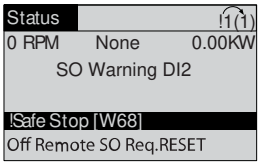
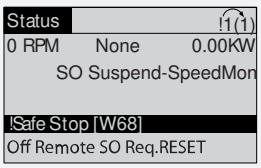
At any possible failure or warning indicated from the safety option, the LCP shows *warning, !Safe Option Failure [W252]* at the least.

8.2.2 Safety Option Reset Message

For some messages, the safety option requires an acknowledgement of an ongoing action or failure on the safety option. The safety option uses *Safe Option RESET* as a *Restart and Failure Acknowledgement*.

Table 35: LCP Reset Messages

LCP message	Description
 e30bd126.11	In the following cases, the safety option requests a restart and failure acknowledgement signal: • The safety option is in safety sub-function pending-state (remark: Occurs only if reset behavior is set/configured to *Manual*). • After a power cycle with a safety sub-function. • In PUST (power up self-test), if an external failure occurred before power cycle. • When an external failure occurred. • When customization was aborted or completed. • At the reception of a general reset (required after blank initial state or in the customization state).
 e30bd127.11	The safety option indicates that it is in PUST State (Power Up Self Test). • Ensure that no safe function is active after a power cycle.
 e30bd127.11	A safety sub-function is pending at the start-up, if the drive was powered down while a safety function was active. It is also pending, when the drive was powered down while the safety option has detected a failure during an active safety sub-function.
 e30bd129.11	The safety option requests a Restart and Failure Acknowledge signal, which is always required after a PUST and when a safety sub-function gets released and is configured to be confirmed that the motor is able to run.

LCP message	Description
 e30bd130.11	Occurs only if general reset is performed from MCT 10. It is an indication to the user. The safety option is set to blank initial state and safe parameters are set to default.
 e30bd131.11	Zero speed timer contains the remaining time until the fail prec thresh timer elapsed after the monitoring time expires. The safety option signals Warning.
 e30bd132.11	PUST warning has occurred. Warning cause: Expiry of PUST timer. Memory test required, perform power cycle.
 e30bd133.11	DI1 offline warning has occurred. Warning cause: Expiry of offline timer for DI1.
 e30bd134.11	DI2 offline warning has occurred. Warning cause: Expiry of offline timer for DI2.
 e30bd131.11	Speed monitoring suspension warning has occurred. Warning cause: Suspension of speed monitoring for a certain duration.

9 Technical Specifications

9.1 Consumption

Power consumption	2 W (equivalent power consumption related to VDD)
Current consumption VCC (5 V)	<200 mA
Current consumption VDD (24 V)	<30 mA (<25 mA for VLT® Safety Option MCB 150)

9.2 Inputs

9.2.1 Digital Inputs

Number of digital inputs	4 (2x2-channel digital safety input)
Input voltage range	0–24 V DC
Input voltage range, logic 0	<5 V DC
Input voltage range, logic 1	>12 V DC
Input voltage (maximum)	28 V DC
Input current (minimum)	6 mA @V_{in}=24 V (inrush current 12 mA peak)
Input resistance	Approximately 4 kΩ
Galvanic isolation	No
Short-circuit proof	Yes
Input pulse recognition time (minimum)	3 ms
Discrepancy time	9 ms
Cable length	<30 m (98.4 ft) (shielded or unshielded cable), >30 m (98.4 ft) (shielded cable)

9.2.2 TTL Encoder Input (VLT® Safety Option MCB 150)

Number of encoder inputs	4 (2 x differential inputs A, A/; B,/B)
Encoder types	TTL, RS422/RS485 incremental encoders
Input differential voltage range	-7 to +12 V DC
Input common-mode voltage	-12 to +12 V DC
Input voltage, logic 0 (differential)	<-200 mV DC
Input voltage, logic 1 (differential)	>+200 mV DC
Input resistance	Approximately 120 Ω
Maximum frequency	410 kHz
Short-circuit proof	Yes
Cable length	<150 m (492 ft) (tested with shielded cable - Heidenhain AWM Style 20963 80 °C 30V E63216, 100 m (328 ft) shielded motor cable, no load on motor)

9.2.3 HTL Encoder Input (VLT® Safety Option MCB 151)

Number of encoder inputs	2 (2 x single ended inputs A; B)
Encoder types	HTL incremental encoders, HTL proximity sensor, VLT® Sensorless Safety MCB 159

Logic input	PNP
Input voltage range	0–24 V DC
Input voltage, logic 0	<5 V DC
Input voltage, logic 1	>12 V DC
Input voltage (maximum)	28 V DC
Input resistance	Approximately 4 Ω
Maximum frequency	110 kHz
Short-circuit proof	Yes
Cable length	<100 m (328 ft) (tested with shielded cable - Heidenhain AWM Style 20963 80 °C 30V E63216, 100 m (328 ft) shielded motor cable, no load on motor)

9.3 Outputs

9.3.1 Digital Output (Safe Output)

Number of outputs	1
Output voltage low	<2 V DC
Output voltage high	>19.5 V DC
Output voltage (maximum)	24.5 V DC
Nominal output current (@24 V)	<100 mA
Nominal output current (@0 V)	<0.5 mA
Galvanic isolation	No
Diagnostic test pulse	300 µs
Short-circuit proof	Yes
Cable length	<30 m (98.4 ft) (shielded cable)

9.3.2 24 V Supply Output

Supply voltage	24 V DC (voltage tolerance: +0.5 V DC to -4.5 V DC)
Maximum output current	150 mA
Short-circuit proof	Yes
Cable length	<30 m (98.4 ft) (shielded or unshielded cable), >30 m (98.4 ft) (shielded cable)

9.4 Other Specifications

9.4.1 Ground I/O Section

Cable length	<30 m (98.4 ft) (shielded or unshielded cable), >30 m (98.4 ft) (shielded cable)

9.4.2 Cable Cross-sections

Digital inputs/output supply voltage	0.75 mm^2/18 AWG, AEH without plastic collar in accordance with DIN 46228/1

9.4.3 Reset Characteristics

Manual reset time	≤5 ms (safety option), ≤5 ms (drive), ≤10 ms (fieldbus)
Manual reset pulse time	10 µs (safety option and drive)
Automatic reset time	≤4 ms
Start-up reset time	≤5 s (*parameter 42-90 Restart Safe Option*)

9.4.4 Response Time

Input to output response time	≤2 ms
Emergency stop until beginning of SS1/SLS	≤7 ms
Cross fault detection time	≤3 ms (@activated output)

9.4.5 Safety Characteristic Data

NOTICE

The safety-related characteristic data are valid for all safety sub-functions. All units used within a safety sub-function must be considered when calculating the safety characteristic data.

Table 36: European Directives

Name of directive	Number/Description
Machinery Directive (2006/42/EC)	EN ISO 13849-1 EN IEC 62061 EN IEC 61800-5-2
EMC Directive (2014/30/EU)	EN 50011 EN 61000-6-3 EN 61800-3
Low Voltage Directive (2014/35/EC)	EN 50178 EN 61800-5-1

Table 37: Safety Standards

Name of standard	Number/description
Safety of Machinery	EN ISO 13849-1 IEC 62061 IEC 60204-1
Functional Safety	IEC 61508-1 to -7 IEC 61800-5-2

Table 38: Safety Sub-function

IEC 61800-5-2	IEC 60204-1
Safe Torque Off (STO)	Stop Category 0
Safe Stop 1 (SS1)	Stop Category 1
Safely Limited Speed (SLS)	–

Table 39: Safety Performance

Name of performance	Type/description
Safety Integrity Level	SIL 2 SIL CL2
HFT (IEC 61508)	Hardware Fault Tolerance = 1
Subsystem classification	Type B
Probability of dangerous failure per hour	PFH: 1,52 e-8
Probability of dangerous failure on demand	PFD: 1,33 e-3
Category	Cat 3
Performance level	PL d (cat 3)
Mean time to dangerous failure of each channel	MTTFd: 245 years (High)
Average diagnostic coverage	DC_{ave}: 86% (Low)
Safe failure fraction	SFF: 90%
Proof test interval	20 years

10 Appendix

10.1 Abbreviations

Abbreviation	Description
Cat.	Category (EN ISO 13849-1).
CCF	Common cause failure (IEC 61508, IEC 62061, EN 61511-1, EN ISO 13849-1).
CCW	Counterclockwise.
CW	Clockwise.
DC	Diagnostic coverage (EN ISO 13849-1, IEC 62061 (IEC61508-2)).
DIx	DI1: Digital input 1. DI2: Digital input 2.
EMC	Electromagnetic compatibility.
MFFT/MTTFd	Mean time to failure/mean time to dangerous failure (EN ISO 13849-1).
OSSD	Output signal switching device (EN 61496-1).
PDS(SR)	Power drive system (safety related).
PELV	Protective extra low voltage, low voltage with isolation. For more information: IEC 60364-4-41 or IEC 60204-1.
PFD	Probability of failure on demand (IEC 61508, IEC 62061).
PFH	Probability of failure per hour (IEC 61508, IEC 62061).
PLC	Programmable logic controller.
PUST	Power up self-test. Internal self-test on the safety option.
SF	Safe function.
SIL	Safety integrity level (IEC 61508, IEC 61800-5-2, IEC 62061).
SLS	Safely Limited Speed.
SO	Safety option.
SRECS	Safety-related electrical control system (IEC 62061).
SRP/CS	Safety-related part of control systems (EN ISO 13849-1).
SS1	Safe stop 1.
STO	Safe Torque Off.
TM	Mission time (EN ISO 13849-1).

10.2 Conventions

- Numbered lists indicate procedures.
- Bulleted and dashed lists indicate listings of other information where the order of the information is not relevant.
- Bolded text indicates highlighting and section headings.
- Italicized text indicates the following:
  - Cross-reference.
  - Link.
  - Footnote.
  - Parameter name.
  - Parameter option.
  - Parameter group name.
- All dimensions in drawings are in metric values (imperial values in brackets).
- An asterisk (*) indicates the default setting of a parameter.

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T

U

V

Glossary - VLT® Safety Option MCB 150/151

B

Blank initial state — Factory settings

D

Degree of protection — The degree of protection is a standardized specification for electrical equipment that describes the protection against the ingress of foreign objects and water (for example, IP20).

E

Encoder — Sensor for detection of the angular position of a rotating component. Installed on/in a motor, the encoder shows the angular position of the rotor.

Error — Discrepancy between a computed, observed, or measured value or condition and the specified or theoretically correct value or condition.

Error class — Classification of errors into groups. The different error classes allow for specific responses to errors, for example by severity.

F

Factory settings — Factory settings when the product is shipped.

Fatal error — If a fatal error occurs, the product is no longer able to control the motor so that the power stage must be immediately disabled.

Fault — Fault is a state that can be caused by an error.

Fault reset — A function used to restore the drive to an operational state after a detected error is cleared by removing the cause of the error so that the error is no longer active.

P

Parameter — Device data and values that can be read and set (to a certain extent) by the user.

PL/Performance level — Discrete level used to specify the ability of safety-related parts of control systems to perform a safety sub-function under foreseeable conditions (EN ISO 13849-1).

R

RS485 — Fieldbus interface as per EIA-422/485 Bus Description, which enables serial data transmission with multiple devices.

S

Safe state — If a safe state fault is detected, the safety option goes into safe state. This includes faults related to integrity of hardware and firmware.

SLS - Safely limited speed
Safety sub-function in accordance with EN IEC 61800-5-2, monitors the drive to check that it stays within a defined speed limit.

SMS - Safe maximum speed
In accordance with EN IEC 61800-5-2, the safety sub-function monitors the drive continuously to check that it stays within a defined speed limit.

SS1 - Safe stop 1
Safety sub-function in accordance with EN IEC 61800-5-2, ensures that the motor decelerates in the expected way.

STO - Safe Torque Off
Safety sub-function in accordance with EN IEC 61800-5-2, prevents torque from being generated by the motor. This function is integrated within the drive as a standard.

W

Warning
If the term is used outside the context of safety instructions, a warning alerts to a potential problem that was detected by a monitoring function. A warning is not an error and does not cause a transition of the operating state.

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