



# Operating Instructions Safety Option MCB 150/151





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# 1 Introduction

## 1.1 Purpose of the Manual

### **NOTICE**

Retain this documentation for instruction and for future reference.

These Operating Instructions explain the function and operation and provide installation and wiring guidelines for the safety option.

Also refer to the following documents from the motion control range:

- *MCT 10 Set-up Software Operating Instructions* describe the configuration of the safety option.
- *VLT® AutomationDrive FC 301/FC 302 Operating Instructions* describe the frequency converter.
- The online help for the MCT 10 Set-up Software describes how to set the parameters for the frequency converter and the safety option.

Be conversant with the information in these documents to fully understand this manual.

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## 1.2 Overview of Documentation

### **Chapter 1 Introduction**

Explains the contents, structure and specific order of this manual.

### **Chapter 2 Legal Information and Safety**

Provides information on the most important product features.

### **Chapter 4 Installation**

Explains how to install and wire the product.

### **Chapter 5 Commissioning**

Describes how to commission the product.

### **Chapter 6 General Parameter Set-up**

Describes the basic parameters for setting.

### **Chapter 7 Service and Repair**

Describes how to replace a defective safety option and how to update, service and modify its firmware.

### **Chapter 8 Warnings and Alarms**

Contains a table overview of the warnings and alarms. Troubleshooting tips are also part of the overview.

### **Chapter 9 Technical Specifications**

Specifies the technical details of the safety option.

The manuals listed below contain important information about safety systems that must be used to mount and set up the speed monitoring safety functions of the safety option module.

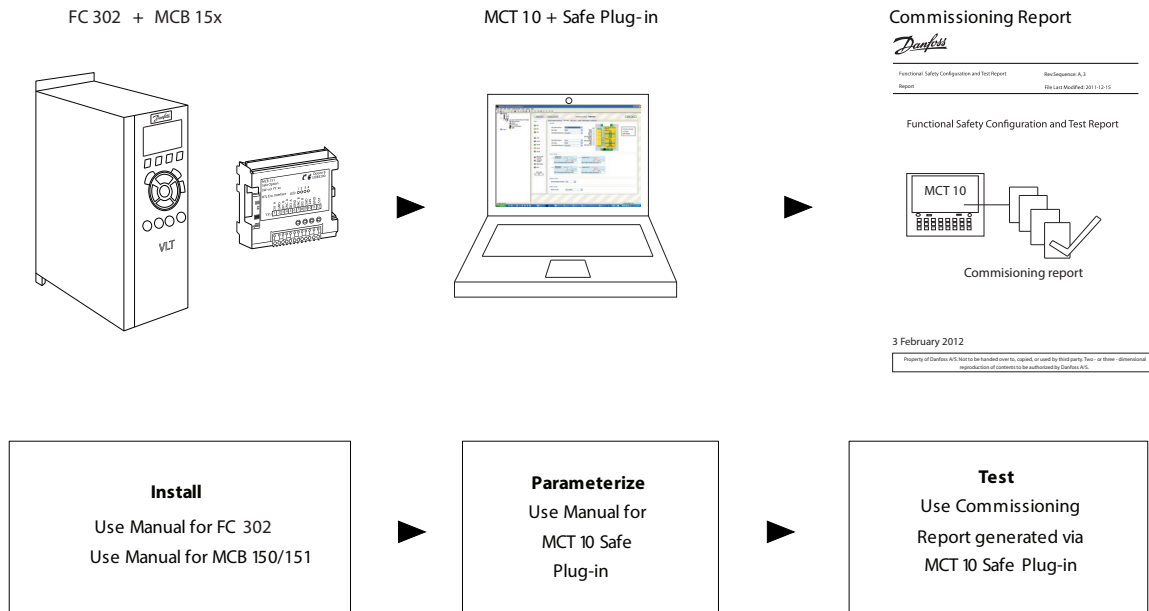


Illustration 1.1 System Overview

Referenced literature

- VLT® AutomationDrive FC 301/FC 302 Operating Instructions
- MCT 10 Set-up Software Operating Instruction

Also refer to [www.danfoss.com/drives](http://www.danfoss.com/drives) for additional information.

1.3 Abbreviations and Definitions

Blank Initial State	Factory settings
Cat.	Category (EN ISO 13849-1)
CCF	Common Cause Failure (IEC 61508, IEC 62061, EN 61511-1, EN ISO 13849-1)
CCW	Counter Clockwise
CW	Clockwise
DC	Diagnostic Coverage (EN ISO 13849-1, IEC 62061(IEC 61508-2))
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).
Dlx	DI1: Digital Input 1 DI2: Digital Input 2
EMC	Electromagnetic compatibility
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.
Factory setting	Factory settings when the product is shipped
Fatal error	In the case of fatal error, 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 frequency converter 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.
MTTF/MTTFd	Mean time to failure/Mean time to dangerous failure (EN ISO 13849-1)
OSSD	Output Signal Switching Device (EN 61496-1)
Parameter	Device data and values that can be read and set (to a certain extent) by the user
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 62061 and IEC61508)
PLC	Programmable logic controller



PL/ Performance Level	Discrete level used to specify the ability of safety-related parts of control systems to perform a safety function under foreseeable conditions (EN ISO 13849-1)
PUST	Power Up Self Test. Internal self test on the safety option.
RS-485	Fieldbus interface as per EIA-422/485 Bus Description, which enables serial data transmission with multiple devices.
Safe state	If a safe state fault is detected, the safety option goes into safe state. This includes faults related to integrity of hardware or firmware.
SF	Safe Function
SIL	Safety Integrity level (IEC61508, IEC61800-5-2, IEC62061)
SLS - Safely limited speed	Safety function in accordance with EN IEC 61800-5-2, monitors the frequency converter to check that it stays within a defined speed limit. SLS is the abbreviation for safely limited speed.
SO	Safety Option
SRECS	Safety Related Electrical Control System (IEC 62061)
SRP/CS	Safety related parts of control systems (EN ISO 13849-1)
SS1 - Safe Stop 1	Safety function in accordance with EN IEC 61800-5-2, ensures that the motor decelerates in the expected way. SS1 is the abbreviation for safe stop 1.
STO - Safe Torque Off	Safety function in accordance with EN IEC 61800-5-2, prevents torque from being generated by the motor. This function is integrated within the frequency converter as standard. STO is the abbreviation for safe torque off.
TM	Mission Time (EN ISO 13849-1)
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.

Table 1.1 Abbreviations and Definitions

## 2

## 2 Legal Information and Safety

### 2.1 Legal Information

According to the Machinery Directive regulation, it is hereby stated that the original language of these Operating Instructions is English UK.

#### 2.1.1 Copyright and Revisions

This publication contains information proprietary to Danfoss and is protected by Copyright laws of Denmark, international treaties and most other countries. All trademarks in this publication are property of the respective companies. Danfoss and the Danfoss logotype are trademarks of Danfoss A/S. All rights reserved.

Although Danfoss has tested and reviewed the correctness, completeness and documentation of this publication, Danfoss makes no warranty or representation, neither express or implied, with respect to this publication, including but not limited to its quality, correctness, completeness, performance, or fitness for a particular purpose.

Danfoss reserves the right to revise, update and change this publication at any time without prior notice or specific obligation to inform former or present users of such revisions or changes.

#### 2.1.2 Warranty and Liability

All claims to warranty and liability are rendered invalid if

- the product was used contrary to the purpose for which it is 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 (e.g. exchanging components on the PCB boards, soldering work etc.).

### 2.2 Safety

#### 2.2.1 Safety Precautions

##### **▲WARNING**

##### **HIGH VOLTAGE!**

Frequency converters contain high voltage when connected to AC mains input power. Installation, start up, and maintenance should be performed by qualified personnel only. Failure to perform installation, start up, and maintenance by qualified personnel could result in death or serious injury.

##### **▲WARNING**

##### **UNINTENDED START!**

When the frequency converter is connected to AC mains, the motor may start at any time. The frequency converter, motor, and any driven equipment must be in operational readiness. Failure to be in operational readiness when the frequency converter is connected to AC mains could result in death, serious injury, equipment, or property damage.

##### **▲CAUTION**

This option is suitable for performing mechanical work on the frequency converter system or affected area of a machine only. It does NOT provide electrical safety. This option should NOT be used as a control for starting and/or stopping the frequency converter. See the requirements for those applications in ISO 12100.

#### 2.2.2 Risk Assessment

##### **CAUTION**

The safety option is intended to be part of the safety-related control system of a machine. Before installation, a risk assessment shall be performed 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

- the set-up, safety rating and validation of any sensors or 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 desired 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.
- analysing all configuration settings and selecting the proper setting to achieve the required safety rating.

### 2.2.3 Safety Regulations

- Check that the mains supply has been disconnected and that the necessary time has elapsed before removing motor and mains supply plugs and before commencing any repair work.
- The [Off] key on the LCP does not disconnect mains supply and must never be used as a safety switch.
- Ensure the following in accordance with national and local regulations:
  - The equipment must be properly earthed
  - The user must be protected against supply voltage
  - The motor must be protected against overload
- The earth leakage current exceeds 3.5 mA.
- Protection against motor overload is not included in the factory setting. If this function is desired, set *1-90 Motor Thermal Protection* to data value [4] *ETR trip 1* or data value [3] *ETR warning 1*.
- Do not remove the plugs for the motor and mains supply while the frequency converter is connected to mains.

#### **NOTICE**

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

### 2.2.4 Qualified Personnel

The products may 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 description and also the instructions given in the *VLT® AutomationDrive FC 301/FC 302 Operating Instructions*.
- have a good knowledge of the generic and specialist standards applicable to the specific application.

Users of PDS(SR)s are responsible for

- hazard and risk analysis of the application.
- identifying safety functions required and allocating SIL or PLr to each of the functions.
- other subsystems and the validity of signals and commands from them.
- designing appropriate safety-related control systems (hardware, software, parameterisation, etc.).

The following symbols are used in this document:

#### **⚠ WARNING**

Indicates a potentially hazardous situation which could result in death or serious injury.

#### **⚠ CAUTION**

Indicates a potentially hazardous situation which could result in minor or moderate injury. It may also be used to alert against unsafe practices.

#### **NOTICE**

Indicates important information, including situations that may result in damage to equipment or property.

#### Approvals



### 3 Functions and System Overview

#### 3.1 System Overview

3

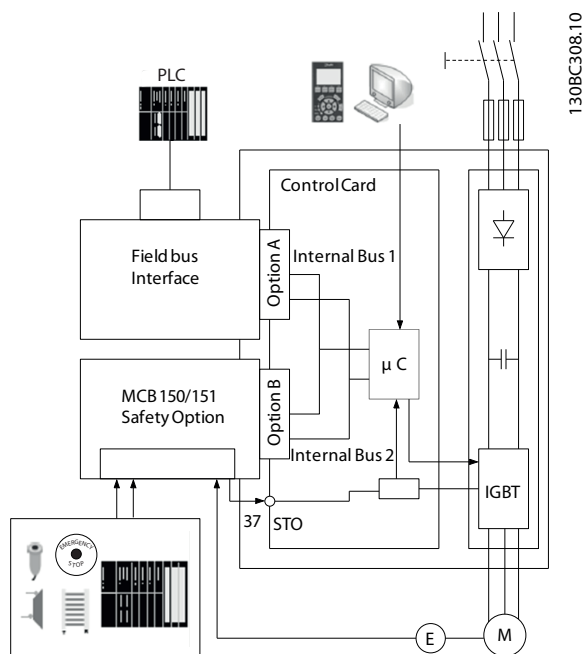


Illustration 3.1 FC 302 with Safety Option and Fieldbus Option

The safety option performs safety functions in accordance with EN IEC 61800-5-2. It monitors safe motion sequences on frequency converters, which are safely brought to a stop and shut down in the event of an error.

##### The safety option

- activates safety functions
- monitors safe motion sequences
- signals the status of safety functions to the safety control system via possible connected Profibus fieldbus
- activates the selected failure reaction Safe Torque Off or Safe Stop 1, in the event of an error

There are 2 variants of the safety option, one with HTL encoder interface (MCB 151) and one 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 in combination

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 frequency converter

- removes the power to the motor,
- switches the motor to torque-free, if Safe Torque Off is activated

##### The safety control system

- activates the safety 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 functions (shorts across contacts, short circuit) on signal between the safety control system and safety option

#### 3.1.1 Behaviour of Holding Brake

### CAUTION

#### RISK OF HAZARD!

If external forces act on the motor (vertical axis) and an unwanted movement, for example caused by gravity, could cause a hazard, add measures for fall protection before operating the motor.

Triggering the Safe Torque Off safety 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 additional measures have to be taken; for example, this may cause the load of vertical axes to lower.

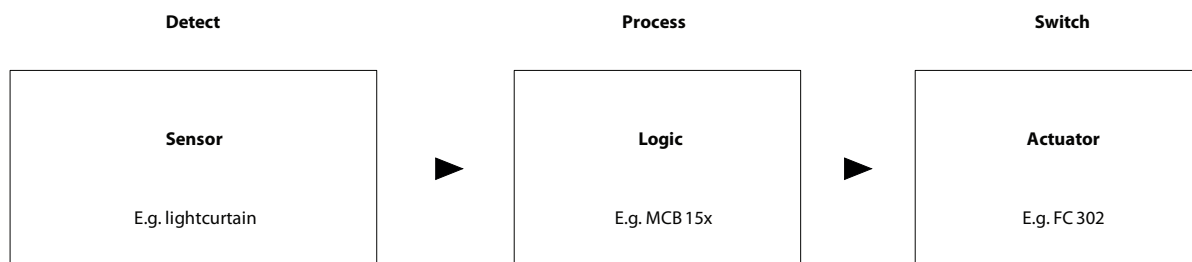
### 3.1.2 Safety Certification

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-energised state is considered to be the safe state. All of the examples related to I/O included in this manual are based on achieving de-energisation as the safe state.

### 3.1.3 Implementation in Control Systems

In many cases design measures are not sufficient and protective devices are needed to minimise risk. In this context, safety functions executed by SRP/CS (safety related parts of control systems) are defined. SRP/CS includes the entire safety chain with sensor (detect), logic (process) and actuator (switch).

Safety functions are defined on the basis of both 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 functions. Typical safety functions are described in more detail in EN ISO 13849-1, section 5, *Specification of Safety Functions*. The safety functions for frequency converter systems are described in IEC 61800-5-2.



130BC962.10

Illustration 3.2 Sensor-Logic-Actuator Safety Chain

## 3.2 Functions

### 3.2.1 Specification of Safety Functions

The standards require a specification of functional requirements. The specification must contain details about each safety 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 functions.

All of 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 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. Library can be downloaded from [www.dguv.de/ifa/en/prs/softwa/sistema](http://www.dguv.de/ifa/en/prs/softwa/sistema).

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

### 3.2.3 Activation of Safety Functions

- The safety 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 functions via a 1/0 transition.
- Deactivate the safety functions before applying any changes to them.

### 3.2.4 Simultaneous Activation of Safety Functions

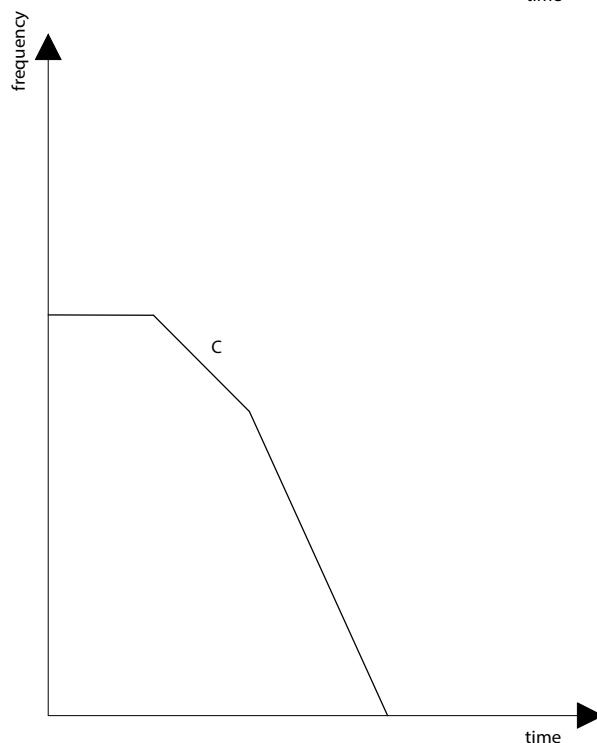
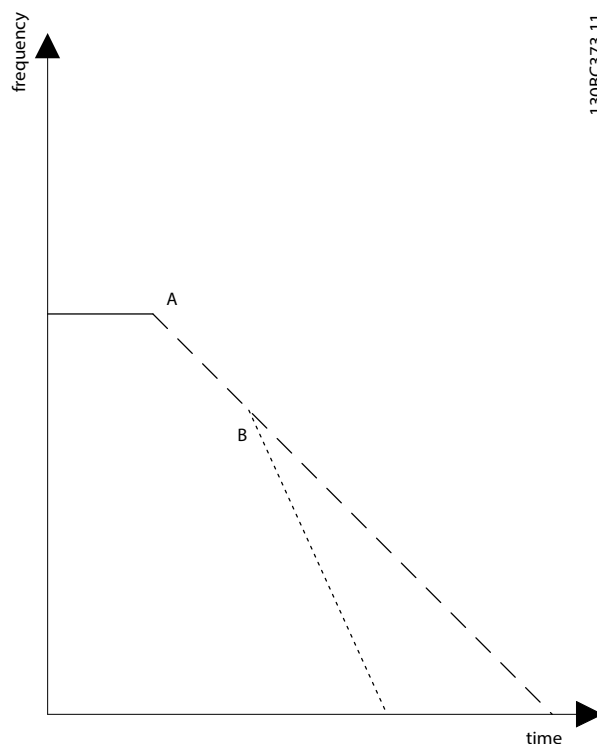
All safety functions can be active at the same time. However, Safe Torque Off has priority over all other safety functions. Functions already started (e.g. Safe Stop 1 or Safely Limited Speed) are canceled and the frequency converter coasts.

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



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

Illustration 3.3 2 Safe Stop 1 Safety Functions Active

Illustration 3.3 shows the result of activating first a Safe Stop 1 function with a given ramp and afterwards

activating a second 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 are dependent 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 no greater than once per year.

#### High Demand/Continuous mode

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

The SIL value for a low demand safety-related system is directly related to order-of-magnitude ranges of 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

## CAUTION

### RISK OF PERSONAL INJURY AND EQUIPMENT DAMAGE!

To avoid personal injury and equipment damage, only use the safety option for its intended purpose.

The following is considered as improper use

- any component, technical or electrical modification to the frequency converter
- use of the frequency converter outside the allowed electrical and environmental conditions specified in *chapter 9 Technical Specifications* and in the *VLT® AutomationDrive FC 301/FC 302 Operating Instructions*.

The safety option is designed for use in safety-related applications. It meets the requirements for safety 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 MCT 10 Set-up Software to configure the safety functions supported in safety option.

- Configuration of the safety functions is required for safe motion sequences. In the event of an error or fault, these functions shut down the frequency converter's power element in a safe and controlled way.
- Setting of limit values, braking ramps for the safety functions, monitoring of motion sequences.

The software

- runs in full with a license key. All functions are available from MCT 10 Set-up Software version 3.18.
- supports the configuration of applications with up to max. 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 functions in accordance with EN IEC 61800-5-2
  - Safe Torque Off (STO)
  - Safe Stop 1 (SS1)
  - Safely Limited Speed (SLS)
- Reset function
  - Digital input 2 can be used for resetting the safety option after an error or after deactivation of a safety function.
- Status indicators
  - Safe input status (LED 1 and LED 2)
  - Safe output status (LED 4)
  - LED 3 reserved for future use (always in off state)
  - By Fault or warning the LEDs indicate a failure via flash pattern, see *Table 8.2*
- Supply voltage
  - Internally supplied by the frequency converter.
  - 24 V DC output for safety sensors and encoder available.

3

### 3.4 Front View

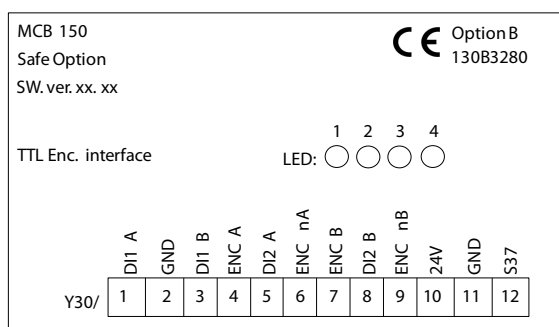


Illustration 3.4 MCB 150

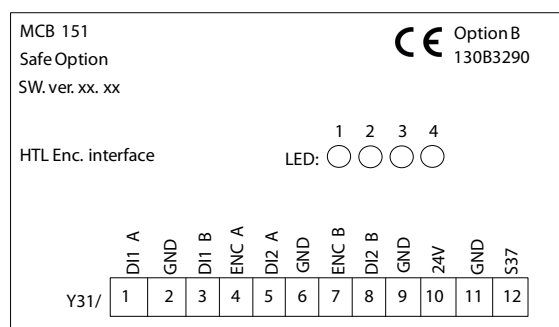


Illustration 3.5 MCB 151

### 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 zero 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 61800-5-2:2007 (4.2.2.2) 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 function Safe Torque Off after the stop to shut off the motor torque.

Refer to EN IEC 61800-5-2:2007 (4.2.2.3) 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 (e.g., PNP proximity switch) or higher resolution TTL or HTL encoders to monitor for either safe stop or speed conditions.

### 3.5.2 Safety Functions

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

The safety option implements the following safety 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 zero 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



### 3.5.3 Safe Torque Off - STO

The safety function Safe Torque Off disconnects power to the motor. It is implemented via the frequency converter's shutdown path and the safety option's safe outputs.

#### Features of the safety function

- The motor becomes torque-free and no longer generates any hazardous movements
- To prevent the frequency converter from running down in an uncontrolled manner. In normal operation, activate the safety function Safe Torque Off via the safety 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 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 function is activated

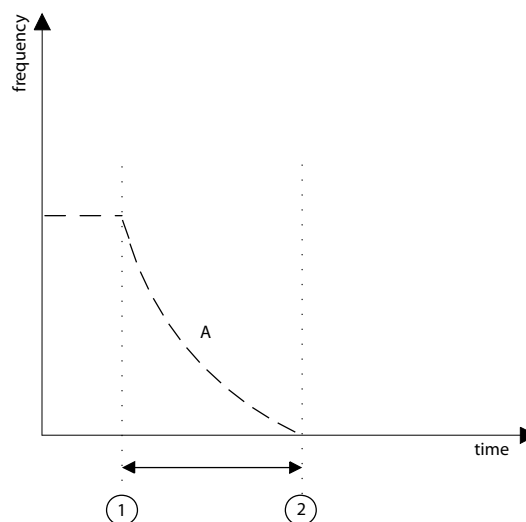
- By an error after limit values have been exceeded for Safe Stop 1 and Safely Limited Speed
- By an internal error on the safety option or frequency converter, if the frequency converter can no longer be controlled
- By executing the safety function Safe Stop 1 (1/0 transition). In this case the frequency converter is monitored before it is switched to torque-free.
- By download of parameterisation via MCT 10 Safe Plug-in if the current frequency converter is running.
- By executing the safety 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.

### **⚠ WARNING**

If any external forces influence the motor axis (e.g. suspended loads), additional measures (e.g. a safety holding brake) are required to eliminate hazards.

The Safe Torque Off (STO) may be used where power removal is required to prevent an unintended start. The function disables the control voltage of the frequency converter output stage. Thus, it prevents the frequency

converter from generating the voltage required to rotate the motor (see *Illustration 3.6*). The function allows for performing maintenance work on non-electrical parts of the machinery without switching off the power supply to the frequency converter.



130BC318.10

A	Actual frequency
1	Activation of Safe Torque Off
2	Motor standstill

Illustration 3.6 Safe Torque Off

### 3.5.4 Safe Stop 1 - SS1

The safety function Safe Stop 1 monitors the deceleration to zero 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 function

- The safety 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 SS1 Delay to activate Safe Stop 1 function while a parameterised safety delay timer expires.

3

Safe Torque Off is activated immediately when the configured Stop Delay has expired, regardless of speed, see *chapter 6.1 Configuration* for parameter settings.

**Selecting the SS1 settings**

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

By using SS1 Delay, the frequency converter attempts to follow the selected ramp. After a specified delay time, Safe Torque Off is activated and the motor is made torque free.

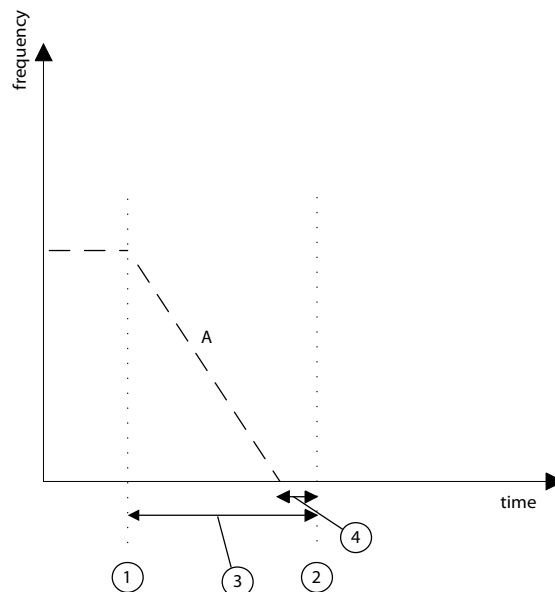
**CAUTION**

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 behaviour can be tolerated. An interlock may be required.

Default value in 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 42-42 Delay Time. This means that the braking ramp is linear. Select the value of 42-43 Delta T (the % of the delay time), which is a reasonable tolerance after the SS1 Delay Time has expired.

**NOTICE**

The SS1 delayu function does not monitor the stopping of the frequency converter!  
 The safety relevant time, Delta T, allows the frequency converter 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 frequency converter does not come to a stop. It coasts after the time delay no matter of the speed of the frequency converter.



130BC321.10

A	Actual frequency
1	Activation of SS1 Delay Timer
2	Activation of Safe Torque Off
3	42-42 Delay Time
4	42-43 Delta T

Illustration 3.7 SS1 Delay

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

3.5.4.2 SS1 Delay with S-ramp Stop Profile

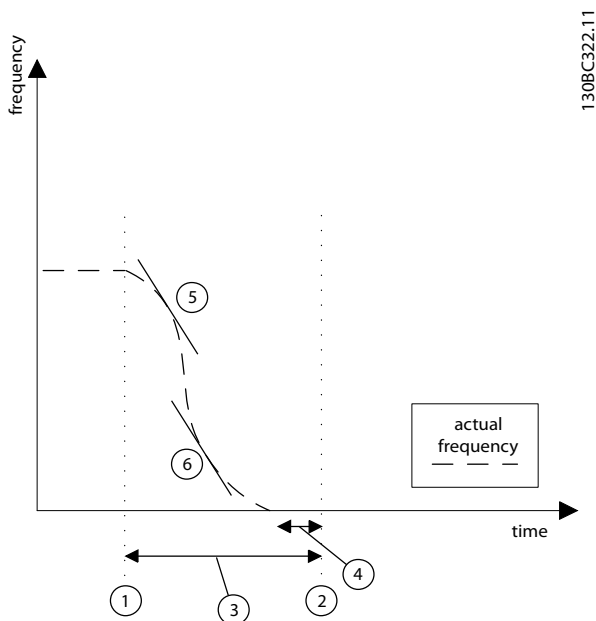
An S-ramp gives non-linear deceleration, compensating for jerks in the application.

1. Define a speed profile by a delay (a "worst case" delay from actual frequency to zero speed) and a delay tolerance. The safety relevant time, Delta T, allows the frequency converter 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 frequency converter does not come to a stop. It coasts after the time delay regardless of the frequency converter speed.
2. Define an S-ramp configuration, which achieves zero speed within the delay.

3. Configure the S-Ramp ratio at deceleration start in 42-48 S-ramp Ratio at Decel. Start and set 42-49 S-ramp Ratio at Decel. End for S-Ramp ratio at deacceleration end.

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

Table 3.1 Parameters for SS1 Delay with S-ramp Stop Profile



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

Illustration 3.8 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 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 42-45 Delta V.
- Braking ramp in normal operation
  - The frequency converter starts with the configured braking ramp when safety function Safe Stop 1 has been activated. Once the speed is at zero speed limit, Safe Torque Off is activated.
- Safety function Safe Torque Off is activated when the configured limit value for the position error is exceeded

A standstill threshold Zero speed (42-46 Zero Speed) for activating the safety function Safe Torque Off can be specified in MCT 10 Set-up Software.

Safety function Safe Torque Off is activated when zero speed is achieved.

#### Prerequisites for normal operation

- Input DI1 or DI2: "1" Signal (+24 V DC)
- S37 output: "1" Signal (+24 V DC). The safety option is ready for operation

A 1/0 transition at the selected DI1 or DI2 input activates the safety function.

#### Signal status of the inputs DI1 and DI2

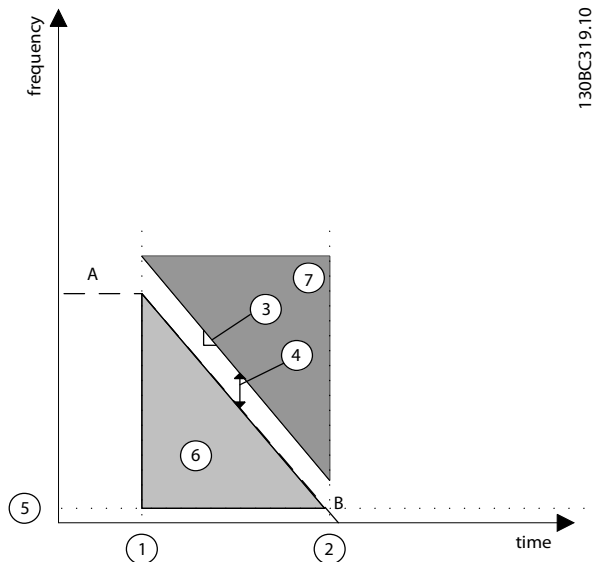
The Safe Stop 1 ramp starts when one of the 2 inputs is set to "0". The safety function Safe Torque Off is activated once the braking ramp has reached zero speed.

### 3.5.4.4 SS1 Ramp Slope

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

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

Table 3.2 Parameters for SS1 Ramp Slope



130BC319:10

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

Illustration 3.9 SS1 Ramp Slope

When the Safe Stop 1 function is active, the frequency converter brings the motor to zero speed. The deceleration is monitored. If the monitored deceleration is slower than expected or at zero speed, Safe Torque Off is triggered.

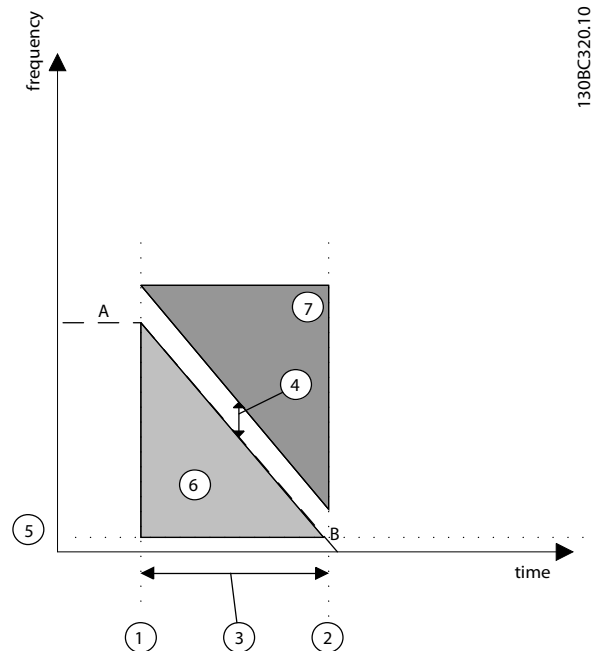
This safety function corresponds to a controlled stop of the frequency converter according to EN IEC 60204-1, stop category.

### 3.5.4.5 SS1 Ramp Time

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

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

Table 3.3 Parameters for SS1 Ramp Time



130BC320:10

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

Illustration 3.10 SS1 Ramp Time

### 3.5.5 Safely Limited Speed (SLS)

#### NOTICE

The Safely Limited Speed function can only be used when an encoder 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 set point. There are 2 types of Safely Limited Speed

- SLS without ramp: Monitors the motor speed and, depending on the setting of 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 set point and, depending on the setting of 42-52 Fail Safe Reaction, trips in Safe Torque Off or Safe Stop 1, if an overspeed occurs

The Safe Limited Speed is given as speed limit in 42-51 Speed Limit. The value for the cut-off speed partly depends on the motor that is being used. A suggested value from 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 42-50 Cut Off Speed.

### 3.5.5.1 SLS without Ramp

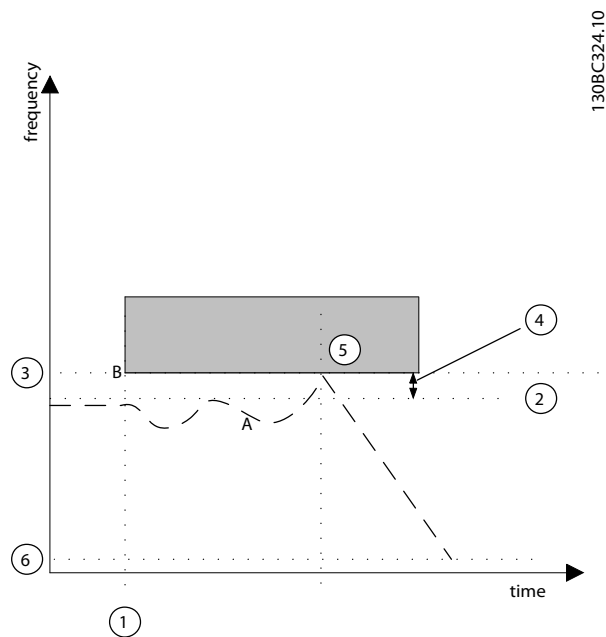
The safety function Safely Limited Speed monitors whether a specified velocity value is exceeded since it was activated via DI1 or DI2. The function is active until the selected input has been put to high again.

If 2 Safe Speed limits must be monitored, set one of the 2 Safe Digital Inputs DI1 or DI2 in 42-20 Safe Function to SLS-a or SLS-b. Then select the input type under 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 realised should be parameterised in 42-50 Cut Off Speed.

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

Table 3.4 Parameters for SLS without Ramp



130BC324.10

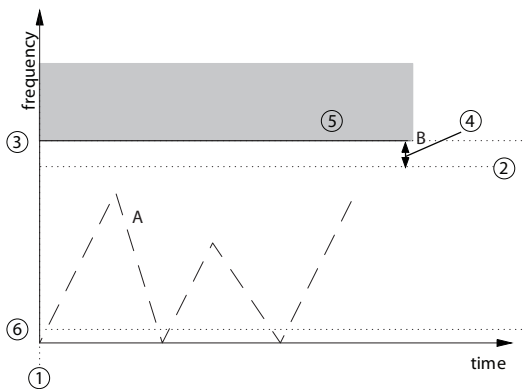
3

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

Illustration 3.11 SLS without Ramp

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

Safe jog in combination with SLS



130BC959.10

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

Illustration 3.12 Safe Jog

Access under specific conditions of reduced risk

Under specific conditions of reduced risk, safe jog allows for access to areas for fault-finding, commissioning, etc. On machines where safe jog (jogging or inching) is needed, this is also possible from zero speed setpoint.

By activating Safely Limited Speed, the motor can be moved at safe jog resulting in a number of cycles and with safely monitored movements. The motor can be started and stopped continuously also from zero speed.

3.5.5.2 SLS with Ramp

If this safety 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 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 safe 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 and the safety option initiates the configured Safe Stop type selected in 42-52 Fail Safe Reaction.

The ramping begins at the absolute value of the actual speed. If the actual speed is already below the Safely

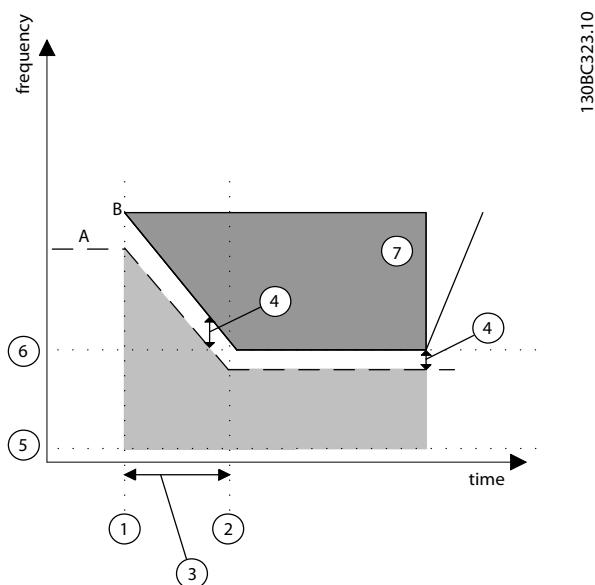
Limited Speed limit, the limit comes into effect immediately without ramping. When the Safely Limited Speed function is deactivated, the speed limits are ramped up back to the values defined in parameter group 3-1\* References, and the actual speed returns to the reference value if it was limited by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

Follow these steps to configure the Safely Limited Speed operation

1. If a safe speed limit must be monitored, set one of the 2 safe digital inputs, DI1 or DI2, to [1] SLS-a or [2] SLS-b in 42-20 Safe Function.
2. Select input type in 42-21 Type.
3. Select 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 Safe Limited Speed in 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 42-50 Cut Off Speed.



130BC323.10

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

Illustration 3.13 SLS with Ramp

Activation of failure function set in 42-52 Fail Safe Reaction.

Parameter	Unit	Range	Default
42-50 Cut Off Speed	RPM	120-10000 RPM	270 RPM
42-51 Speed Limit	RPM	1-9999 RPM	150 RPM
42-52 Fail Safe Reaction	n/a	Safe Torque Off/ Safe Stop 1	Safe Torque Off
42-53 Start Ramp	n/a	No/Yes	No
42-54 Ramp Down Time	s	0.1-3600.0 s	1.0 s

Table 3.5 Parameters for SLS with Ramp

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

### 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

#### Routing of the sensor cables

All proximity switch sensor/encoder cables must be shielded when laid. The shielding must be connected to chassis at both ends.

#### 3.6.1 Inputs

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

- STO: Safe Torque Off
- SS1: Safe stop 1
- SLS: Safely limited speed

Signals at DI 1

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

DI 2 can be

- STO: Safe Torque Off
- SS1: Safe stop 1
- SLS: Safely limited speed
- Reset: Additional safe input to reset the safety option after an error, or after deactivating a safety function on input DI1

Signals at DI 2

- 1/0 transition at the input: Activates the safety function
- "0" signal (0 V) at the input: Activates the safety function
- "1" signal (+24 V) at the input: Does not activate the safety 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 Safe Torque Off input of the frequency converter.

- Safe Torque Off Acknowledge
  - Internal error on frequency converter or safety option
  - Limit values exceeded
  - Activated via SS1
  - PUST (Power Up Self Test)
  - External failure

### 3.6.4 Permitted Sensor Types on Digital Inputs

The following sensor types are applicable

- sensors with 2 NC contacts
- antivalent contacts (1 NO contact and 1 NC contact)
- sensor output of type 2xPNP

Sensors with 2 NO contacts are not applicable.

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

### 3.6.5 Reset

## CAUTION

**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 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 functions or errors.

## NOTICE

First, trip alarms displayed on the frequency converter must be acknowledged after which a pending safety function can be acknowledged. A single reset for the alarm mode and a second reset for acknowledgment of the active safety function. Alarms caused by the frequency converter 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 (e.g. emergency stop buttons or door switches), the 2 sensor contacts 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 *42-22 Discrepancy Time*, the safety option suppresses the discrepancy monitoring of the safe inputs.

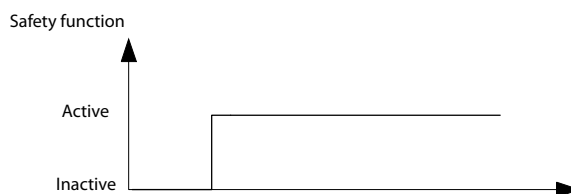
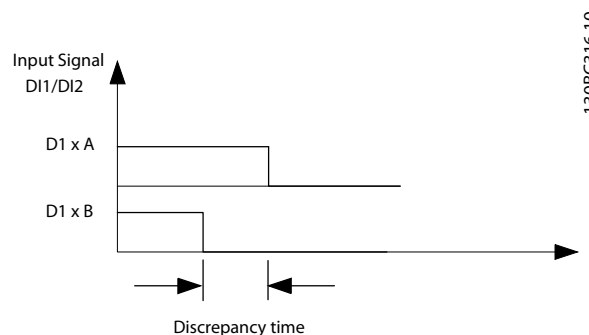


Illustration 3.14 Discrepancy Time

Parameterise 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 function as soon as one 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 functions being incorrectly activated, can be filtered.

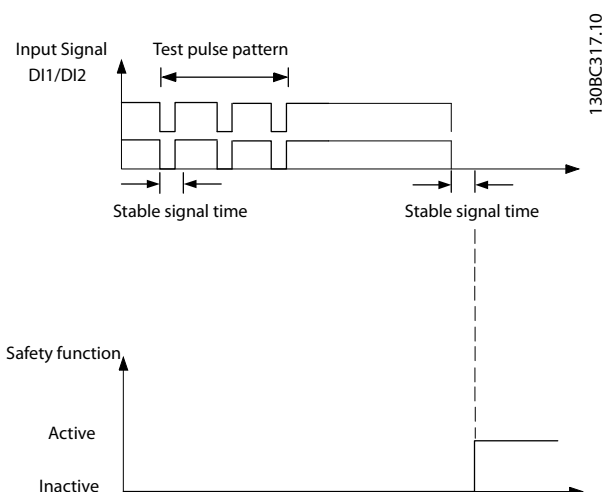
**NOTICE**

The stable signal time extends the safety option response time. The safety option only activates the safety 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 42-23 *Stable Signal Time* to select an appropriate stable signal time. A constant signal level is a high or a low state, for at least 42-23 *Stable Signal Time*.



**Illustration 3.15 Filter for Suppressing Temporary Signal Changes**

### 3.6.8 Zero Speed Time Error Detection

Zero Speed Timer monitors if the frequency converter is operated below 120 RPM during Safely Limited Speed.

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 Safe Torque Off function is selected. The safety option monitors the regular test interval of its safety-relevant circuits using a time module.

After one year in operation, the frequency converter displays a message that a yearly test must be performed. The frequency converter must be power cycled 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 on the non-volatile memory on the option.

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

#### **NOTICE**

If the safety option is reinstalled in another frequency converter, all safety parameters can be selected either from the safety option or from the frequency converter in which the option is now installed. A commissioning test must always be performed to ensure the correct functionality.

#### 3.6.11 Encoder Interface

### **CAUTION**

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) or a PNP proximity switch (MCB 151). The HTL encoder uses 2 signal tracks, A and B. TTL encoders uses 4 signal tracks A, B and their inverted tracks nA, nB.

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

### 3.7 Limitations

#### 3.7.1 Exceeded Limit Value and Internal Errors

- Exceeding set limit values activate the stop braking ramp.
- Any internal error on the safety option or frequency converter activates the safety function Safe Torque Off. The frequency converter coasts the motor.

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

#### 3.7.2 Compatibility between Safety and Frequency Converter Functions

The safety option is compatible with all VLT® AutomationDrive FC 302 frequency converters in the range of 0.37 kW to 75 kW. Compliance to higher power ranges is to come. Contact the local supplier for latest information.

MCB150/151 can be combined with the following A-options:

- PROFIBUS MCB 101
- DeviceNet MCA 104
- CanOpen MCA 105
- PROFINET MCA 120
- Ethernet/IP MCA 121
- Modbus TCP MCA 122
- PowerLink MCA 123
- EtherCAT MCA 124

The safety option is compatible with asynchronous and synchronous (PM) motors. Asynchronous motors can be used in U/f and VVC<sup>+</sup> in closed and open loop as well as in FLUX open loop control. Synchronous (PM) motors can be used in U/f open or closed 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 minimum for using MCB150/151:

- LCP software version 7.0
- VLT® AutomationDrive FC 302 Firmware Version 6.64

All frequency converters, options and control mode combinations not listed above are not permitted.

## 4 Installation

### 4.1 Installing the Safety Option

#### **⚠ WARNING**

Before start, disconnect the power supply voltage to the frequency converter. Never install an option card into the frequency converter during operation.

Ensure that all dangerous voltages connected from external control circuits to the inputs and outputs of the frequency converter are switched off. In addition to conventional installation tools, have the Operating Instructions for VLT® AutomationDrive FC 301/FC 302 and MCT 10 Set-up Software available as they contain important information that is not included in this manual.

The safety option is exclusively intended for use in option slot B. The mounting position of B options is shown in *Illustration 4.1*.

#### **⚠ WARNING**

##### **ELECTRICAL HAZARD!**

Safe Stop activation (Safe Torque Off) does not provide electrical safety. The safety device connected to the dual pole input of the safety option must fulfill the requirements safety level for the application for interrupting the voltage/current to safety option. This is also valid for the connections between the safety option's safe output S37 and terminal T37 on the frequency converter. To connect the safety device correctly to the safety option, read and follow the instructions.

#### 4.1.1 Requirements for Safe Use

#### **⚠ CAUTION**

Ensure that the installation and wiring are EMC-compliant to avoid personal injury and damage to the product.

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

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

The safety option may only be used with the following frequency converters

- VLT® AutomationDrive FC 302, power sizes from 0.37 kW to 75 kW, from SW Version 6.64

### 4.1.2 Protected Cable Installation

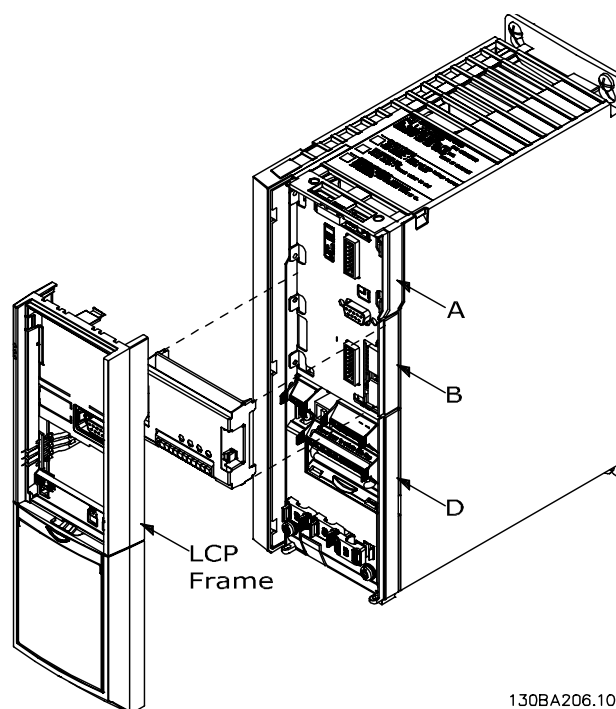
If short circuits and cross circuits can be expected with safety-related signals and if they are not detected by upstream devices, protected cable installation is required as per EN ISO 13849-2.

### 4.1.3 Installation

#### **⚠ CAUTION**

The VLT® AutomationDrive with safety option (including the connection between output S37 (Y30/12 or Y31/12) on MCB150/151 and X44/12 on the control card) must be placed in an IP54 enclosure as per IEC 60529.

These step-by-step instructions describe how to mount the control cables



A	A-option slot
B	B-option slot
D	D-option slot

Illustration 4.1 How to Fit the Safety Option

1. Disconnect power to the frequency converter.
2. Remove the LCP, the terminal cover, and the LCP frame from the frequency converter.

4

3. Fit the safety option in slot B.
4. Remove the jumper wire between control terminals 37 and 12 or 13.
  - Cutting or breaking the jumper is not sufficient to avoid short circuiting.

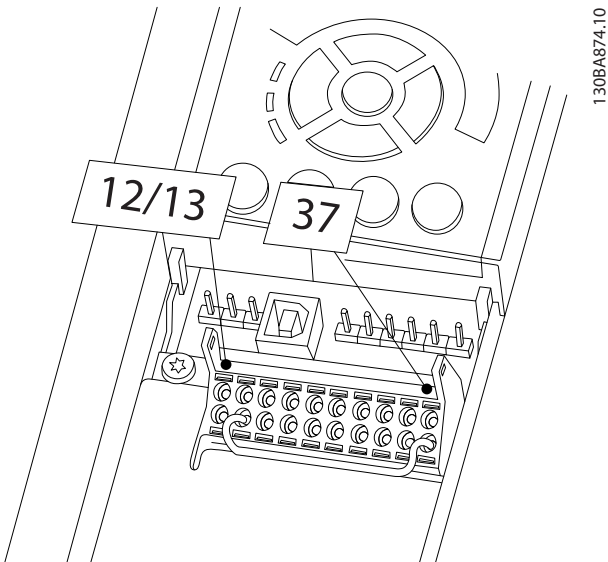


Illustration 4.2 Jumper between Terminal 12/13 (24 V) and 37

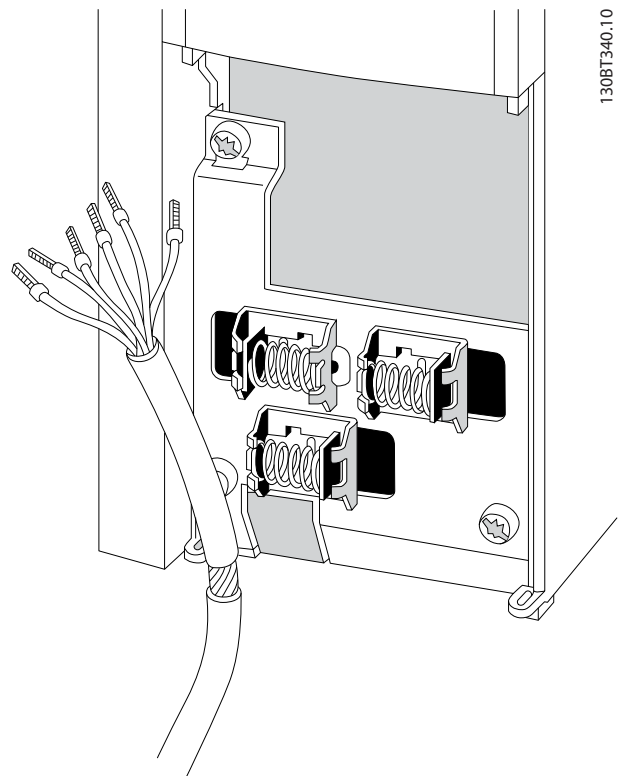


Illustration 4.3 Connecting Screened Wire

5. Connect the safe output S37 on the safety option to terminal 37 on the control card (maximum length of this wire is 10 cm).
6. Connect the control cables to safety option and relieve the cable by the enclosed cable strips.

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

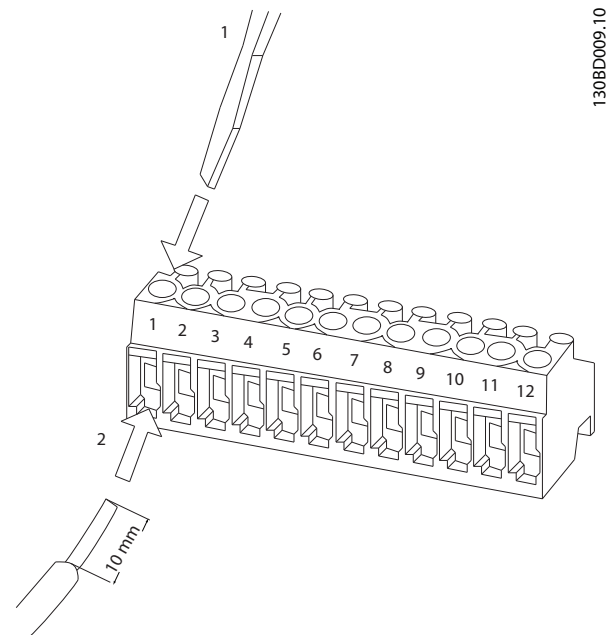


Illustration 4.4 Connecting Control Wiring

**NOTICE**

The connections are not pre-wired from factory.

9. Fit the LCP or blind cover in the extended LCP frame.
10. Connect power to the frequency converter.
11. Set up the input/output functions in the corresponding parameters, as mentioned in the manual for the Safe Plug-in in MCT 10

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

**CAUTION**

The operator or electrical installer is responsible for proper grounding and compliance with all applicable national and local safety regulations.

## 4.1.4 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

**CAUTION**

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

**NOTICE**

Control cables must be screened/armoured.

See the section *Earthing of Screened Control Cables* in the *VLT® AutomationDrive Design Guide* for detailed specifications.

Only screened cables are suitable for connecting encoders.

**NOTICE**

All signals to 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 with optimum screen support at both ends

- Connect screens at both ends to the grounded enclosures through a good electrical connection and through a large surface area
- Connect cable screens as close as possible to the cabinet cable entry
- If at all possible, intermediate terminals should not interrupt cable screens
- Retain cable screens for both power cables as well as for signal and data cables using the appropriate EMC clamps. The screen clamps must connect the screen to the EMC shield bar or the screen support element for control cables through a low inductive connection through a large surface area.

### 4.1.5 Connector Pin Assignment

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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

Table 4.1 Connector Pin Assignment, MCB 150

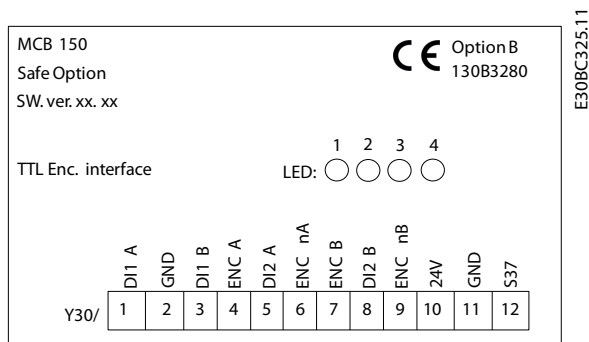


Illustration 4.5 Nameplate MCB 150

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
	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

4

Table 4.2 Connector Pin Assignment, MCB 151

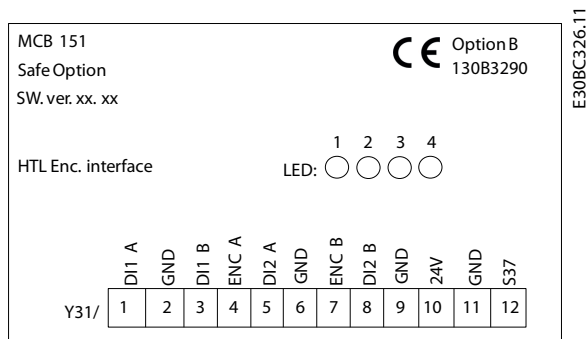


Illustration 4.6 Nameplate MCB 151

## 4.2 Encoder

### 4.2.1 Permissible Encoder Cable Length

The permissible cable length depends on the selected encoder. The longest cable can be achieved when using bipolar TTL encoders.

Unipolar HTL encoders only permit 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 one signal is evaluated) is 100 m.

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

The minimum cross-section of the power supply conductor is 0.75 mm<sup>2</sup>.

#### **NOTICE**

#### **Routing of the sensor cables**

All proximity switch sensor/encoder cables must be screened when laid. The screen must be connected to chassis at both ends. Always connect chassis on the rotary encoder to chassis on the frequency converter.

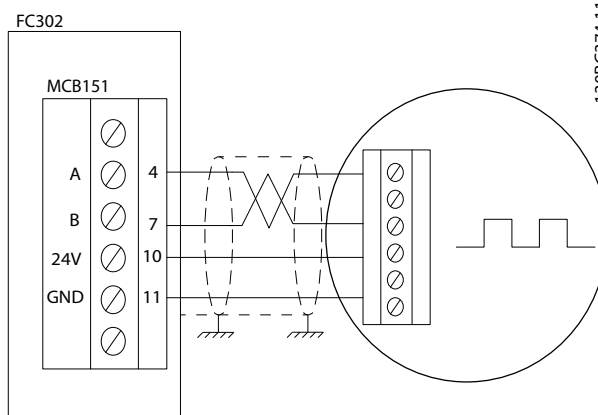
#### **CAUTION**

The sensor connections must not be plugged in or pulled off during operation. This could damage the electrical components of the encoder. Always de-energise connected encoders and the safety option before plugging in or pulling off encoder connections. Lines twisted in pairs for signal transmission according to RS-485 standard must be used for data signals or track A and track B. The wire cross section must in each individual case be chosen in compliance with the current consumption of the encoder and the cable length required for the installation.

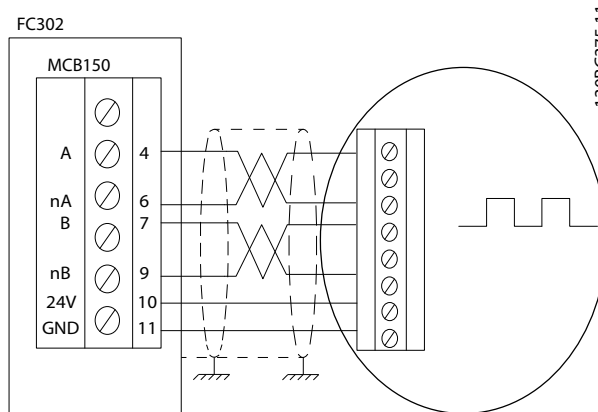
Diagnostics are performed on the encoder input signals. If the encoder diagnostic tests fail, an error 99 (Safe State fault) occurs.

### 4.2.2 Encoder Wiring Examples

*Illustration 4.7* and *Illustration 4.8* show examples of how to connect encoder power and encoder signals.



**Illustration 4.7 Y31/ Connecting Power and Encoder Signals to HTL Encoder (MCB 151)**



**Illustration 4.8 Y30/ Connecting Power and Differential Encoder Signals to TTL Encoder (MCB 150)**

*Illustration 4.8* shows TTL encoder 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, e.g. 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.



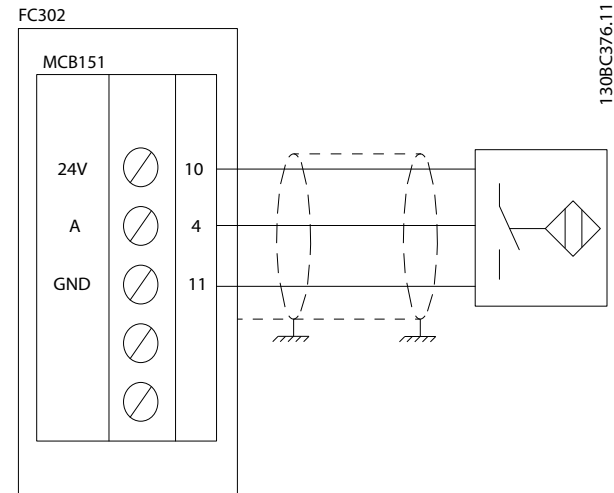
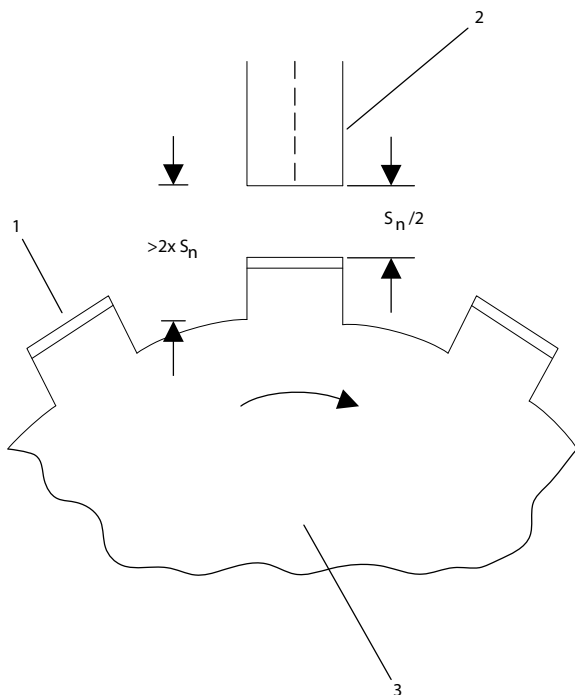


Illustration 4.9 Y/31 Connecting MCB 151 to Proximity Switch (only HTL)

**NOTICE**

The proximity switch cable must be screened and terminated 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 4.10 Gear Wheel for Proximity Switch

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

**NOTICE**

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

4.3 Application Examples

4.3.1 Connecting Safe Digital Inputs

The following pages contain 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.

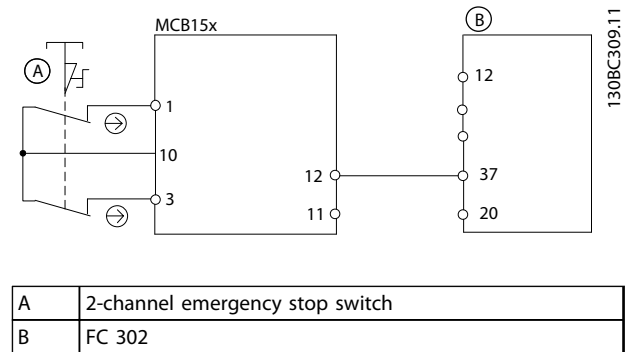


Illustration 4.11 Connecting a Sensor, e.g. 2-channel Emergency Stop Mushroom Push Button or Limit Switch

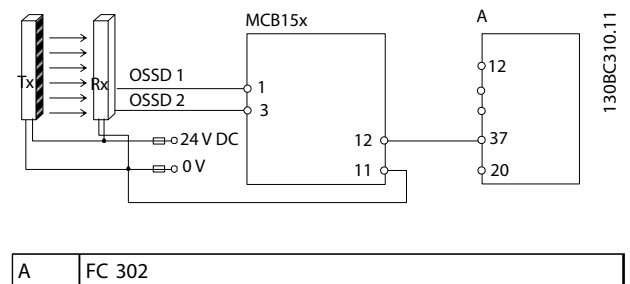
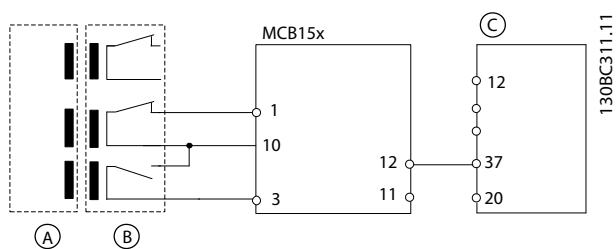
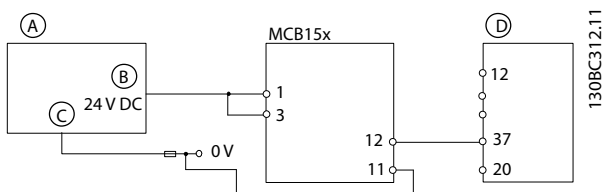


Illustration 4.12 Connecting an Electronic Sensor, e.g. Safety Light Curtain



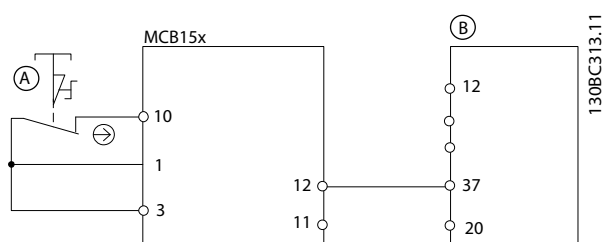
A	Actuator
B	Switch
C	FC 302

Illustration 4.13 Connecting 1 NO/1 NC Sensor, e.g. Magnetic Switch



A	Safety PLC
B	Safety output
C	GND
D	FC 302

Illustration 4.14 Connecting a Digital Output Module, e.g. Safety PLC



A	1-channel emergency stop switch
B	FC 302

Illustration 4.15 Connecting a Sensor, e.g. 1-channel Emergency Stop Mushroom Pushbutton 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 (e.g., 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.

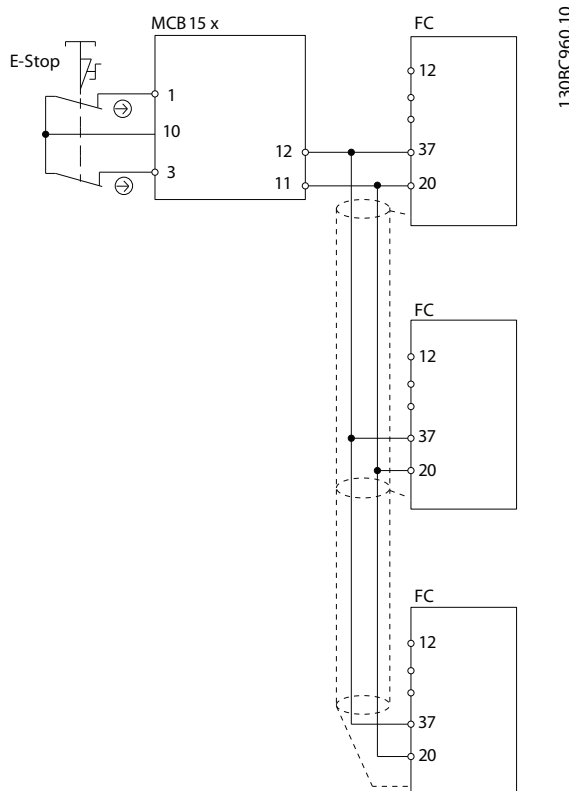


Illustration 4.16 Example of Multiple Frequency Converters in Daisy Chain

Up to 3 frequency converters may be connected in a daisy chain. Total cable length must not exceed 30 m.

## 5 Commissioning

### 5.1 Before Commissioning

#### 5.1.1 Safety Guidelines

When commissioning/recommissioning

- Secure the site in accordance with regulations (barrier, warnings, signs, etc.). Only qualified personnel is allowed to commission/recommission the system
- Refer to the guidelines, information and specifications stated in the *Operating Instructions* 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, e.g. by touching an earthed, conductive surface or by wearing an earthed armband.

### **⚠**WARNING

#### RISK OF ELECTROCUTION!

Never wire the electrical connections on the frequency converter while voltage is applied.

Switch off power.

Make sure that the control cabinet is provided with access lock or warning signs.

DO NOT switch on the voltages until the system is commissioned.

Refer to *VLT® AutomationDrive FC 301/FC 302 Operating Instructions* for further information on the frequency converter.

Refer to *MCT 10 Set-up Software Operating Instructions* for further information on the Safe Plug-in.

#### 5.1.2 Commissioning Requirements

The procedure requires installation of MCT 10 Set-up Software, version 3.18 or later, and a successful connection to VLT® AutomationDrive FC 302 with integrated safety option.

1. Configure the safety option in the MCT 10 with Safe Plug-in. Ensure only to configure safety

functions that are wired up to the safety option inputs.

2. Ensure that the device number (serial number and order number) of the safety option on the frequency converter matches the device number of the safety option in the MCT 10 Safe Plug-in.
3. Ensure that the frequency converter is ready for commissioning (see *VLT® AutomationDrive FC 301/FC 302 Operating Instructions*)

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

- MCT 10 Set-up Software (licensed version)
- USB or fieldbus connection or RS-485 Interface adaptor for connecting the control card of the frequency converter with the PC

### NOTICE

If RS-485 is used, the protocol for serial communication needs to be set to [0] FC-MC in 8-30 Protocol (only accessible through the LCP).

Observe the following

- When setting up the option for the first time, ensure to have a commissioning report at hand, see further information in *MCT 10 Set-up Software Operating Instructions*

### NOTICE

Only LCP SW version 7.0 or newer is supported.

### 5.2 Initial Commissioning

#### 5.2.1 Power-up/Self-test

Once the power supply has been applied to the frequency converter, 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 permissible range, the safety function **Safe Torque Off** is triggered. The safety-related output S37 on the option is switched off.

### 5.2.2 Initial Commissioning

1. Connect the configuration PC to the frequency converter or motion control system
  - 1a Make the interface in the MCT 10 Safe Plug-in (refer to the chapter *Functional Safety Configuration Plug-in* in the *MCT 10 Set-up Software Operating Instructions* and the Tool-Tip for help).
2. Switch on the supply voltages
  - 2a Switch on all the supply voltages for the frequency converter and safety option
  - 2b The display elements on the frequency converter and on the safety option show when they are ready for operation. The display elements on the safety option are described in *chapter 5.3 Operation*.
3. Download configuration file
  - 3a Establish communication between the PC and the frequency converter by selecting *Write to drive* in the MCT 10 Safe Plug-in
  - 3b Make sure that no other system is accessing the interface
  - 3c Apply password, unequal to default password
  - 3d 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.

When the configuration file is downloaded, the LCP reads "SO Custom. completed".

The configuration is checked as it is downloaded.

- Feasibility of the configuration data
- Proper wiring
- Correct device number (order number). If the self test is successful, the frequency converter's power element is enabled.

#### **NOTICE**

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

### 5.2.3 Safety Option Customisation

LCP messages used to indicate the different states of the customisation processes.

LCP message	Description
	MCT 10 Customisation of safety option requested
	MCT 10 Customisation of safety option aborted
	MCT 10 Customisation of safety option complete

### 5.2.4 Setting up the Encoder

1. Select the type of feedback device, either [1] *Safe Option* or [0] *None* in *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 set *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 *42-13 Gear Ratio*.
4. Set the correct encoder value (1-4096 PPR) in *42-11 Encoder Resolution*.
5. Set *42-12 Encoder Direction* to [0] *Clockwise* (default) or [1] *Counter clockwise*.
6. Set *42-14 Feedback Type* to [0] *With direction info* or [1] *Without direction info*. Select [1] *Without direction info* if proximity switch sensor is used for speed detection.

**NOTICE**

If the selected encoder resolution is below 150 PPR for HTL/TTL encoder, set a feedback filter value in 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.

## 5.2.5 Commissioning Test

The MCT 10 Safe Plug-in creates a commissioning report based on the commissioning test result. It generates the frequency converter 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 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**

After hardware and/or software components have been modified or replaced, all protective equipment must be closed before system start-up and activation of the frequency converter. Personnel must keep out of the danger zone. It is mandatory to carry out a partial or complete commissioning test after having made certain changes or replacements. Before allowing anybody to re-enter the danger zone, test the steady control response by briefly moving the frequency converters in forward and reverse direction ( $\pm$ ).

EN IEC 61508, EN IEC 62061 and EN ISO 13849 require that the final assembler of the machine validates the operation of the safety function with a commissioning test. The commissioning tests for the standard safety functions Safe Stop of the frequency converter are described in the frequency converter manuals. The tests for the optional safety 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 function
- after any changes related to the safety function (wiring, components, settings, etc.)
- after any maintenance work related to the safety function.

## 5.3 Operation

**WARNING****UNINTENDED BEHAVIOUR**

Numerous stored data or settings govern the behaviour of the frequency converter system. Unsuitable settings or data may trigger unexpected movements or responses to signals and disable monitoring functions.

- Do NOT operate the frequency converter 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

Failure to follow these instructions can result in death, serious injury or equipment damage.

Prerequisites for normal operation are

- commissioning is complete
- the safety option contains the configuration data
- the safety 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 functions are performed in accordance with the configuration

## 6 General Parameter Set-up

### 6.1 Configuration

#### 6.1.1 General Parameter Set-up

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

##### Speed monitoring by the safety option

If an external encoder is connected to the safety option and selected in *42-10 Measured Speed Source*, speed monitoring is active all the time whether a safety function is requested or not. However, if a Safe Torque Off 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 *42-10 Measured Speed Source*.

#### 6.1.2 Safety Functions Configuration

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

- Configurations of the safety functions
- Setting of limit values, braking ramps for the safety 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 safety option.

- On single-drive systems, via the RS-485/USB interface on the frequency converter
- On networked systems, via the RS-485 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 functions is available in the online help for the MCT 10 Safe Plug-in and in the *MCT 10 Set-up Software Operating Instructions*.

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.

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

- General Speed Monitoring
- Safe Input
- Safe Stop 1
- Safely Limited Speed
- Parameters
- Status

The menu items are described in detail in the *MCT 10 Set-up Software Operating Instruction*.

The menu item *Status* shows the following

- Current signal states of inputs and output
- Option operating mode
- Active safety 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 Password Forgotten

**NOTICE**

Resetting the password resets all option parameters to factory default.

Forgot the safety option parameter password?

- Select [Reset] in [Administration]
- Checkmark "Yes, I want to reset Safe Option configuration in the drive"
- Enter default password (12345678)
- Click "Reset"
- On the prompt that appears click "yes"
- 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 performing a reset of the safety option and pending safe function. The configuration of *42-31 Reset Source* is decisive for which method to use.

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

**NOTICE**

The frequency converter specific alarms are also reset.

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

**NOTICE**

The frequency converter 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. It's behaviour changes based on the selected control word profile.

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

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

*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.

**CAUTION**

Only active safe function is set in 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	Reserved for further SF
8	Reserved for further SF
9	Reserved for further SF
10	Reserved for further SF
11	Int_fail
12	Reset required
13	Pending fail safe state
14	Ext_fail
15	Safe function pending
16	General reset
17	Customisation_confirmed
18	Customisation_aborted
19	Customisation_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

Bit	Description
26	Error code
27	Error code
28	Error code
29	Error code
30	Error code
31	Error code

Table 6.1 Explanation of the Status Bits for Safety Option Status

**Bit 00, Safety function deactive/active**

Bit 00 = "0", "Safety function, fail safe reaction is active or pending or warning is active"  
 Bit 00 = "1", Normal Operation.

**Bit 01, Power Up Self Test**

Bit 01 = "1", Safety option is in PUST state.

**Bit 02, Safe Torque Off**

Bit 02 = "0", Safe Torque Off is not active.  
 Bit 02 = "1", Safe Torque Off is active.

**Bit 03, Safe Stop 1 a**

Bit 03 = "0", Safe Stop 1-a is not active.  
 Bit 03 = "1", Safe Stop 1-a is active.

**Bit 04, Safe Stop 1 b**

Bit 04 = "0", Safe Stop 1-b is not active.  
 Bit 04 = "1", Safe Stop 1-b is active.

**Bit 05, Safely Limited Speed a**

Bit 05 = "0", Safely Limited Speed-a is not active.  
 Bit 05 = "1", Safely Limited Speed-a is active.

**Bit 06, Safely Limited Speed b**

Bit 06 = "0", Safely Limited Speed-b is not active.  
 Bit 06 = "1", Safely Limited Speed-b is active.

**Bit 07-10**

For future safety functions reserved

**Bit 11, Internal failure**

Bit 11 = "0", No Internal failure is active.  
 Bit 11 = "1", Internal failure is active.

**Bit 12, Reset**

Bit 12 = "0", No Safety option reset required  
 Bit 12 = "1", Safety option reset required

**Bit 13, Pending fail safe state**

Bit 13 = "0", No pending fail safe state  
 Bit 13 = "1", Safety option is in this state at each power up.

**Bit 14, External failure**

Bit 14 = "0", No External failure is active.  
 Bit 14 = "1", External failure is active.

**Bit 15, Safe function pending**

Bit 15 = "0", No Safe function pending  
 Bit 15 = "1", Safe function pending

**Bit 16, General Reset**

Bit 16 = "0", No change in state  
 Bit 16 = "1", General Reset is done

**Bit 17, Customisation confirmed**

Bit 17 = "0", No change in state  
 Bit 17 = "1", Customisation confirmed by user

**Bit 18, Customisation aborted**

Bit 18 = "0", No change in state  
 Bit 18 = "1", Customisation aborted by user

**Bit 19, Customisation requested**

Bit 19 = "0", No change in state  
 Bit 19 = "1", Customisation is requested by user

**Bit 20, Suspension of speed monitoring**

Bit 20 = "0", No change in state  
 Bit 20 = "1", Suspension of speed monitoring – see error code

**Bit 21, Power Up Self Test Warning**

Bit 21 = "0", No change in state  
 Bit 21 = "1", Power Up Self Test Warning is issued

**Bit 22, Digital Input 1 Offline Test Warning**

Bit 22 = "0", No change in state  
 Bit 22 = "1", Digital Input 1 Offline Test Warning

**Bit 23, Digital Input 2 Offline Test Warning**

Bit 23 = "0", No change in state  
 Bit 23 = "1", Digital Input 2 Offline Test Warning

**Bit 24-31**

It contains reason for possible internal errors or external errors – see error code

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.



Bit	Description	State
0	DI1 Safety Status	00 - Inactive
1		01 - Active
		10 - Pending
2	DI2 Safety Status	00 - Inactive
3		01 - Active
		10 - Pending
4	Blank initial state	0 (inactive)/1 (active)
5	Unused	
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Table 6.2 Explanation fo the Status Bits for Safety Option Status 2

**Bit 00-01, DI1 Safety Status**

Bit 00-01 = "00" Inactive

Bit 00-01 = "01" Active

Bit 00-01 = "10" Pending

**Bit 02-03, DI2 Safety Status**

Bit 00-01 = "00" Inactive

Bit 00-01 = "01" Active

Bit 00-01 = "10"

**Pending Bit 04, Blank Initial Status**

Bit 04 = "0" Safety option is configured

Bit 04 - "1" Safety option is in blank initial state

**Bit 05-31**

Reserved for future use

### 6.3 Parameter List

All parameters except *42-90 Restart Safe Option* are read only.

Refer to *VLT® AutomationDrive FC 302 Programming Guide* for general information about usage of conversion index and data type.

Group	Group Name	Parameter	Value range/ available choices	Default	Description	Conversion index	Data type
42-1*	Speed Monitoring	42-10 Measured Speed Source	[0] None [1] Safe Option	[1] Safe Option	The source of the speed feedback.	-	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
		42-18 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

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Group	Group Name	Parameter	Value range/ available choices	Default	Description	Conversion index	Data type
42-2*	Safe Input	42-20 Safe Function	[0] STO [1] SS1-a [2] SS1-b [3] SLS-a [4] SLS-b [5] disable	[0] STO	This can be one of the safety functions or disabled. Remark: Both Safe Inputs can NOT be disabled at the same time!	-	u_int8
		42-21 Type	[0] NCNC [1] Antivalent [2] NC	[0] NCNC	NCNC, antivalent (NC/NO) or 1NC.	-	u_int8
		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 Behaviour	[0] Manual [1] Automatic	[0] Manual	In case of an activated safety function, the safety option can either restart automatically or wait for a RESET signal from the user.	-	u_int8
42-3*	General	42-30 External Failure Reaction	[0] STO [1] SS1-a [2] SS1-b	[0] STO	Safety function that is executed in case of an external failure.	-	u_int8
		42-31 Reset Source	[0] Drive Reset [1] Drive Safe Reset [2] Safe Option DI2_A	[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 frequency converter or via the LCP. By selecting <i>Drive Safe Reset</i> , only the safety option is reset.	-	u_int8
		42-33 Parameter Set Name	Visible String, length: 8	SafeSet1	Name of the safe parameter Set ( <b>must</b> be 8 characters to avoid a bad customisation data error).		

Group	Group Name	Parameter	Value range/ available choices	Default	Description	Conversion index	Data type
42-4*	SS1	42-40 Type	[0] Delay [1] Ramp (slope) [2] Ramp (time)	[0] Delay	The type of the SS1 Safety Function.	-	u_int8
		42-41 Ramp Profile	[0] Linear [2] S-ramp Const Time	[0] Safe Option Linear	The ramp profile for a SS1 Delay can be either specified as linear or S-ramp.	-	u_int8
		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%	$\Delta T$ subtracts from the time in <i>42-42 Delay Time</i> 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 ( <i>42-42 Delay Time</i> ) 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 ( <i>42-42 Delay Time</i> ) 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

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Group	Group Name	Parameter	Value range/ available choices	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 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 [1] SS1-a [2] SS1-b	[0] STO	Safety function that is activated, if the speed exceeds the limit. Only for SLS.	-	u_int8
		42-53 Start Ramp	[0] No [1] Yes	[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
		42-54 Ramp Down Time	0.1 - 3600.0 s	1.0 s	Ramp-down time for start ramp.	-1	u_int16
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. e.g. it contains DI1, DI2 and blank initial state status.	0	u_int32
		42-85 Active Safe Func.	<ul style="list-style-type: none"> <li>• [0] STO</li> <li>• [1] SS1-a</li> <li>• [2] SS1-b</li> <li>• [3] SLS-a</li> <li>• [4] SLS-b</li> </ul>	None	Shows the currently active safe function. Can be used on LCP. <b>NOTICE</b> 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. <b>NOTICE</b> Can only be selected in 0-23 Display Line 2 Large and 0-24 Display Line 3 Large.	0	

Group	Group Name	Parameter	Value range/ available choices	Default	Description	Conversion index	Data type
		42-89 Customi- zation File Version	0.00 - 99.99	1.00	Stores the customi- sation 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 frequency converter.	-	u_int8

Table 6.3 Safety Option Parameters

Refer to VLT® AutomationDrive FC 301/FC 302 Operating Instructions 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

Only Danfoss is authorized to change the firmware. If other parties make changes to the firmware, the warranty expires. Furthermore, Danfoss cannot be held liable for any consequences the changes may have on the functional safety.

#### **CAUTION**

##### Modifications to the Unit

Only Danfoss is allowed to make hardware modifications of the safety option. If other parties make changes to the unit, the warranty expires. Furthermore, Danfoss cannot be held liable for any consequences the changes may have on the functional safety.

## CAUTION

### Servicing

Once a year, check that the safety option functions properly to ensure the safety of the machine. Perform the check by either

- testing the function, or
- switching off the options used in the safety chain

### 7.2 Repair

#### **WARNING**

##### ELECTRICAL SHOCK HAZARD!

Always disconnect mains supply to the frequency converter before removing the safety option.

Only Danfoss is authorised to make repair to the safety option. A defect option must be shipped back to Danfoss.

### 7.3 Replacing

#### 7.3.1 Removing the Safety Option

##### Before removing the safety option

1. Save all parameters of the safety option, see *MCT 10 Set-up Software Operating Instructions*.
2. Duplicate the existing device setting.

#### **NOTICE**

The frequency converter generates an error message after removing the safety option.

##### How to remove the safety option

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 *Installation in VLT® AutomationDrive FC 301/FC 302 Operating Instructions*.

#### **NOTICE**

If the removed safety module is installed in another frequency converter, the frequency converter issues a warning for safety option parameter selection. The user can then select the safety configuration from either the frequency converter or from the Safety Option.

#### 7.3.2 Replacing the Safety Option

#### **WARNING**

##### ELECTRICAL SHOCK HAZARD!

Always disconnect mains supply to the frequency converter before removing the safety option.

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 *chapter 7.3.3 Copying Safe Parameter Set-up*.



**NOTICE**

Option Change (Alarm 67) detection informs that a change of the frequency converter hardware configuration has occurred after a power-up. This situation could occur after installing/removing an option, or if an option is defect. If the configuration changes, the frequency converter freezes the hardware configuration, trips and refuses to start up, thus avoiding any unintended parameter changes.

Reset all option parameters to factory settings to avoid this trip.

1. Order a new safety option at Danfoss.
2. Replace the defective option, see *chapter 4 Installation*.

At the first power-up, the frequency converter recognises different configurations between the safety option and the frequency converter if the safety option parameters are not set to default.

3. Select *Frequency converter*.
4. If configured, enter the password for the copied SO configuration from LCP.
5. Accept to download the safe parameters to the frequency converter/safety option.
6. Select *OK*.
7. Restart the frequency converter.

After replacing the safety option, download the configuration data again, either from

- MCT 10 Safe Plug-in to the safety option via RS-485 or USB
- an LCP in the frequency converter 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 *chapter 5.2.5 Commissioning Test*.

### 7.3.3 Copying Safe Parameter Set-up

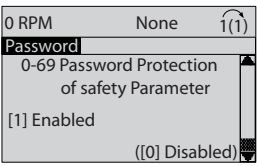
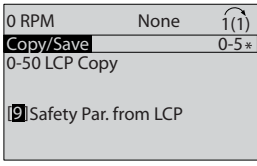
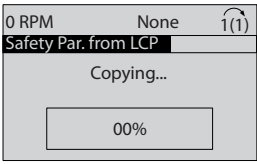
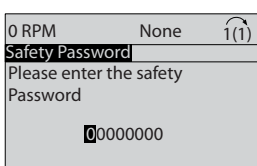
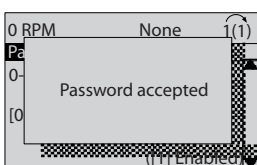
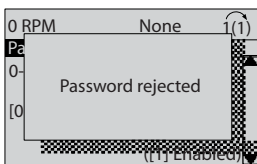
To copy the safe parameter set-up to another frequency converter

1. Prepare a commissioning report.
2. Select *[1] All to LCP* in *0-50 LCP Copy*. Monitor the upload on the progress bar.
3. Install the LCP with all the copied parameters on the frequency converter that needs to be updated.
4. Select *[2] All from LCP* in *0-50 LCP Copy*. The normal password protection can be applied in *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 frequency converter, which now has a new configuration assigned to it.
7. Reset the frequency converter to activate the new configuration.

#### Password protection LCP copy and safe parameter mismatch

Optionally, a password protection can be used for the function LCP-copy (see *Table 7.1*) and in case of a parameter mismatch (see *Table 7.2*). Password protection can be enabled/disabled in *0-69 Password Protection of Safety Parameters*. The password is set in *0-68 Safety Parameters Password*. Default password is 300.

LCP Copy

Message	Description
	<p>130BD114.10</p> <p>The password protection of the safety parameters is enabled.</p>
	<p>130BD116.10</p> <p>Copying the safety parameters from the LCP into the frequency converter is selected.</p>
	<p>130BD117.10</p> <p>The safety parameters get copied from the LCP into the frequency converter.</p>
	<p>130BD118.10</p> <p>If password protection is enabled in 0-69 Password Protection of Safety Parameters, enter the correct LCP-copy/parameter mismatch password (0-68 Safety Parameters Password).</p>
	<p>130BD119.10</p> <p>If the entered password is correct, this overlay message is shown for some seconds.</p>
	<p>130BD123.10</p> <p>If the entered password is wrong, this overlay message is shown for some seconds. Then the password can be entered again.</p>

Message	Description
<p>130BD120.10</p>	Decision box for continuing overwriting the existing data or to abort the procedure.
<p>130BD121.10</p>	
<p>130BD122.10</p>	Press [OK] to complete the customisation of the safety option. A reset is required to finalise this procedure.
<p>130BD124.10</p>	Press [Cancel] to abort the customisation of the safety option. A reset is required to finalise this procedure.

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Table 7.1 LCP Copy Messages

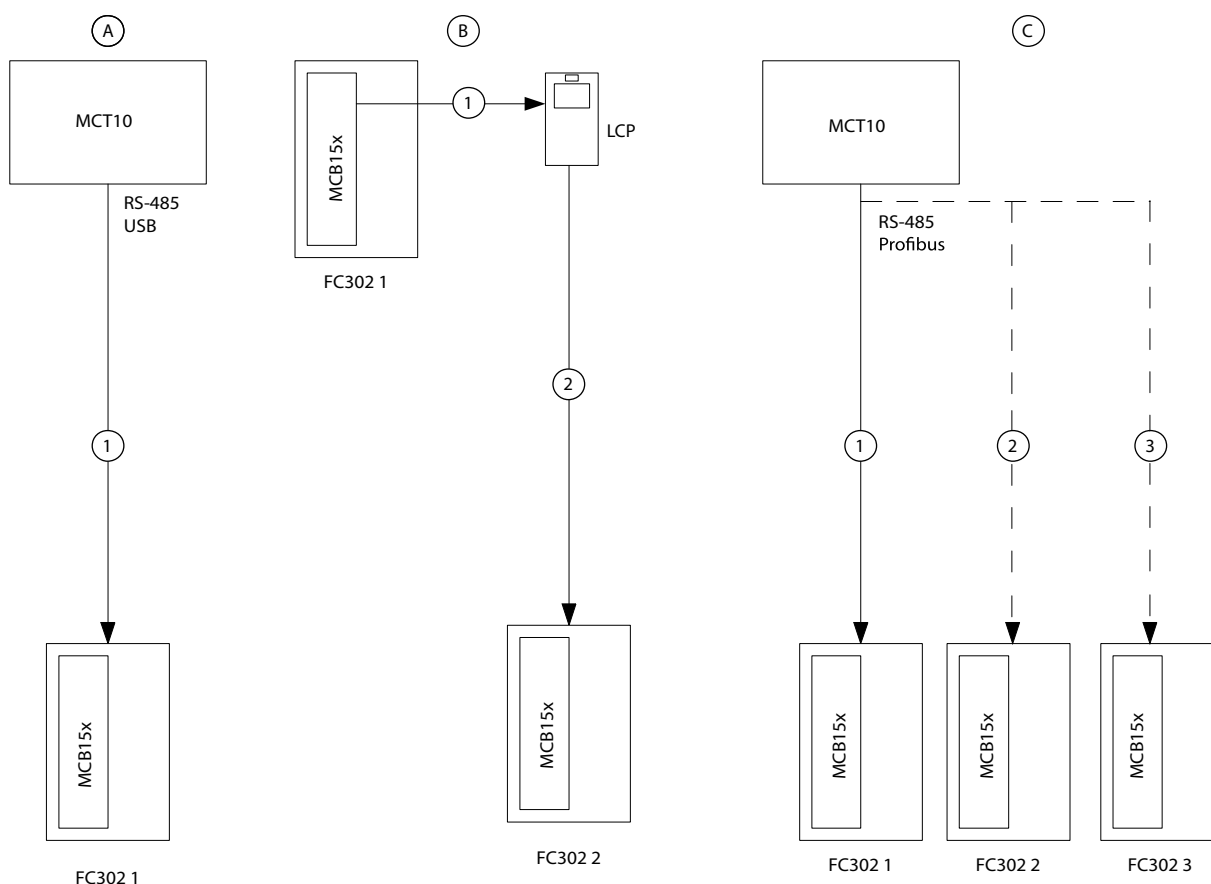
Mismatch of Safety Option Parameters

Message	Description
<p>130BD115.10</p>	Whenever there is mismatch of safety parameters within the safety option and the frequency converter, this selection form is displayed on the LCP. Select between the 'safety data on safe option' or the 'safety data on frequency converter' as valid data.
<p>130BD122.10</p>	If selecting [SO:...], the customization of the safety option is completed and a reset is required to finalize this procedure.

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Message	Description
 <p>0 RPM None 1(1)  <b>Safety Password</b>          Please enter the safety Password          0000000</p>	<p>130BD118.10</p> <p>If selecting [VLT:... ] and the password protection in <i>0-69 Password Protection of Safety Parameters</i> is enabled, enter the correct LCP-copy/parameter mismatch password (<i>0-68 Safety Parameters Password</i>).</p>
 <p>0 RPM None 1(1)          Password accepted          (1) Enabled</p>	<p>130BD119.10</p> <p>If the entered password is correct, this overlay message is shown for some seconds.</p>
 <p>0 RPM None 1(1)          Password rejected          (1) Enabled</p>	<p>130BD123.10</p> <p>If the entered password is wrong, this overlay message is shown for some seconds. Then the password can be entered again.</p>
 <p>0 RPM 0.00A 1(1)  <b>SO Data Confirmation</b>          Are you sure that you want to overwrite the safety parameters including the level 1 password?</p>	<p>130BD120.10</p> <p>Decision box for continuing overwriting the existing data or to abort the procedure.</p>
 <p>0 RPM 0.00A 1(1)  <b>SO Data Confirmation</b>          Press [OK] to confirm (commissioning test must be performed) or [CANCEL] to abort</p>	
 <p>Status 1(1)          0 RPM None 0.00KW          SO Custom. completed          SO RESET required!          !Safe Stop [W68]          Off Remote SO Req.RESET</p>	<p>130BD122.10</p> <p>Press [OK] to complete the customisation of the safety option. A reset is required to finalise this procedure.</p>
 <p>Status 1(1)          0 RPM None 0.00KW          SO Custom. aborted          SO RESET required!          !Safe Stop [W68]          Off Remote SO Req.RESET</p>	<p>130BD124.10</p> <p>Press [Cancel] to abort the customisation of the safety option. A reset is required to finalise this procedure.</p>

Table 7.2 Mismatch between Safety Parameters in the safety Option and the Frequency Converter



1308C327:10

Illustration 7.1 Possible Parameter Set-up

## 7.4 Commissioning Test

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

The test objective is to verify proper configuration of the defined safety 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 etc.). The system may only

be commissioned/recommissioned by qualified personnel.

- Refer to the information and specifications stated in the operating instructions 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 *Start up and Functional Testing* chapter in the operating instructions for the frequency converter.

### 7.4.2 Condition before Performing the Commissioning Test

The system integrator/machine manufacturer performs 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 functions used. The commissioning test must be performed on the basis of the risk analysis. All applicable standards and regulations must be adhered to.

- The machine is properly wired
- Check the effectiveness of all safety components used in the application
- 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 frequency converter

A commissioning test of the safety option must be performed 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)

Check the effectiveness of all safety functions used.

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 frequency converter and check that the motor runs normally.

### 7.4.3 Safety Functions of the Frequency Converter

#### Commissioning test report

After making e.g. LCP copy of safe parameters a commissioning test is required. Use this short version of the commissioning test report to follow and approve the test sequence.

Safety functions	Test procedure	Approved <input type="checkbox"/>
Safe Torque Off (STO)	1. Safe Torque Off function must be disabled <ul style="list-style-type: none"> <li>- via DI1.</li> <li>- via DI2.</li> <li>- Check the Safe Torque Off circuit connections against the circuit diagram.</li> </ul>	
	2. No safety faults and alarms.	
	3. Run the frequency converter.	
	4. Ensure that the correct frequency converter is running.	
	5. Select Safe Torque Off while the frequency converter is running.	
	6. Check the following <ul style="list-style-type: none"> <li>- The frequency converter coasts to zero speed.</li> <li>- The motor is braked and stopped by the mechanical brake (if available and configured).</li> <li>- Warning/Alarm 68 is displayed.</li> </ul>	
	7. Deselect Safe Torque Off.	
	8. Check the following <ul style="list-style-type: none"> <li>- Depending on the configuration, Safety Func. Pending is displayed.</li> <li>- Safe Torque Off deselected and inactive.</li> </ul>	
	9. Restart the frequency converter and check that the motor runs normally.	
	10. Ensure that the Safe Torque Off function is safe and accepted to operate.	
	11. Document and sign the commissioning test report.	

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Table 7.3 Commissioning Test Report, Safe Torque Off

Safety functions	Test procedure	Approved <input checked="" type="checkbox"/>
Safe Stop 1 time based (SS1)	1. Safe Stop 1 function must be disabled <ul style="list-style-type: none"> <li>- via DI1.</li> <li>- via DI2.</li> <li>- Check the Safe Stop 1 circuit connections against the circuit diagram.</li> </ul>	
	2. No safety faults and alarms.	
	3. Run the frequency converter.	
	4. Ensure that the correct frequency converter is running.	
	5. Select Safe Stop 1 while the frequency converter is running.	
	6. Check the following <ul style="list-style-type: none"> <li>- The frequency converter ramps down to zero speed. Ensure that it stops within the delay time specified.</li> <li>- The motor is braked and stopped by the mechanical brake (if available and configured).</li> <li>- The SS1 will end with an STO warning or alarm, depending on configuration.</li> </ul>	
	7. Deselect Safe Stop 1.	
	8. Check the following <ul style="list-style-type: none"> <li>- Safety Func. Pending is displayed.</li> <li>- Safe Stop 1 deselected and inactive.</li> </ul>	
	9. Restart the frequency converter and check that the motor runs normally.	
	10. Ensure that the Safe Stop 1 function is ready to operate.	
	11. Document and sign the commissioning test report.	

Table 7.4 Commissioning Test Report, Safe Stop 1 Time Based

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Safety functions	Test procedure	Approved <input type="checkbox"/>
Safe Stop 1 Delay	1. Safe Stop 1 Delay function must be disabled <ul style="list-style-type: none"> <li>- via DI1.</li> <li>- via DI2.</li> <li>- Check the Safe Stop 1 circuit connections against the circuit diagram.</li> </ul>	
	2. No safety faults and alarms.	
	3. Run the frequency converter.	
	4. Ensure that the correct frequency converter is running.	
	5. Select Safe Stop 1 Delay while the frequency converter is running.	
	6. Check the following <ul style="list-style-type: none"> <li>- The frequency converter ramps down to zero speed. Ensure that it stops within the delay time specified.</li> <li>- The motor is braked and stopped by the mechanical brake (if available and configured).</li> <li>- The SS1 will end with an STO warning or alarm depending on configuration.</li> </ul>	
	7. Deselect Safe Stop 1 Delay.	
	8. Check the following <ul style="list-style-type: none"> <li>- Safety Func. Pending is displayed.</li> <li>- Safe Stop 1 Delay deselected and inactive.</li> </ul>	
	9. Restart the frequency converter and check that the motor runs normally.	
	10. Ensure that the Safe Stop 1 function is ready to operate.	
	11. Document and sign the commissioning test report.	

Table 7.5 Commissioning Test Report, Safe Stop 1 Delay

Safety functions	Test procedure	Approved <input checked="" type="checkbox"/>
Safe Stop 1 ramp based (SS1)	1. Safe Stop 1 function must be disabled <ul style="list-style-type: none"> <li>- via DI1.</li> <li>- via DI2.</li> <li>- Check the Safe Stop 1 circuit connections against the circuit diagram.</li> </ul>	
	2. No safety faults and alarms.	
	3. Run the frequency converter.	
	4. Ensure that the correct frequency converter is running.	
	5. Select Safe Stop 1 while the frequency converter is running.	
	6. Check the following <ul style="list-style-type: none"> <li>- The frequency converter ramps down to zero speed.</li> <li>- The motor is braked and stopped by the mechanical brake (if available and configured).</li> <li>- The SS1 will end with an STO warning or alarm depending on configuration.</li> </ul>	
	7. Deselect Safe Stop 1.	
	8. Check the following <ul style="list-style-type: none"> <li>- Safety Func. Pending is displayed.</li> <li>- Safe Stop 1 deselected and inactive.</li> </ul>	
	9. Restart the frequency converter and check that the motor runs normally.	
	10. Ensure that the Safe Stop 1 function is ready to operate.	
	11. Document and sign the commissioning test report.	

Table 7.6 Commissioning Test Report, Safe Stop 1 Ramp Based

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Safety functions	Test procedure	Approved <input checked="" type="checkbox"/>
Safely Limited Speed (SLS) without ramp	1. Safely Limited Speed function must be disabled <ul style="list-style-type: none"> <li>- via DI1.</li> <li>- via DI2.</li> </ul> Check the Safely Limited Speed circuit connections against the circuit diagram.	
	2. No safety faults and alarms.	
	3. Run the frequency converter. <ul style="list-style-type: none"> <li>- Up and down ramps can be separately entered for JOG operation (JOG-Mode). This can be parameterised as part of the Quick Menu.</li> <li>- The motor speed must be higher than the Safely Limited Speed selected, if the machine allows this</li> </ul>	
	4. Ensure that the correct frequency converter is running.	
	5. Select Safely Limited Speed while the frequency converter is running.	
	6. Check the following <ul style="list-style-type: none"> <li>- The frequency converter coasts to zero speed if Safe Torque Off is selected as fault reaction.</li> <li>- Run Safe Stop 1 if that is selected as fault reaction.</li> <li>- The motor is braked and stopped by the mechanical brake (if available and configured).</li> <li>- Ensure that Error 70 is displayed.</li> </ul>	
	7. Deselect Safely Limited Speed.	
	8. Check the following <ul style="list-style-type: none"> <li>- Safety Func. Pending is displayed.</li> <li>- Safely Limited Speed deselected and inactive.</li> </ul>	
	9. Restart the frequency converter and check that the motor runs normally.	
	10. Ensure that the Safely Limited Speed function is ready to operate. <ul style="list-style-type: none"> <li>- Run motor below SLS limit</li> <li>- Activate SLS</li> <li>- Increase reference above SLS limit</li> <li>- Make sure that SLS limit will not be exceeded</li> </ul>	
	11. Document and sign the commissioning test report.	

7

Table 7.7 Commissioning Test Report, Safely Limited Speed without Ramp

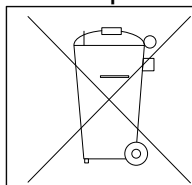
7

Safety functions	Test procedure	Approved <input type="checkbox"/>
Safely Limited Speed (SLS) with ramp	1. Safely Limited Speed function must be disabled <ul style="list-style-type: none"> <li>- via DI1.</li> <li>- via DI2.</li> <li>- Check the Safely Limited Speed circuit connections against the circuit diagram.</li> </ul>	
	2. No safety faults and alarms.	
	3. Run the frequency converter. <ul style="list-style-type: none"> <li>- The motor speed must be higher than the Safely Limited Speed selected, if the machine allows this</li> </ul>	
	4. Ensure that the correct frequency converter is running.	
	5. Select Safely Limited Speed while the frequency converter is running.	
	6. Check the following <ul style="list-style-type: none"> <li>- The speed ramps down according to the chosen ramp time/slope to Safely Limited Speed set point.</li> </ul>	
	7. Deselect Safely Limited Speed.	
	8. Safe Func. Pending is displayed.	
	9. Run the frequency converter. <ul style="list-style-type: none"> <li>- The motor speed must be higher than the Safely Limited Speed selected, if the machine allows this</li> </ul>	
	10. Ensure that the correct frequency converter is running.	
	11. Select Safely Limited Speed while the frequency converter is running.	
	12. Check the following <ul style="list-style-type: none"> <li>- The frequency converter ramps down to the Safe Limited Speed.</li> </ul>	
	13. Deselect Safely Limited Speed.	
	14. Check the following <ul style="list-style-type: none"> <li>- No safety faults.</li> <li>- Safe Func. Pending is displayed.</li> </ul>	
	15. Reset the frequency converter and check that the motor runs normally.	
	16. Ensure that the Safely Limited Speed function is ready to operate.	
	17. Document and sign the commissioning test report.	

Table 7.8 Commissioning Test Report, Safely Limited Speed with Ramp

Tester/Approver	Date: _____
	Signature: _____

## 7.5 Disposal



Equipment containing electrical components may not be disposed of together with domestic waste. It must be separately collected with electrical and electronic waste according to local and currently valid legislation.

## 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 the fault types shown in *Table 8.1*.

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 displayed. The system is in stop mode.	Output S37 is switched off	Reset possible by power cycling the frequency converter or restart the safety option via <i>42-90 Restart Safe Option</i>
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 Field bus or via <i>42-90 Restart Safe Option</i>

**Table 8.1** Fault Types

Colour	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

**Table 8.2** LED Status Indicators

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, *42-90 Restart Safe Option* and configuration.

#### 8.1.1 Messages

Any errors on the safety option are indicated on the frequency converter display with different messages

The following options are available for detailed diagnostics 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, i.e. active safety functions, failures and warnings, if any.
- LCP text or info via bus display the status of the safety functions (e.g. SS1a).

The following are displayed 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 displayed in the expanded diagnostics system of MCT 10 Set-up Software.

## 8.2 Warnings and Alarms

### **NOTICE**

The errors are listed numerically.

Error No.	Description	Led Indications				
		Reason	Action	LED1	LED 2	LED4
	<b>Internal failure</b>					Green constant
1	Diagnostic in progress					Green constant
67	Int Fail tolerance error exceeded: Reaction STO	<ul style="list-style-type: none"> <li>• Check that data for feedback (ppr., type of feedback and gear ratio) are entered correctly</li> <li>• Direction of feedback is wrong</li> <li>• Due to use of feedback filter the dynamic of the system does not match with dynamic of feedback filter (<i>42-15 Feedback Filter</i>). System is ramping too fast.</li> <li>• Feedback signals are not received at all</li> <li>• No proper shielding of feedback cables</li> </ul>	<ul style="list-style-type: none"> <li>• Make a re-customisation with correct data if needed</li> <li>• Set <i>42-12 Encoder Direction</i> to the opposite value</li> <li>• Decrease ramping time on frequency converter</li> <li>• Try to run the system at e.g. 60 RPM. If error nr. 99 now occurs, this is the reason.</li> <li>• Improve shielding of feedback cables and motor cables.</li> </ul>			Red constant
68	Int fail Speed limit SS1a Ramp: Reaction STO	<ul style="list-style-type: none"> <li>• The value of Delta V is too small. For closed loop system it must often be larger than the recommended value.</li> <li>• Due to use of feedback filter the dynamic of the system does not match with dynamic of feedback filter (<i>42-15 Feedback Filter</i>).</li> <li>• Load change takes place during ramping.</li> </ul>	<ul style="list-style-type: none"> <li>• If running in closed loop, try to adjust PID setting and if needed increase SS1 ramping time.</li> <li>• Try to increase <i>42-15 Feedback Filter</i>, but this might cause error nr. 67 to occur.</li> <li>• Otherwise increase <i>42-45 Delta V</i>.</li> </ul>			Red constant
69	Int fail Speed limit SS1b Ramp: Reaction STO	See 68	See 68			Red constant

Status of LED 1 and LED2 depends on safety function state assigned to DI1 and DI2

Error No.	Description	Led Indications				
		Reason	Action	LED1	LED 2	LED4
	<b>Internal failure</b>					Green constant
70	Int fail speed limit SLSa : Reaction STO	Happens during ramping to SLS limit, see 68. Happens during speed below SLS limit: <ul style="list-style-type: none"> <li>If speed is above cut-off speed at activation point and 42-53 Start Ramp is set to "No", this error occurs.</li> <li>Noise on the feedback signal (incl. quantisation noise) is larger than expected.</li> <li>Load change takes place, do as in above point)</li> </ul>	<ul style="list-style-type: none"> <li>Change 42-53 Start Ramp to "Yes" and set 42-54 Ramp Down Time accordingly.</li> <li>Increase 42-50 Cut Off Speed or decrease 42-51 Speed Limit to get a larger tolerance</li> </ul>			Red constant
71	Int fail speed limit SLSb : Reaction STO	See 70	See 70			Red constant
72	Internal failure MCB 150/151		<ul style="list-style-type: none"> <li>First, power cycle the frequency converter or restart the safety option by 42-90 Restart Safe Option. Secondly, try to make a general reset of the safety option with the "Administration" button (safety option goes back to blank initial state)</li> <li>If the problem persists, contact Danfoss</li> </ul>	Status of LED 1 and LED2 depends on safety function state assigned to DI1 and DI2		Red constant
73	Internal failure MCB 150/151		<ul style="list-style-type: none"> <li>First, power cycle the frequency converter or restart the safety option by 42-90 Restart Safe Option.</li> <li>If the problem persists, contact Danfoss</li> </ul>			Red constant



Error No.	Description	Led Indications				
				LED1	LED 2	LED4
	<b>Internal failure</b>	<b>Reason</b>	<b>Action</b>	Status of LED 1 and LED2 depends on safety function state assigned to DI1 and DI2		Green constant
74	Internal failure MCB 150/151		<ul style="list-style-type: none"> <li>First, power cycle the frequency converter or restart the option by <i>42-90 Restart Safe Option</i>.</li> <li>If the problem persists, contact Danfoss</li> </ul>			Red constant
75	Int Fail DI2 in PUST: Reaction STO	<ul style="list-style-type: none"> <li>Safety input connected to DI2 has illegal signal level.</li> <li>Sensor is broken</li> </ul>	<ul style="list-style-type: none"> <li>Check that configuration of DI2 <i>42-21 Type</i> parameter is set correctly or that the connected sensor is installed according to specification.</li> <li>Extend discrepancy time on safe input tab in MCT 10 safe plug-in <i>14-22 Operation Mode</i>.</li> </ul>			Red constant
76	Int Fail DI1 in PUST: Reaction STO	<ul style="list-style-type: none"> <li>Safety input connected to DI1 has illegal signal level.</li> <li>Sensor is broken</li> </ul>	<ul style="list-style-type: none"> <li>Check that the configuration of DI1 (<i>42-21 Type</i> sub index [0]) is set correctly or the connected sensor is installed according to specification.</li> <li>Extend discrepancy time on safe input tab in MCT 10 safe plug-in <i>14-22 Operation Mode</i>.</li> </ul>			Red constant
77	Int Fail failsafe data CRC mismatch: Reaction STO	The CRC of the safety option does not match the stored CRC value on the frequency converter.	Configure the safety option with MCT 10 safe plug-in or by CRC select/LCP copy		Red constant	

Error No.	Description	Led Indications			
		Reason	Action	LED1	LED 2
	<b>Internal failure</b>				Green constant
78	Internal failure safety option		<ul style="list-style-type: none"> <li>First, power cycle the frequency converter or restart the safety option by <i>42-90 Restart Safe Option</i>.</li> <li>If the problem persists, contact Danfoss</li> </ul>		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		<ul style="list-style-type: none"> <li>First, power cycle the frequency converter.</li> <li>If the problem persists, contact Danfoss</li> </ul>		Red constant
82	Internal failure safety option		<ul style="list-style-type: none"> <li>First, power cycle the frequency converter.</li> <li>If the problem persists, contact Danfoss</li> </ul>	Status of LED 1 and LED2 depends on safety function state assigned to DI1 and DI2	Red constant
83	Internal failure safety option		<ul style="list-style-type: none"> <li>First, power cycle the frequency converter.</li> <li>If the problem persists, contact Danfoss</li> </ul>		Red constant
84	Internal failure safety option		<ul style="list-style-type: none"> <li>First, power cycle the frequency converter.</li> <li>If the problem persists, contact Danfoss</li> </ul>		Red constant
85	Internal failure safety option		<ul style="list-style-type: none"> <li>First, power cycle the frequency converter.</li> <li>If the problem persists, contact Danfoss</li> </ul>		Red constant

Error No.	Description	Led Indications				
		Reason	Action	LED1	LED 2	LED4
	<b>Internal failure</b>					Green constant
86	Internal failure safety option		<ul style="list-style-type: none"> <li>First, power cycle the frequency converter.</li> <li>If the problem persists, contact Danfoss</li> </ul>			Red constant
87	Internal failure safety option		<ul style="list-style-type: none"> <li>First, power cycle the frequency converter.</li> <li>If the problem persists, contact Danfoss</li> </ul>			Red constant
88	Internal failure safety option		<ul style="list-style-type: none"> <li>First, power cycle the frequency converter.</li> <li>If the problem persists, contact Danfoss</li> </ul>			Red constant
89	Internal failure safety option		<ul style="list-style-type: none"> <li>Perform a general reset of the safety option with the "Administration" button.</li> <li>If the problem persists, contact Danfoss</li> </ul>			Red constant
90	Internal failure safety option		<ul style="list-style-type: none"> <li>Perform a general reset of the safety option with the "Administration" button.</li> <li>If the problem persists, contact Danfoss</li> </ul>			Red constant
91	Internal failure safety option		<ul style="list-style-type: none"> <li>First, power cycle the frequency converter.</li> <li>If the problem persists, contact Danfoss</li> </ul>			Red constant
92	Internal failure safety option		<ul style="list-style-type: none"> <li>First, power cycle the frequency converter.</li> <li>If the problem persists, contact Danfoss</li> </ul>			Red constant

Status of LED 1 and LED2 depends on safety function state assigned to DI1 and DI2

Error No.	Description	Led Indications						
		Reason	Action	LED1	LED 2	LED4		
	<b>Internal failure</b>			Status of LED 1 and LED2 depends on safety function state assigned to DI1 and DI2		Green constant		
93	Internal failure safety option		<ul style="list-style-type: none"> <li>First, power cycle the frequency converter.</li> <li>If the problem persists, contact Danfoss</li> </ul>				Red constant	
94	Internal failure safety option		<ul style="list-style-type: none"> <li>First, power cycle the frequency converter.</li> <li>If the problem persists, contact Danfoss</li> </ul>				Red constant	
95	Internal failure safety option		<ul style="list-style-type: none"> <li>First, power cycle the frequency converter.</li> <li>If the problem persists, contact Danfoss</li> </ul>				Red constant	
96	Internal failure safety option		<ul style="list-style-type: none"> <li>First, power cycle the frequency converter.</li> <li>If the problem persists, contact Danfoss</li> </ul>				Red constant	
97	Internal failure safety option		<ul style="list-style-type: none"> <li>Contact Danfoss</li> </ul>				Red constant	
98	Int fail invalid customer file version	Version of customisation file of safety option stored in EEPROM does not match the customisation 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 the connection is done according to the specification or if the feedback source is broken.				Red	
113	Ext Fail DI1 : Reaction STO	<ul style="list-style-type: none"> <li>Safety input connected to DI1 has illegal signal level.</li> <li>Sensor is broken.</li> </ul>	<ul style="list-style-type: none"> <li>Check that configuration of DI1 42-21 Type parameter is set correctly or the connected sensor is installed according to specification</li> </ul>			Red Constant	Status depends on safety function state assigned to DI2	Red flashing, cycle (on 500 ms, off 500 ms)

Error No.	Description	Led Indications				
				LED1	LED 2	LED4
114	Ext Fail DI2 : Reaction STO	<ul style="list-style-type: none"> <li>Safety input connected to DI2 has illegal signal level.</li> <li>Sensor is broken</li> </ul>	<ul style="list-style-type: none"> <li>Check that configuration of DI2 <i>42-21 Type</i> parameter is set correctly or the connected sensor is installed according to specification</li> <li>Extend discrepancy time on safe input tab in MCT 10 safe plug-in <i>14-22 Operation Mode</i>.</li> </ul>	Status depends on safety 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 frequency converter has been running below 120 RPM for more than the time entered in parameter <i>42-18 Zero Speed Timer</i> with safe function SLS active.	Increase speed to above 120 RPM.	Status of LED 1 and LED2 depends on Safety 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 frequency converter has been running below 120 RPM for more than 1 year and a safety function that need 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	Status of LED 1 and LED2 depends on safety function state assigned to DI1 and DI2		Red constant
135	Int fail speed limit SLSb :Reaction SS1a	See 70	See 70			Red constant
177	Ext Fail DI1 :Reaction SS1a	See 113	See 113	Red constant	Status depends on safety 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 function state assigned to DI1	Red constant	Red flashing, cycle (on 500 ms, off 500 ms)

Error No.	Description	Led Indications				
				LED1	LED 2	LED4
179	Ext Fail Prec Thresh Timer Elapsed :Reaction SS1a	See 115	See 115	Status of LED 1 and LED2 depends on safety 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 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 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	Status of LED 1 and LED2 depends on Safety function state assigned to DI1 and DI2		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 frequency converter. If the problem persists, contact Danfoss			

### 8.2.1 Safety Option Warning

#### Safety option warning messages

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 displays Warning '!Safe Option Failure [W252]' at the least.

### 8.2.2 Safety Option Reset Message

#### Requests for safety option RESET

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'

LCP message	Description
	<p>130BD126.10</p> <p>In the following cases, the safety option requests a restart and failure acknowledgement-signal:</p> <ol style="list-style-type: none"> <li>The safety option is in safety function pending-state (Remark: Occurs only if reset behaviour is set/ configured to 'manual')</li> <li>After a power cycle with a safety function</li> <li>In PUST (power up self test), if an external failure occurred before power cycle</li> <li>When an external failure occurred</li> <li>When customisation was aborted or completed</li> <li>At the reception of a general reset (required after blank initial state or in the customisation state.)</li> </ol>
	<p>130BD127.10</p> <p>The safety option indicates that it is PUST State (Power Up Self Test).</p> <ol style="list-style-type: none"> <li>Ensure that no safe function is active after a power cycle.</li> </ol>
	<p>130BD128.10</p> <p>A safety function is pending at the start-up, if the frequency converter was powered down while a safety function was active. It is also pending, when the frequency converter was powered down while the safety option has detected a failure during an active safety function.</p>
	<p>130BD129.10</p> <p>The safety option requests a 'Restart and Failure Acknowledge signal', which is always required after a PUST and when a safety function gets released and is configured to be confirmed that the motor is able to run.</p>

LCP message	Description
	<p>130BD130.10</p> <p>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.</p>
	<p>130BD131.10</p> <p>Zero speed timer contains the remaining time until the fail prec thresh timer elapsed after the monitoring time expires. The safety option signals Warning.</p>
	<p>130BD132.10</p> <p>PUST warning has occurred. Warning cause: Expiry of PUST timer. Memory test required, perform power cycle.</p>
	<p>130BD133.10</p> <p>DI1 offline warning has occurred. Warning cause: Expiry of offline timer for DI1.</p>
	<p>130BD134.10</p> <p>DI2 offline warning has occurred. Warning cause: Expiry of offline timer for DI2.</p>
	<p>130BD131.10</p> <p>Speed monitoring suspension warning has occurred. Warning cause: Suspension of speed monitoring for certain duration.</p>

Table 8.3 LCP Messages

## 9 Technical Specifications

### 9.1 Consumption

#### Safety option

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 MCB 150)

### 9.2 Inputs

#### Digital inputs

Number of digital inputs	4 (2 x 2-channel Digital Safety Input)
Input voltage range	0 to 24 V DC
Input voltage, logic '0'	< 5 V DC
Input voltage, logic '1'	> 12 V DC
Input voltage (max)	28 V DC
Input current (min)	6 mA @Vin=24 V (inrush current 12 mA peak)
Input resistance	approx. 4 k $\Omega$
Galvanic isolation	No
Short circuit-proof	Yes
Input pulse recognition time (min)	3 ms
Discrepancy time (min)	9 ms
Cable length	< 30 m (screened or unscreened cable) > 30 m (screened cable)

#### TTL encoder input (MCB 150)

Number of encoder inputs	4 (2 x differential inputs A/A; B/B)
Encoder types	TTL, RS-422/RS-485 incremental encoders
Input differential voltage range	-7 to +12 V DC
Input common mode voltage	-12 to +12 V DC
Input voltage, logic '0' (diff)	< -200 mV DC
Input voltage, logic '1' (diff)	> +200 mV DC
Input resistance	approx. 120 $\Omega$
Maximum frequency	410 KHz
Short circuit-proof	Yes
Cable length	< 150 m (Tested with screened cable - Heidenhain AWM Style 20963 80°C 30V E63216, 100 m screened motor cable, no load on motor)

#### HTL encoder input (MCB 151)

Number of encoder inputs	2 (2 x single ended inputs A; B)
Encoder types	HTL incremental encoders; HTL Proximity sensor
Logic input	PNP
Input voltage range	0 to 24 V DC
Input voltage, logic '0'	< 5V DC
Input voltage, logic '1'	> 12 V DC
Input voltage (max)	28 V DC
Input resistance	approx. 4 $\Omega$
Maximum frequency	110 kHz
Short circuit-proof	Yes
Cable length	< 100 m (Tested with screened cable - Heidenhain AWM Style 20963 80°C 30V E63216, 100 m screened motor cable, no load on motor)



### 9.3 Outputs

#### Digital output (Safe output)

Number of outputs	1
Output voltage low	< 2 V DC
Output voltage high	> 19.5 V DC
Output voltage (max)	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 us
Short circuit-proof	Yes
Cable length	< 30 m (screened cable)

#### 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 (screened or unshielded cable) > 30 m (screened cable)

### 9.4 Other Specifications

#### Ground I/O section

Cable length	< 30 m (screened or unshielded cable) > 30 m (screened cable)
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#### Cable cross-sections

Digital inputs/output supply voltage	0.75 mm <sup>2</sup> /AWG 18, AEH without plastic collar in accordance with DIN 46228/1
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#### Reset characteristics

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

#### 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)

## 9.5 Safety Characteristic Data

European directives	Machinery Directive (2006/42/EC)	EN ISO 13849-1 EN IEC 62061 EN IEC 61800-5-2	
	EMC Directive (2004/108/EC)	EN 50011 EN 61000-6-3 EN 61800-3	
	Low Voltage Directive (2006/95/EC)	EN 50178 EN 61800-5-1	
Safety standards	Safety of Machinery	EN ISO 13849-1 IEC 62061 IEC 60204-1	
	Functional Safety	IEC 61508-1 to -7 IEC 61800-5-2	
Safety 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)	
Safety performance	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 <sub>ave</sub> : 86% (Low)	
	Safe Failure Fraction	SFF: 90%	
	Proof Test Interval	20 Years	

**Table 9.1 Safety Characteristic Data**

The safety-related characteristic data are valid for all safety functions.

All units used within a safety function must be considered when calculating the safety characteristic data.

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