ENGINEERING
TOMORROW

Operating Guide

VLT® Midi Drive FC 280

with FSoE

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1 Introduction

1.1 Purpose of this Operating Guide

This operating guide provides information for safe installation and commissioning of the AC drive. It is intended for use by qualified personnel.

Read and follow the instructions to use the drive safely and professionally.

Pay particular attention to the safety instructions and warnings. Always keep this operating guide with the drive.

VLT® is a registered trademark for Danfoss A/S.

1.2 Additional Resources

Other resources are available to understand advanced drive functions, programming, and maintenance.

- The VLT® Midi Drive FC 280 Programming Guide provides information on how to program and includes complete parameter descriptions.
- The VLT® Midi Drive FC 280 Design Guide provides detailed information about the design and applications of the drive.

Supplementary publications and manuals are available from the Danfoss website.

1.3 Version History

This guide is regularly reviewed and updated. All suggestions for improvement are welcome.

The original language of this guide is English.

Table 1: Version History

Edition	Remarks
AQ450729109605, version 0101	First edition.

1.4 Product Overview

1.4.1 Intended Use

The drive is an electronic motor controller intended for:

- Regulation of motor speed in response to system feedback or to remote commands from external controllers. A power drive system consists of the drive, the motor, and equipment driven by the motor.
- System and motor status surveillance.

The drive can also be used for motor overload protection.

Depending on the configuration, the drive can be used in standalone applications or form part of a larger appliance or installation. The drive is allowed for use in residential, industrial, and commercial environments in accordance with local laws and standards.

NOTICE

In a residential environment, this product can cause radio interference, in which case supplementary mitigation measures can be required.

Foreseeable misuse

Do not use the drive in applications which are non-compliant with specified operating conditions and environments. Ensure compliance with the conditions specified in *chapter Specifications*.

1.4.2 Block Diagram of the Drive

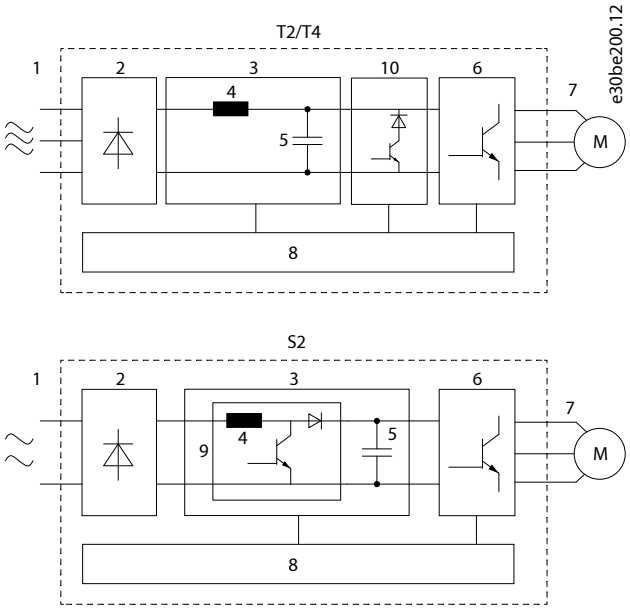


Figure 1: Block Diagram of the Drive

Table 2: Functions of Each Component

Area	Component	Functions
1	Mains input	• AC mains supply to the drive.
2	Rectifier	• The rectifier bridge converts the AC input to DC current to supply inverter power.
3	DC bus	• Intermediate DC-bus circuit handles the DC current.
4	DC reactor	• Filters the DC-link current. • Provides mains transient protection. • Reduces the root mean square (RMS) current. • Raises the power factor reflected back to the line. • Reduces harmonics on the AC input.
5	Capacitor bank	• Stores the DC power. • Provides ride-through protection for short power losses.
6	Inverter	• Converts the DC into a controlled PWM AC waveform for a controlled variable output to the motor.
7	Output to motor	• Regulated 3-phase output power to the motor.
8	Control circuitry	• Input power, internal processing, output, and motor current are monitored to provide efficient operation and control. • User interface and external commands are monitored and performed. • Status output and control can be provided.
9	PFC	• Power factor correction changes the waveform of current which is drawn by the drive to improve the power factor.
10	Brake Chopper	• Brake chopper is used in the DC link to control DC voltage when the load feeds energy back.

1.4.3 Enclosure Sizes and Power Ratings

For enclosure sizes and power ratings of the drives, refer to 9.9 Enclosure Sizes, Power Ratings, and Dimensions.

1.4.4 Safety Functions

The following safety functions are integrated in this drive according to EN IEC 61800-5-2:

- Safe Torque Off (STO)
- Safe Stop 1 time controlled (SS1-t).

See *Chapter 6 Safety Functions* for details about the installation, configuration, commissioning, maintenance, and technical data.

1.5 Approvals and Certifications







EtherCAT®, EtherCAT P®, and Safety over EtherCAT® are registered trademarks and patented technologies, licensed by Beckhoff Automation GmbH, Germany.

For compliance with the European Agreement concerning International Carriage of Dangerous Goods by Inland Waterways (ADN), refer to the *chapter ADN-compliant Installation* in the *VLT® Midi Drive FC 280 Design Guide*.

The drive complies with UL 508C thermal memory retention requirements. For more information, refer to the *chapter Motor Thermal Protection* in the *VLT® Midi Drive FC 280 Design Guide*.

1.6 Applied Standards and Compliance for Safety Functions

Safe Torque Off (STO)

The STO function is designed and approved according to the following standards:

- EN IEC 61508, SIL3
- EN IEC 61800-5-2, SIL3
- EN ISO 13849-1, Category 3, PL e

Safe Stop 1 time controlled (SS1-t)

The SS1-t function is designed and approved according to the following standards:

- EN IEC 61508, SIL3
- EN IEC 61800-5-2, SIL3
- EN ISO 13849-1, Category 3, PL e

1.7 **Disposal**

Do not dispose of equipment containing electrical components together with domestic waste.
Collect it separately in accordance with local and currently valid legislation.

2 Safety

2.1 Safety Symbols

The following symbols are used in Danfoss documentation.

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

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

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

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

The guide also includes ISO warning symbols related to hot surfaces and burn hazard, high voltage and electrical shock, and referring to the instructions.

	ISO warning symbol for hot surfaces and burn hazard
	ISO warning symbol for high voltage and electrical shock
	ISO action symbol for referring to the instructions

2.2 Qualified Personnel

Correct and reliable transport, storage, installation, operation, and maintenance are required for the trouble-free and safe operation of the product. Only qualified personnel are allowed to install and operate this equipment.

Qualified personnel are defined as trained staff, who are authorized to install, commission, and maintain equipment, systems, and circuits in accordance with pertinent laws and regulations. Also, the qualified personnel must be familiar with the instructions and safety measures described in this guide.

2.3 Safety Precautions

⚠ WARNING	
	**HAZARDOUS VOLTAGE** AC drives contain hazardous voltage when connected to the AC mains or connected on the DC terminals. Failure to perform installation, start-up, and maintenance by qualified personnel can result in death or serious injury. • Only qualified personnel must perform installation, start-up, and maintenance.

⚠ WARNING

UNINTENDED START

When the drive is connected to AC mains, DC supply, or load sharing, the motor may start at any time. Unintended start during programming, service, or repair work can result in death, serious injury, or property damage. Start the motor with an external switch, a fieldbus command, an input reference signal from the local control panel (LCP), via remote operation using MCT 10 software, or after a cleared fault condition.

- Disconnect the drive from the mains.
- Press *[Off/Reset]* on the LCP before programming parameters.
- Ensure that the drive is fully wired and assembled when it is connected to AC mains, DC supply, or load sharing.

⚠ WARNING

DISCHARGE TIME

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

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

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

Table 3: Discharge Time

Voltage [V]	Power range [kW (hp)]	Minimum waiting time (minutes)
200–240	0.37–3.7 kW (0.5–5 hp)	4
380–480	0.37–7.5 kW (0.5–10 hp)	4
	11–22 kW (15–30 hp)	15

⚠ WARNING

ELECTRICAL SHOCK HAZARD - LEAKAGE CURRENT HAZARD

Leakage currents exceed 3.5 mA. Failure to connect the drive properly to protective earth (PE) can result in death or serious injury.

- Ensure reinforced protective earthing conductor according to IEC 60364-5-54 cl. 543.7 or according to local safety regulations for high touch current equipment. The reinforced protective earthing of the drive can be done with:
- a PE conductor with a cross-section of at least 10 mm^2 (8 AWG) Cu or 16 mm^2 (6 AWG) Al.
- an extra PE conductor of the same cross-sectional area as the original PE conductor as specified by IEC 60364-5-54 with a minimum cross-sectional area of 2.5 mm^2 (14 AWG) (mechanically protected) or 4 mm^2 (12 AWG) (not mechanically protected).
- a PE conductor completely enclosed with an enclosure or otherwise protected throughout its length against mechanical damage.
- a PE conductor part of a multi-conductor power cable with a minimum PE conductor cross-section of 2.5 mm^2 (14 AWG) (permanently connected or pluggable by an industrial connector. The multi-conductor power cable shall be installed with an appropriate strain relief).
- NOTE: In IEC/EN 60364-5-54 cl. 543.7 and some application standards (for example IEC/EN 60204-1), the limit for requiring reinforced protective earthing conductor is 10 mA leakage current.

⚠ WARNING

EQUIPMENT HAZARD

Contact with rotating shafts and electrical equipment can result in death or serious injury.

- Ensure that only trained and qualified personnel perform installation, start-up, and maintenance.
- Ensure that electrical work conforms to national and local electrical codes.
- Follow the procedures in this guide.

⚠ CAUTION

INTERNAL FAILURE HAZARD

An internal failure in the drive can result in serious injury when the drive is not properly closed.

- Ensure that all safety covers are in place and securely fastened before applying power.

3 Mechanical Installation

3.1 Unpacking

3.1.1 Items Supplied

Items supplied vary according to product configuration.

- Make sure that the items supplied and the information on the nameplate correspond to the order confirmation.
- Check the packaging and the drive visually for damage caused by inappropriate handling during shipment. File any claim for damage with the carrier. Retain damaged parts for clarification.

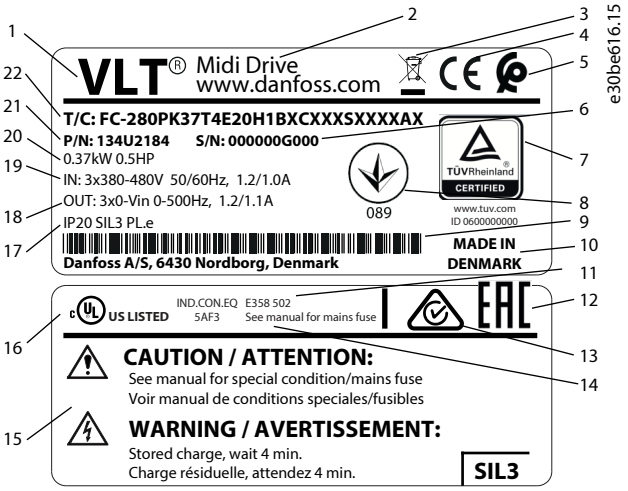


Figure 2: Product Nameplate (Example)

1	Product logo	**2**	Product name
3	Disposal	**4**	CE mark
5	Morocco	**6**	Serial number
7	TÜV logo	**8**	UkrSEPRO logo
9	Barcode	**10**	Country of origin
11	UL reference	**12**	EAC logo
13	RCM logo	**14**	Reference to enclosure type
15	Warning specifications	**16**	UL logo
17	IP rating	**18**	Output voltage, frequency, and current (at low/high voltages)
19	Input voltage, frequency, and current (at low/high voltages)	**20**	Power rating
21	Ordering number	**22**	Type code

NOTICE

Do not remove the nameplate from the drive (loss of warranty).

- For more information of the type code, refer to the *chapter Type Code* in the VLT® Midi Drive FC 280 Design Guide.

3.1.2 Identifying the Drive with Ethernet-based Safety Functions

To identify whether the drive is equipped with the Ethernet-based safety functions, check the following:

- The drive's type code on the product label contains “SFS1” at bits 24~27, for example:

Pos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	F	C	-	2	8	0	P	K	3	7	T	4	E	2	0	H	1	B	X	C	X	X	X	**S**	**F**	**S**	**1**	X	A	L

e30bu891.10

Figure 3: Type Code Example for Drive with Ethernet-based Safety Functions

- The drive has terminal 39.

3.1.3 Storage

Ensure that the requirements for storage are fulfilled. Refer to 9.4 Ambient Conditions for further details

3.2 Installation Environment

NOTICE

REDUCED LIFETIME

In environments with airborne liquids, particles, or corrosive gases, ensure that the IP/Type rating of the equipment matches the installation environment. Failure to meet requirements for ambient conditions can reduce lifetime of the drive.

- Ensure that requirements for air humidity, temperature, and altitude are met.

Vibration and shock

The drive complies with requirements for units mounted on the walls and floors of production premises, and in panels bolted to walls or floors. For detailed ambient conditions, refer to 9.4 Ambient Conditions.

3.3 Mounting

3.3.1 Cooling

NOTICE

Improper mounting can result in overheating and reduced performance.

- Ensure 100 mm (3.9 in) of top and bottom clearance for air cooling.

3.3.2 Lifting

- To determine a safe lifting method, check the weight of the unit, see 9.9 Enclosure Sizes, Power Ratings, and Dimensions.
- Ensure that the lifting device is suitable for the task.
- If necessary, plan for a hoist, crane, or forklift with the appropriate rating to move the unit.
- For lifting, use hoist rings on the unit, when provided.

3.3.3 Mounting

3.3.3.1 Mounting Procedure

1. Ensure that the strength of the mounting location supports the unit weight.
2. Place the unit as near to the motor as possible. Keep the motor cables as short as possible.
3. Mount the unit vertically on a solid flat surface.

4. Use the slotted mounting holes on the unit for wall mount, when provided. For dimensions of mounting holes, see 9.9 Enclosure Sizes, Power Ratings, and Dimensions.

3.3.3.2 Side-by-side Installation

All VLT® Midi Drive FC 280 units can be installed side by side in vertical or horizontal position. The units do not require extra ventilation on the side.

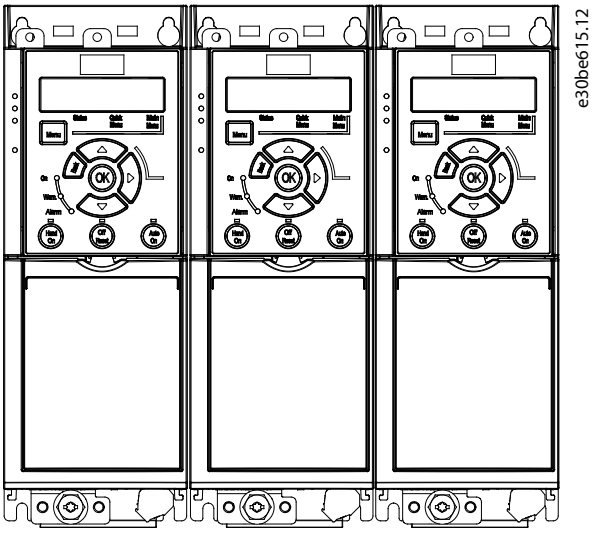


Figure 4: Side-by-side Installation

NOTICE

RISK OF OVERHEATING

If IP21 conversion kit is used, mounting the units side by side could lead to overheating and damage to the unit.

- At least 30 mm (1.2 in) is required between the top cover edges of IP21 conversion kit.

3.3.3.3 Horizontal Mounting

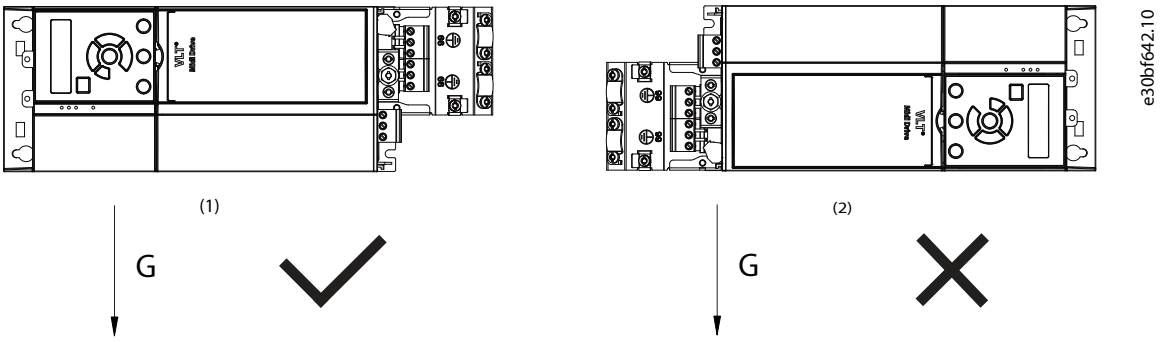


Figure 5: Horizontal Mounting

1	Correct horizontal mounting (left side downwards)	**2**	Incorrect horizontal mounting (right side downwards)

3.3.3.4 Bus Decoupling Kit

The bus decoupling kit ensures mechanical fixation and electrical shielding of cables for the control cassettes with EtherCAT/FSoE.

Each bus decoupling kit contains 1 horizontal decoupling plate and 1 vertical decoupling plate. Mounting the vertical decoupling plate is optional. The vertical decoupling plate provides better mechanical support for Ethernet connectors and cables.

3.3.3.5 Mounting the Bus Decoupling Kit

1. Place the horizontal decoupling plate on the control cassette mounted on the drive and fasten the plate using 2 screws as shown in Figure 6. Tightening torque is 0.7–1.0 Nm (6.2–8.9 in-lb).

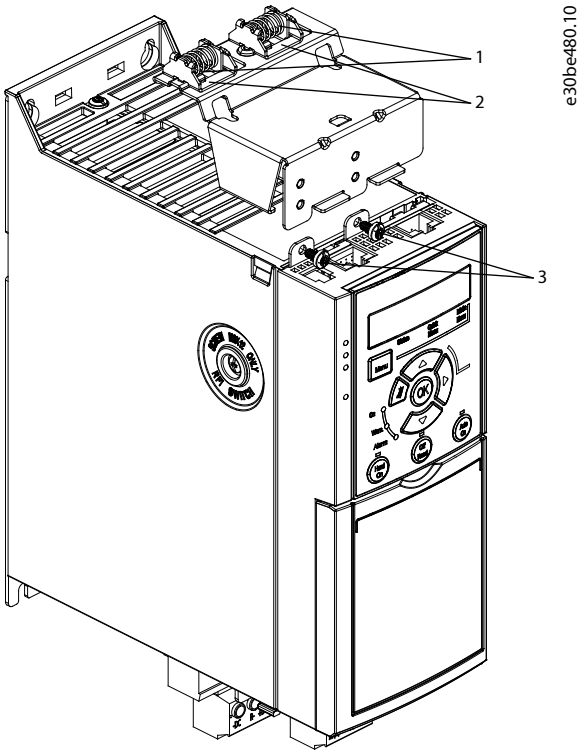


Figure 6: Fasten the Horizontal Decoupling Plate with Screws

Figure 6 shows Ethernet-based connectors (RJ45). The actual connector type depends on the selected fieldbus variant of the drive.

1	Mechanical springs	**2**	Metal clamps
3	Screws		

2. Optional: Mount the vertical decoupling plate as follows:
   - **a.** Remove the 2 mechanical springs and 2 metal clamps from the horizontal plate.
   - **b.** Mount the mechanical springs and metal clamps on the vertical plate.
   - **c.** Fasten the plate with 2 screws as shown in Figure 7. Tightening torque is 0.7–1.0 Nm (6.2–8.9 in-lb).

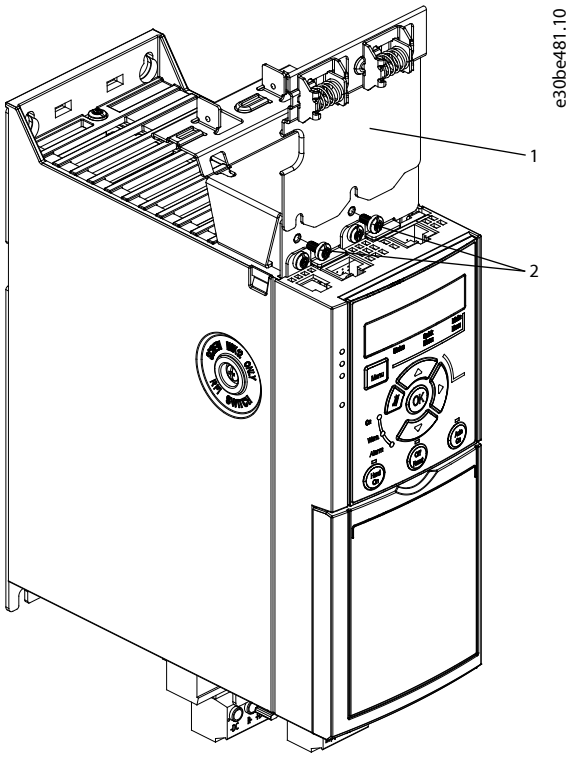


Figure 7: Fasten the Vertical Decoupling Plate with Screws

Figure 7 shows Ethernet-based connectors (RJ45). The actual connector type depends on the selected fieldbus variant of the drive.

1	Vertical decoupling plate	**2**	Screws

3. Push the Ethernet cable connectors (RJ45) into the sockets in the control cassette.
4. Place the Ethernet cables between the spring-loaded metal clamps to establish mechanical fixation between the cables and the clamps.

4 Electrical Installation

4.1 Safety Instructions

See *chapter Safety* for general safety instructions.

⚠ WARNING

INDUCED VOLTAGE

Induced voltage from output motor cables that run together can charge equipment capacitors, even with the equipment turned off and locked out/tagged out. Failure to run output motor cables separately, or to use shielded cables, could result in death or serious injury.

- Run output motor cables separately or use shielded cables.
- Simultaneously lock out/tag out all the drives.

⚠ WARNING

ELECTRICAL SHOCK AND FIRE HAZARD – RCD COMPLIANCE

The drive can cause a DC fault current in the PE conductor. Failure to use a Type B residual current-operated protective device (RCD) can lead to the RCD not providing the intended protection and therefore can result in death, fire, or other serious hazard.

- When an RCD is used for protection against electrical shock or against fire, only a Type B device is allowed on the supply side.

Overcurrent protection

- Extra protective equipment, such as short-circuit protection or motor thermal protection between drive and motor, is required for applications with multiple motors.
- Input fusing is required to provide short-circuit and overcurrent protection. If not factory-supplied, the installer must provide fuses. See maximum fuse ratings in *chapter Fuses and Circuit Breakers*.

Wire type and ratings

- All wiring must comply with local and national regulations regarding cross-section and ambient temperature requirements.
- Power connection wire recommendation: Minimum 75 °C (167 °F) rated copper wire. See 9.5 Cable Specifications for recommended wire sizes and types.

4.2 EMC-compliant Installation

To obtain an EMC-compliant installation, follow the instructions provided in 4.3 Grounding, 4.4 Wiring Diagram, 4.7.1 Connecting the Motor, and *chapter Control Wiring*.

4.3 Grounding

⚠ WARNING

ELECTRICAL SHOCK HAZARD - LEAKAGE CURRENT HAZARD

Leakage currents exceed 3.5 mA. Failure to connect the drive properly to protective earth (PE) can result in death or serious injury.

- Ensure reinforced protective earthing conductor according to IEC 60364-5-54 cl. 543.7 or according to local safety regulations for high touch current equipment. The reinforced protective earthing of the drive can be done with:
- a PE conductor with a cross-section of at least 10 mm^2 (8 AWG) Cu or 16 mm^2 (6 AWG) Al.
- an extra PE conductor of the same cross-sectional area as the original PE conductor as specified by IEC 60364-5-54 with a minimum cross-sectional area of 2.5 mm^2 (14 AWG) (mechanically protected) or 4 mm^2 (12 AWG) (not mechanically protected).
- a PE conductor completely enclosed with an enclosure or otherwise protected throughout its length against mechanical damage.
- a PE conductor part of a multi-conductor power cable with a minimum PE conductor cross-section of 2.5 mm^2 (14 AWG) (permanently connected or pluggable by an industrial connector. The multi-conductor power cable shall be installed with an appropriate strain relief).
- NOTE: In IEC/EN 60364-5-54 cl. 543.7 and some application standards (for example IEC/EN 60204-1), the limit for requiring reinforced protective earthing conductor is 10 mA leakage current.

For electrical safety

- Ground the drive in accordance with applicable standards and directives.
- Use a dedicated ground wire for input power, motor power, and control wiring.
- Do not ground 1 drive to another in a daisy chain fashion (see Figure 8).
- Keep the ground wire connections as short as possible.
- Follow motor manufacturer wiring requirements.
- Minimum cable cross-section for the ground wires: 10 mm^2 (7 AWG).
- Separately terminate individual ground wires, both complying with the dimension requirements.

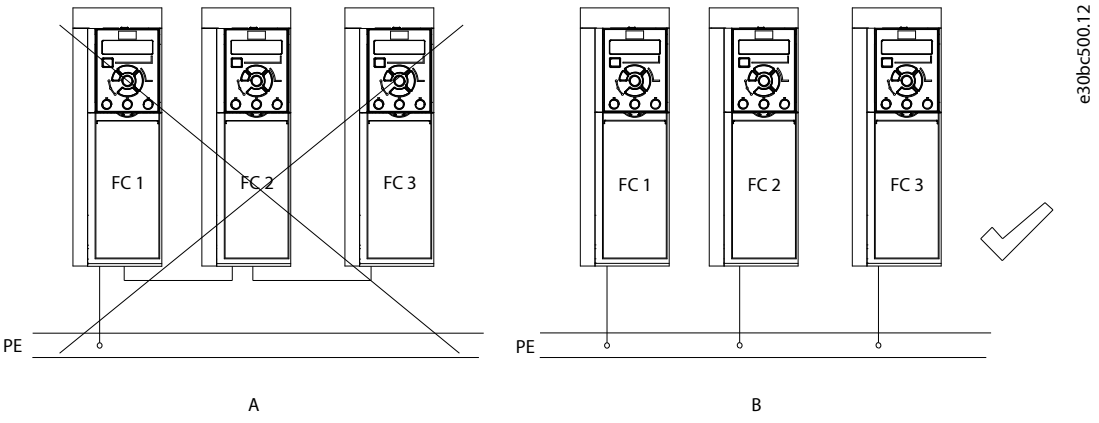


Figure 8: Grounding Principle

For EMC-compliant installation

- Establish electrical contact between the cable shield and the drive enclosure by using metal cable glands or by using the clamps provided on the equipment.
- Use high-strand wire to reduce burst transient.
- Do not use pigtails.

NOTICE

POTENTIAL EQUALIZATION

There is a risk of burst transient when the ground potential between the drive and the control system is different.

- Install equalizing cables between the system components. Recommended cable cross-section: 16 mm^2 (6 AWG).

4.4 Wiring Diagram

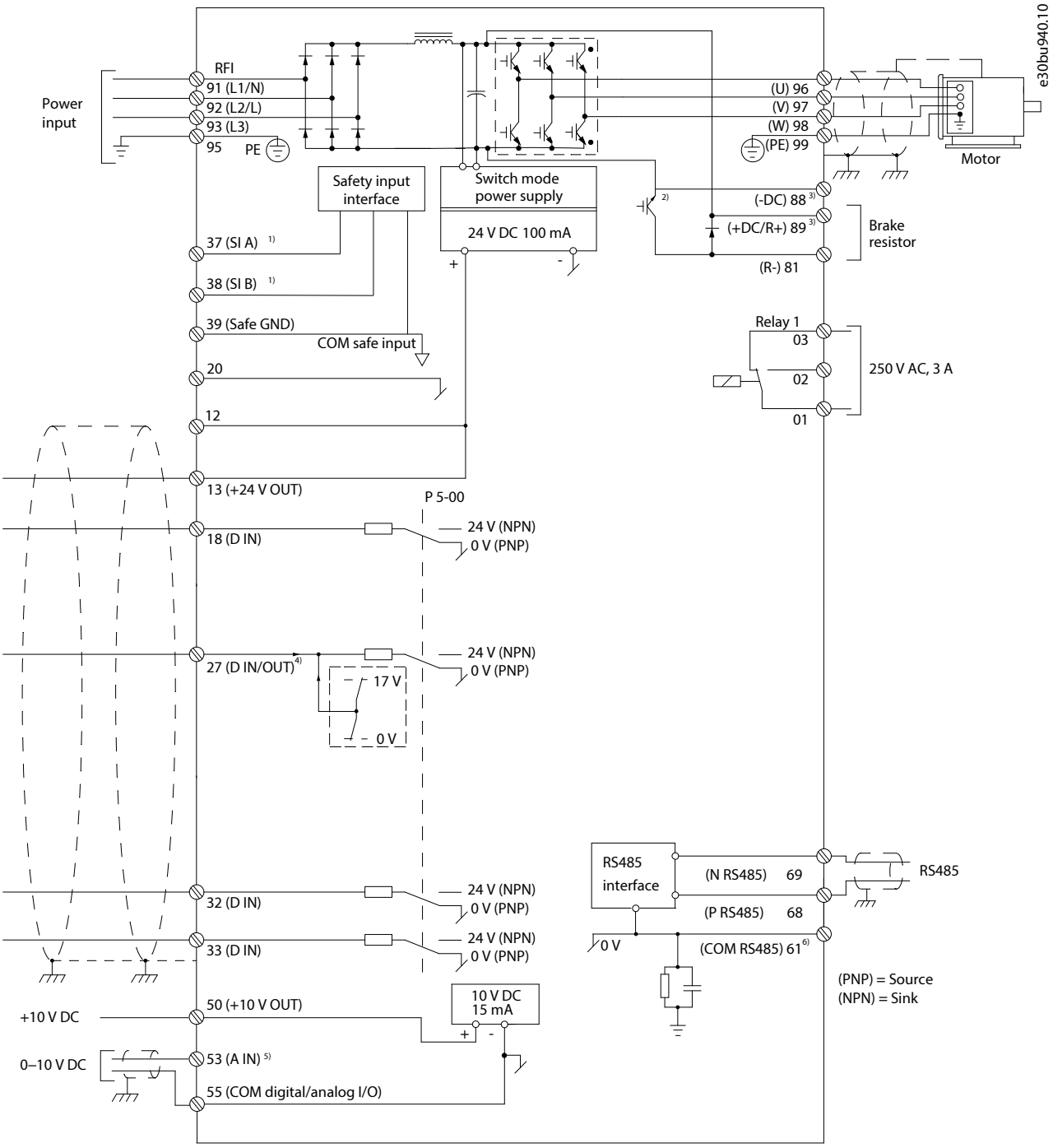


Figure 9: Basic Wiring Diagram

A	Analog	**D**	Digital
1	Refer to *chapter 6 Safety Functions* for the correct safety functions wiring.	**2**	Built-in brake chopper is only available on 3-phase units.
3	The S2 (single-phase 200–240 V) drive does not support load sharing application.	**4**	The maximum voltage is 17 V for terminal 27 as analog output.
5	Terminal 53 can also be used as digital input.	**6**	Terminal 61 is internally connected to terminal 20 and 55.

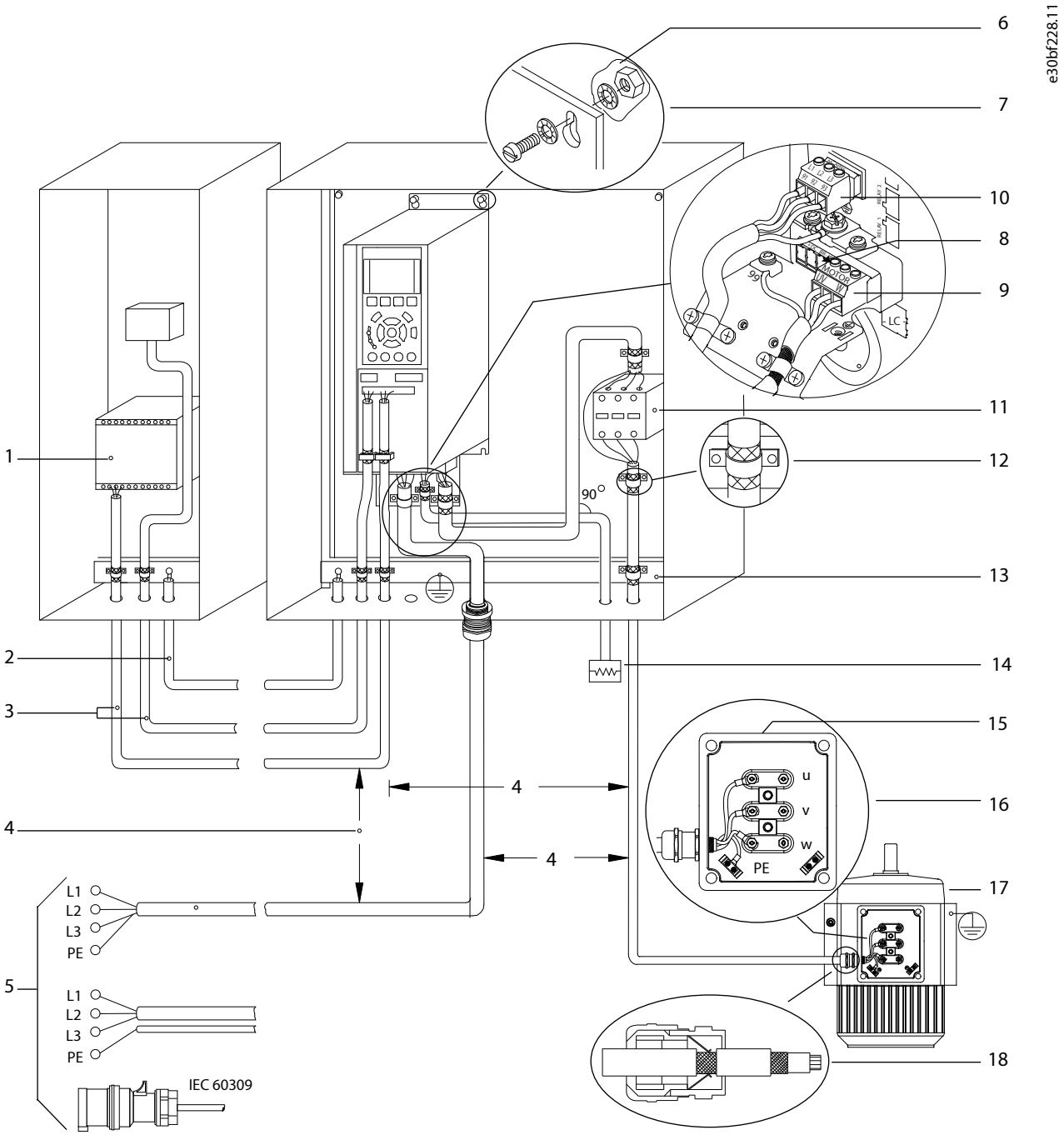


Figure 10: Example of Proper EMC Installation (Generic Drawing)

1	PLC	**2**	Minimum 16 mm^2 (6 AWG) equalizing cable
3	Control cables	**4**	Minimum 200 mm (7.87 in) between control cables, motor cables, and mains cables.
5	Mains supply	**6**	Bare (unpainted) surface
7	Star washers	**8**	Brake cable (shielded)
9	Motor cable (shielded)	**10**	Mains cable (unshielded)
11	Output contactor, and more.	**12**	Cable insulation stripped

13	Common ground busbar. Follow local and national requirements for cabinet grounding.	**14**	Brake resistor
15	Metal box	**16**	Connection to motor
17	Motor	**18**	EMC cable gland

4.5 Control Wiring Access

- Remove the cover plate with a screwdriver. See Figure 11.

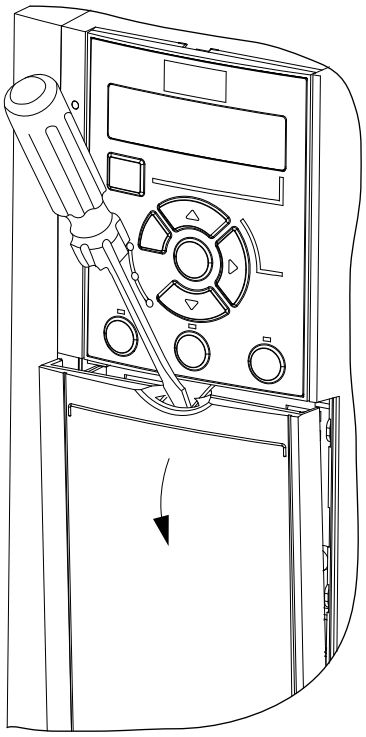


Figure 11: Control Wiring Access

4.6 Examples of Mains, Motor, and Grounding Connection

The mains, motor, and grounding connection for single-phase and 3-phase drives are shown in the following figures, respectively. Actual configurations vary with unit types and optional equipment.

NOTICE

In motors without phase insulation, paper, or other insulation reinforcement suitable for operation with voltage supply, use a sine-wave filter on the output of the drive.

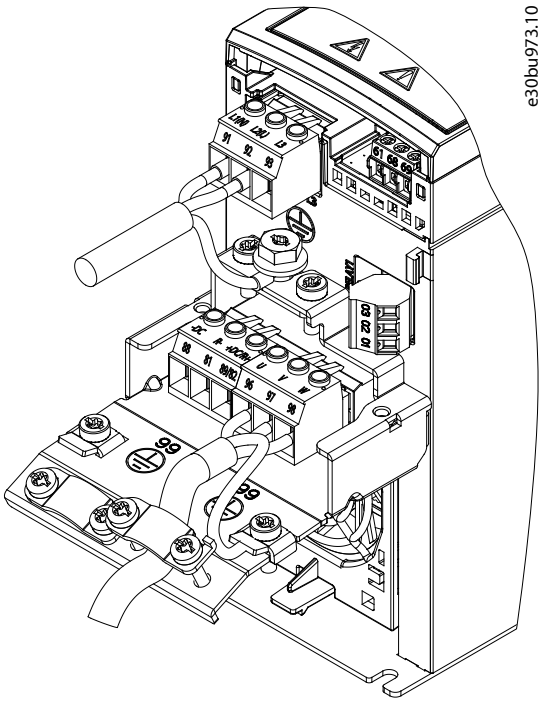


Figure 12: Example of Mains, Motor, and Grounding Connection for Single-phase Units (K1, K2)

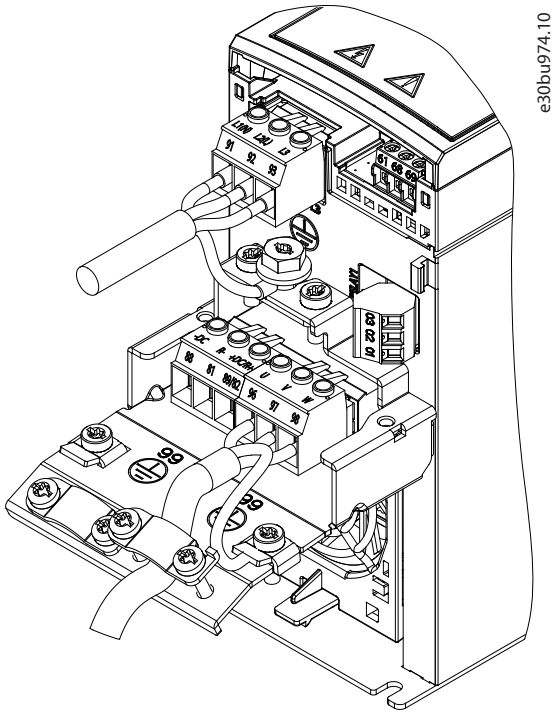


Figure 13: Example of Mains, Motor, and Grounding Connection for 3-phase Units (K1, K2, K3)

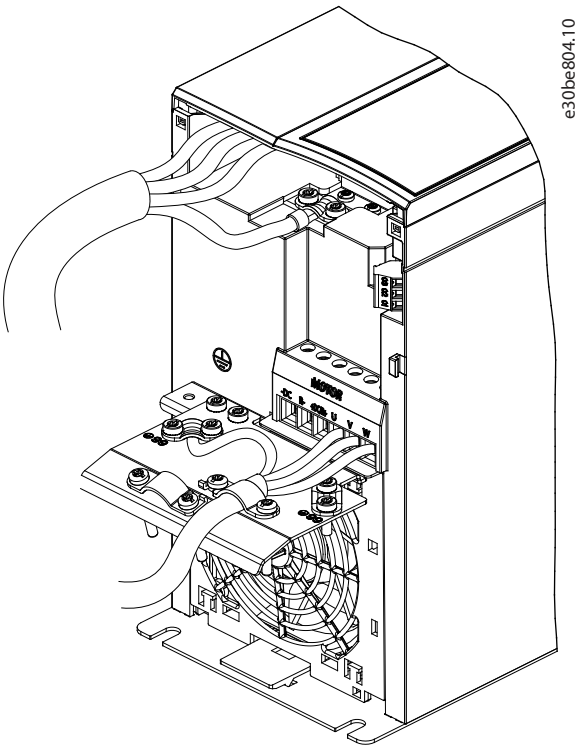


Figure 14: Example of Mains, Motor, and Grounding Connection for 3-phase Units (K4, K5)

4.7 Motor Connection

4.7.1 Connecting the Motor

⚠ WARNING

INDUCED VOLTAGE

Induced voltage from output motor cables that run together can charge equipment capacitors, even with the equipment turned off and locked out/tagged out. Failure to run output motor cables separately, or to use shielded cables, could result in death or serious injury.

- Run output motor cables separately or use shielded cables.
- Simultaneously lock out/tag out all the drives.

- Comply with local and national electrical codes for cable sizes. For maximum cable sizes, see 9.1 Electrical Data.
- Follow motor manufacturer wiring requirements.
- Motor wiring knockouts or access panels are provided at the base of IP21/Type 1 units.
- Do not wire a starting or pole-changing device (for example, Dahlander motor or slip ring induction motor) between the drive and the motor.

4.7.2 Grounding the Cable Shield

1. Strip a section of the outer cable insulation.
2. Position the stripped wire under the cable clamp to establish mechanical fixation and electrical contact between the cable shield and ground.
3. Connect the ground wire to the nearest grounding terminal in accordance with the grounding instructions, see 4.3 Grounding.

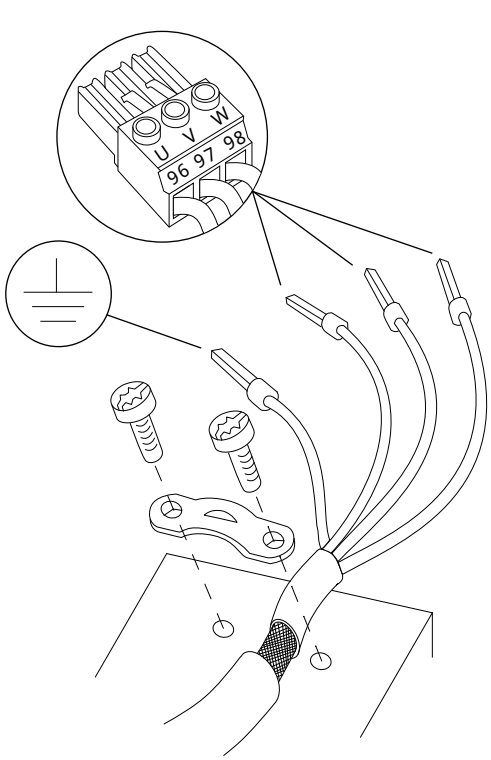


Figure 15: Motor Connection

4. Connect the 3-phase motor wiring to terminals 96 (U), 97 (V), and 98 (W).
5. Torque-tighten the terminals, see 9.7 Connection Tightening Torques.

4.8 AC Mains Connection

4.8.1 Connecting AC Mains

- Size the wiring based on the input current of the drive. For maximum wire sizes, see 9.1 Electrical Data.
- Comply with local and national electrical codes for cable sizes.

4.8.2 Connecting the Drive to Mains

1. Connect the AC input power cables to terminals N and L for single-phase units (see 4.6 Examples of Mains, Motor, and Grounding Connection).
2. Depending on the configuration of the equipment, connect the input power to the mains input terminals or the input disconnect.
3. Ground the cable in accordance with the grounding instructions, see 4.3 Grounding.
4. When supplied from an isolated mains source (IT mains or floating delta) or TT/TN-S mains with a grounded leg (grounded delta), ensure that the RFI filter screw is removed. Removing the RFI screw prevents damage to the DC link and reduces ground capacity currents in accordance with IEC 61800-3 (see 9.9 Enclosure Sizes, Power Ratings, and Dimensions, the RFI screw is on the side of the drive).

4.9 Control Wiring

4.9.1 Control Terminal Types

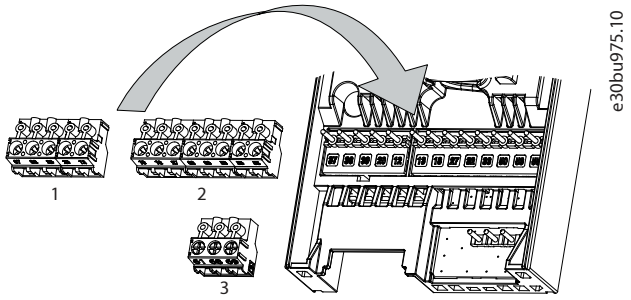


Figure 16: Control Terminal Locations

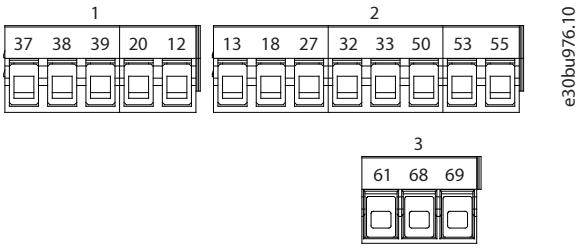


Figure 17: Terminal Numbers

Table 4: Terminal Descriptions

Terminal	Parameter	Default setting	Description
Digital I/O, pulse I/O, encoder			
12, 13	–	+24 V DC	24 V DC supply voltage. Maximum output current is 100 mA for all 24 V loads.
18	***Parameter 5-10 Terminal 18 Digital Input***	***[8] Start***	Digital inputs.
27	***Parameter 5-01 Terminal 27 Mode***, ***parameter 5-12 Terminal 27 Digital Input***, ***parameter 5-30 Terminal 27 Digital Output***	DI ***[2] Coast inverse*** DO ***[0] No operation***	Selectable for either digital input, digital output, or pulse output. The default setting is digital input.
32	***Parameter 5-14 Terminal 32 Digital Input***	***[0] No operation***	Digital input, 24 V encoder. Terminal 33 can be used for pulse input.
33	***Parameter 5-15 Terminal 33 Digital Input***	***[0] No operation***	
37, 38	***Parameter 42-20 Safety Function T37/T38***	***[5] Disable***	Functional safety inputs.
39	–	–	Function safety COM ground.
Analog inputs/outputs			
50	–	+10 V DC	10 V DC analog supply voltage. 15 mA maximum commonly used for potentiometer or thermistor.
53	***Parameter group 6-1* Analog Input 53***	–	Analog input. Only voltage mode is supported. It can also be used as digital input.
55, 20	-	–	Common for digital and analog inputs.

Table 4: Terminal Descriptions (continued)

Terminal	Parameter	Default setting	Description
Serial communication			
61	–	–	Connected to digital/analog ground internally.
68(+)	***Parameter group 8-3* FC Port Settings***	–	RS485 interface. A control card switch is provided for termination resistance.
69(-)	***Parameter group 8-3* FC Port Settings***	–	
Relays			
01, 02, 03	***Parameter 5-40 Function Relay***	***[1] Control Ready***	Form C relay output. These relays are in various locations depending on the drive configuration and size. Usable for AC or DC voltage and resistive or inductive loads.

4.9.2 Wiring to Control Terminals

Prerequisite: Control terminal connectors can be unplugged from the drive for ease of installation, as shown in 4.9.1 Control Terminal Types.

For details about safety functions wiring, refer to the *chapter 6 Safety Functions*. See 9.5 Cable Specifications for control terminal cable sizes and the *chapter Application Examples* for typical control cable connections.

NOTICE

Keep control cables as short as possible and separate them from high-power cables to minimize interference.

1. Loosen the screws for the terminals.
2. Insert sleeved control cables into the slots.
3. Fasten the screws for the terminals.
4. Ensure that the contact is firmly established and not loose. Loose control wiring can be the source of equipment faults or less than optimal operation.

4.9.3 Enabling Motor Operation (Terminal 27)

A jumper wire is required between terminal 12 (or 13) and terminal 27 for the drive to operate when using factory default programming values.

- Digital input terminal 27 is designed to receive 24 V DC external interlock command.
- When no interlock device is used, wire a jumper between control terminal 12 (recommended) or 13 to terminal 27. The jumper provides an internal 24 V signal on terminal 27.
- Only for GLCP: When the status line at the bottom of the LCP reads AUTO REMOTE COAST, it indicates that the unit is ready to operate but is missing an input signal on terminal 27.

NOTICE

UNABLE TO START

The drive cannot operate without a signal on terminal 27, unless terminal 27 is reprogrammed.

4.9.4 Mechanical Brake Control

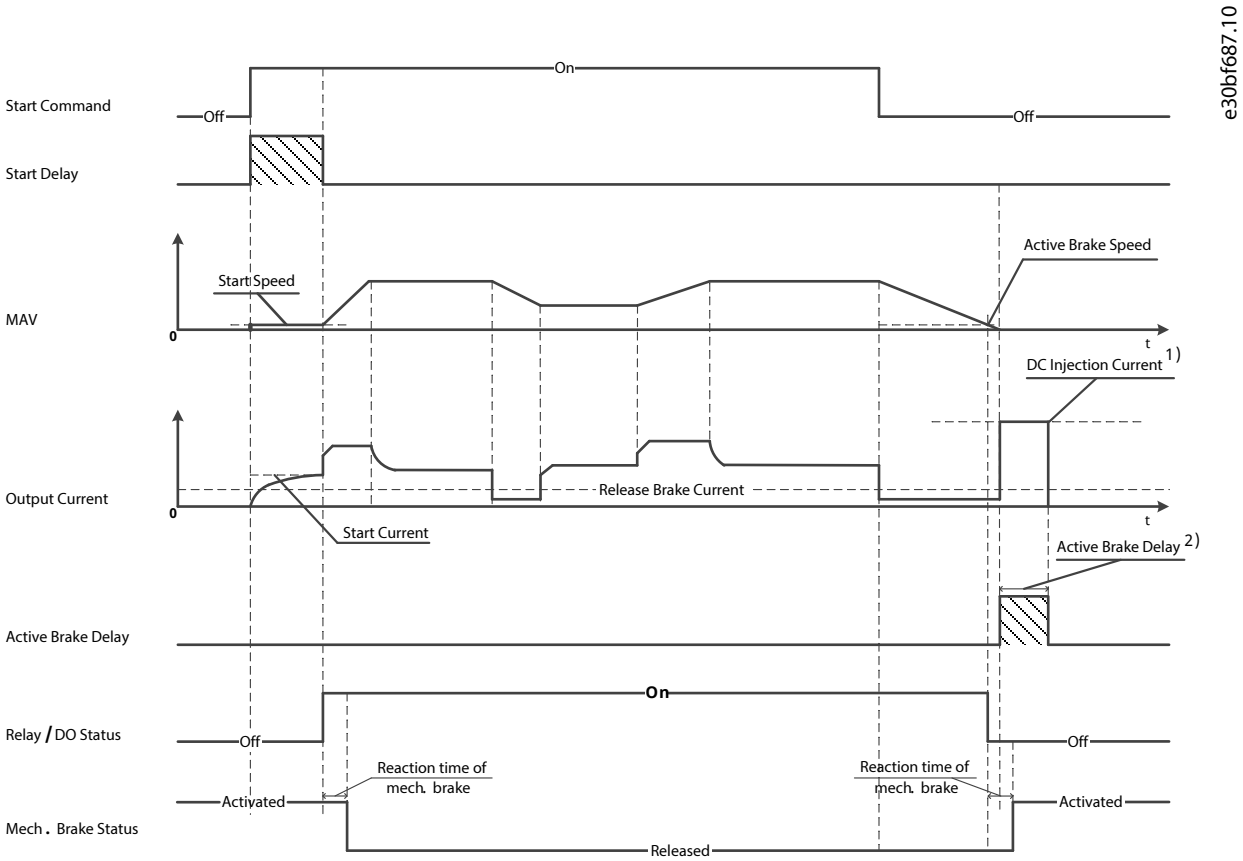
In hoisting/lowering applications, it is necessary to control an electro-mechanical brake.

- Control the brake using any relay output or digital output (terminal 27).

- Keep the output closed (voltage-free) as long as the drive is unable to keep the motor at standstill, for example, due to the load being too heavy.
- Select ***[32] Mechanical brake control*** in ***parameter group 5-4* Relays*** for applications with an electro-mechanical brake.
- The brake is released when the motor current exceeds the preset value in ***parameter 2-20 Release Brake Current***.
- The brake is engaged when the output frequency is less than the frequency set in ***parameter 2-22 Activate Brake Speed [Hz]***, and only if the drive carries out a stop command.

If the drive is in 1 of the following situations, the mechanical brake immediately closes.

- In alarm mode.
- In an overvoltage situation.
- STO is activated.
- Coast command is given.



Note: 1) DC injection current during "Active Brake Delay" after MAV reduced to "0". Only support in some products.

2) Only support in some products.

Figure 18: Mechanical Brake

The drive is not a safety device. It is the responsibility of the system designer to integrate safety devices according to relevant national crane/lift regulations.

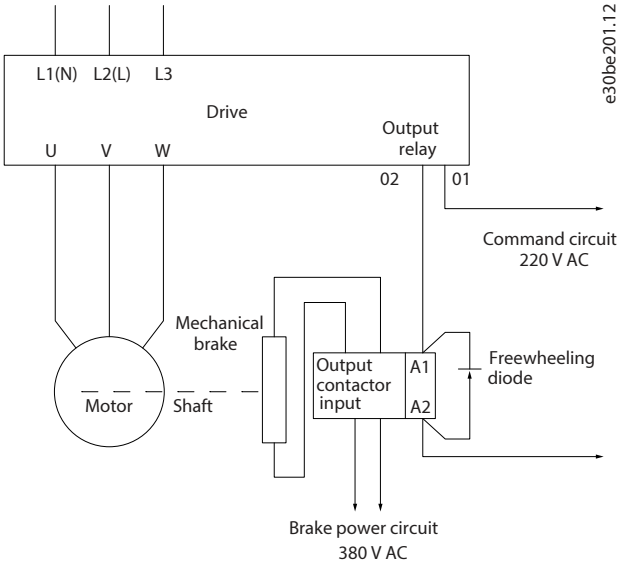


Figure 19: Connecting the Mechanical Brake to the Drive

4.9.5 USB Data Communication

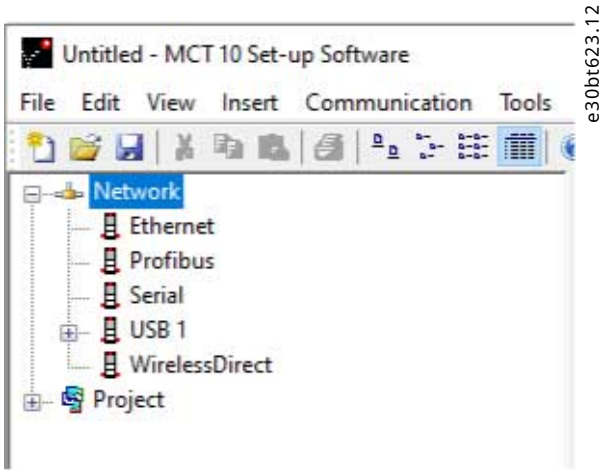


Figure 20: Network Bus List

When the USB cable is disconnected, the drive connected via the USB port is removed from the *Network* bus list.

NOTICE

CONNECT 1 DRIVE VIA USB TO PC

A USB bus has no address-setting capacity and no bus name to configure. If connecting more than 1 drive through USB, the bus name is auto-incremented in the MCT 10 setup software Network bus list.

Connecting more than 1 drive through a USB cable often causes computers installed with Windows to throw an exception and crash.

- Only connect 1 drive via USB to the PC.

4.9.6 Serial Communication

Connect RS485 serial communication wiring to terminals (+) 68 and (-) 69.

- Shielded serial communication cable is recommended.
- See 4.3 Grounding for proper grounding

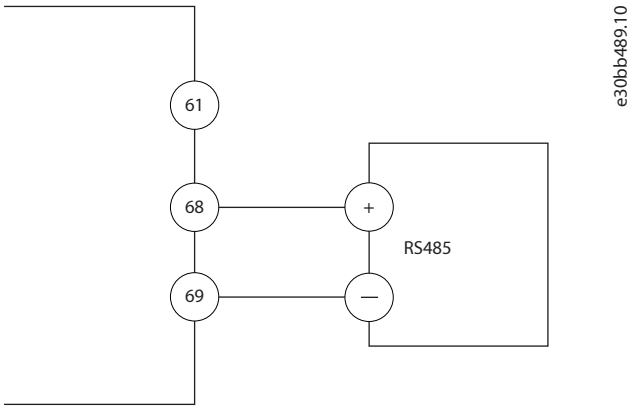


Figure 21: Serial Communication Wiring Diagram

For basic serial communication setup, select the following:

- Protocol type in ***parameter 8-30 Protocol***.
- Drive address in ***parameter 8-31 Address***.
- Baud rate in ***parameter 8-32 Baud Rate***.

Two communication protocols are internal to the drive.

- Danfoss FC
- Modbus RTU

Follow motor manufacturer wiring requirements.

Functions can be programmed remotely using the protocol software and RS485 connection, or in ***parameter group 8-** Communications and Options***.

Selecting a specific communication protocol changes various default parameter settings to match the specifications of the protocol and makes extra protocol-specific parameters available.

4.9.7 Installation Check List

Before completing installation of the unit, inspect the entire installation as detailed in Table 5. Check and mark the items when completed.

Table 5: Installation Check List

Inspect for	Description	✓
Auxiliary equipment	• Look for auxiliary equipment, switches, disconnects, or input fuses/circuit breakers, residing on the input power side of the drive, or output side to the motor. Ensure that they are ready for full-speed operation. • Check the function and installation of any sensors used for feedback to the drive. • Remove any power factor correction capacitors on the motor. • Adjust any power factor correction capacitors on the mains side and ensure that they are dampened.	
Cable routing	• Ensure that the motor wiring and control wiring are separated, shielded, or in 3 separate metallic conduits for high frequency interference isolation.	
Control wiring	• Check for broken or damaged wires and loose connections. • Check that the control wiring is isolated from power and motor wiring for noise immunity. • Check the voltage source of the signals, if necessary. The use of shielded cable or twisted pair is recommended. Ensure that the shield is terminated correctly.	

Table 5: Installation Check List (continued)

Inspect for	Description	✓
Cooling clearance	• Ensure that the top and bottom clearance is adequate to ensure proper airflow for cooling, see *chapter Mounting*.	
Ambient conditions	• Check that requirements for ambient conditions are met.	
Fusing and circuit breaker	• Check for proper fusing or circuit breakers. • Check that all fuses are inserted firmly and are in operational condition, and that all circuit breakers are in the open position.	
Grounding	• Check for sufficient ground connections and ensure that those connections are tight and free of oxidation. • Grounding to conduit, or mounting the back panel to a metal surface, is not a suitable grounding.	
Input and output power wiring	• Check for loose connections. • Check that the motor and mains cables are in separate conduit or separated shielded cables.	
Panel interior	• Inspect that the unit interior is free of dirt, metal chips, moisture, and corrosion. • Check that the unit is mounted on an unpainted metal surface.	
Switches	• Ensure that all switch and disconnect settings are in the proper positions.	
Vibration	• Check that the unit is mounted solidly, or that shock mounts are used, as necessary. • Check for an unusual amount of vibration.	

⚠ CAUTION

INTERNAL FAILURE HAZARD

An internal failure in the drive can result in serious injury when the drive is not properly closed.

- Ensure that all safety covers are in place and securely fastened before applying power.

5 Commissioning

5.1 Safety Instructions

See *chapter Safety* for general safety instructions.

⚠ WARNING

HAZARDOUS VOLTAGE

AC drives contain hazardous voltage when connected to the AC mains or connected on the DC terminals. Failure to perform installation, start-up, and maintenance by qualified personnel can result in death or serious injury.

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

NOTICE

The front covers with warning signs are an integrated part of the drive and considered safety covers. The covers must be in place before applying power and at all times.

5.2 Before Applying Power

1. Close the safety cover properly.
2. Check that all cable glands are firmly tightened.
3. Ensure that input power to the unit is off and locked out. Do not rely on the drive disconnect switches for input power isolation.
4. Verify that there is no voltage on input terminals L1 (91), L2 (92), and L3 (93), phase-to-phase, and phase-to-ground.
5. Verify that there is no voltage on output terminals 96 (U), 97 (V), and 98 (W), phase-to-phase, and phase-to-ground.
6. Confirm continuity of the motor by measuring Ω values on U–V (96–97), V–W (97–98), and W–U (98–96).
7. Check for proper grounding of the drive and the motor.
8. Inspect the drive for loose connections on the terminals.
9. Confirm that the supply voltage matches the voltage of the drive and the motor.

5.3 Applying Power

1. Confirm that the input voltage is balanced within 3%. If not, correct the input voltage imbalance before proceeding. Repeat this procedure after the voltage correction.
2. Ensure that any optional equipment wiring matches the installation application.
3. Ensure that all operator devices are in the OFF position. Panel doors must be closed and covers securely fastened.
4. Apply power to the unit. Do not start the drive now. For units with a disconnect switch, turn it to the ON position to apply power to the drive.

5.4 Local Control Panel Operation

5.4.1 Introduction

The drive supports the numerical local control panel (NLCP), the graphic local control panel (GLCP), and blind cover. This section describes the operations with NLCP and GLCP.

NOTICE

- The drive can also be programmed from the MCT 10 setup software on the PC via the RS485 COM port. This software can be ordered using code number 130B1000 or downloaded from the Danfoss Website: VLT® Motion Control Tool MCT 10 | Danfoss.

5.4.2 Numerical Local Control Panel

The numerical local control panel is divided into 4 functional sections.

- A. Numeric display.
- B. Menu key.
- C. Navigation keys and indicator lights (LEDs).
- D. Operation keys and indicator lights (LEDs).

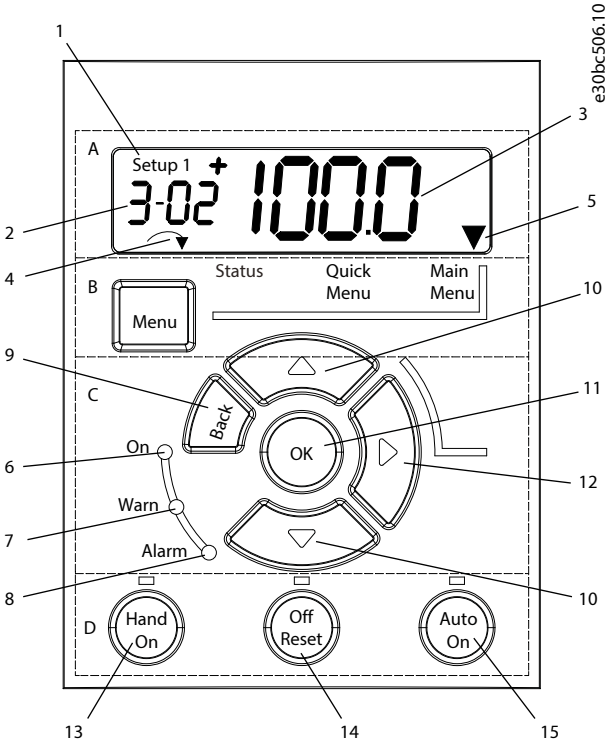


Figure 22: View of the NLCP

A. Numeric display

The LCD display is backlit with 1 numeric line. All data is shown in the LCP.

Table 6: Legend to Section A

Number	Function
1	The setup number shows the active setup and the edit setup. If the same setup acts as both active and edit setup, only that setup number is shown (factory setting). When active and edit setups differ, both numbers are shown in the display (setup 12). The number flashing indicates the edit setup.
2	Parameter number.
3	Parameter value.
4	Motor direction is shown at the bottom left of the display. A small arrow indicates the direction.
5	The triangle indicates whether the LCP is in Status, Quick Menu, or Main Menu.

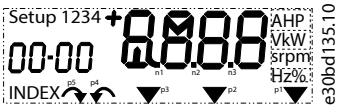


Figure 23: Display Information

B. Menu key

To select between Status, Quick Menu, or Main Menu, press *[Menu]*.

C. Indicator lights (LEDs) and navigation keys

Table 7: Legend to Section C, Indicator Lights (LEDs)

Number	Indicator	Light	Function
6	On	Green	ON turns on when the drive receives power from the mains voltage, a DC bus terminal, or a 24 V external supply.
7	Warn	Yellow	When warning conditions are met, the yellow WARN LED turns on, and text appears in the display area identifying the problem.
8	Alarm	Red	A fault condition causes the red alarm LED to flash and an alarm text is shown.

Table 8: Legend to Section C, Navigation Keys

Number	Key	Function
9	Back	For moving to the previous step or layer in the navigation structure.
10	[▲][▼]	For switching between parameter groups, parameters, and within parameters, or increasing/decreasing parameter values. Arrows can also be used for setting local reference.
11	[OK]	Press to access parameter groups or to enable a selection.
12	[►]	Press to move from left to right within the parameter value to change each digit individually.

D. Operation keys and indicator lights (LEDs)

Table 9: Legend to Section D

Number	Key	Function
13	Hand On	Starts the drive in local control. • An external stop signal by control input or serial communication overrides the local hand on.
14	Off/Reset	Stops the motor but does not remove power to the drive, or resets the drive manually after a fault has been cleared. If in alarm mode, the alarm is reset if the alarm condition is removed.
15	Auto On	Puts the system in remote operational mode. • Responds to an external start command by control terminals or bus communication.

⚠ WARNING

ELECTRICAL HAZARD

Even after pressing the *[Off/Reset]* key, voltage is present at the terminals of the drive. Pressing the *[Off/Reset]* key does not disconnect the drive from mains. Touching live parts can result in death or serious injury.

- Do not touch any live parts.

5.4.3 The Right-key Function on NLCP

Press [▶] to edit any of the 4 digits on the display individually. When pressing [▶] once, the cursor moves to the 1st digit and the digit starts flashing as shown in Figure 24. Press the [▲] [▼] to change the value. Pressing [▶] does not change the value of the digits or move the decimal point.

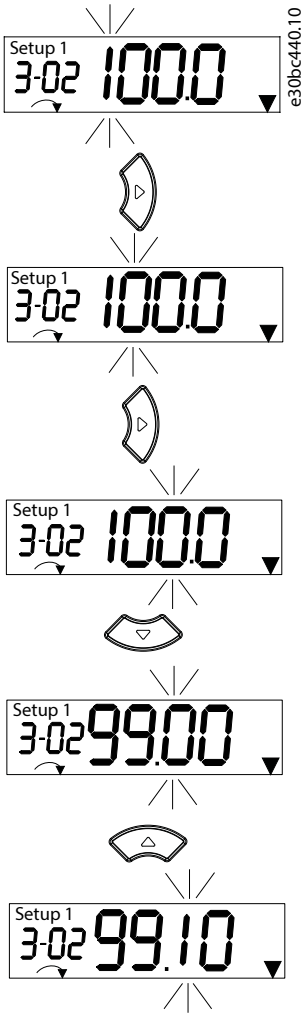


Figure 24: Right-key Function

[▶] can also be used for moving between parameter groups. When in Main Menu, press [▶] to move to the 1st parameter in the next parameter group (for example, move from ***parameter 0-03 Regional Settings[0] International*** to ***parameter 1-00 Configuration Mode[0] Open loop***).

5.4.4 Quick Menu on NLCP

5.4.4.1 Operating Quick Menu

The Quick Menu gives easy access to the most frequently used parameters.

1. To enter *Quick Menu*, press *[Menu]* until the indicator in the display is placed above *Quick Menu*.
2. Press [▲] [▼] to select either *QM1* or *QM2*, then press *[OK]*.
3. Press [▲] [▼] to browse through the parameters in *Quick Menu*.
4. Press *[OK]* to select a parameter.
5. Press [▲] [▼] to change the value of a parameter setting.
6. Press *[OK]* to accept the change.

7. To exit, press either *[Back]* twice (or 3 times if in *QM2* and *QM3*) to enter *Status*, or press *[Menu]* once to enter *Main Menu*.

5.4.4.2 **Quick Menu Structure**

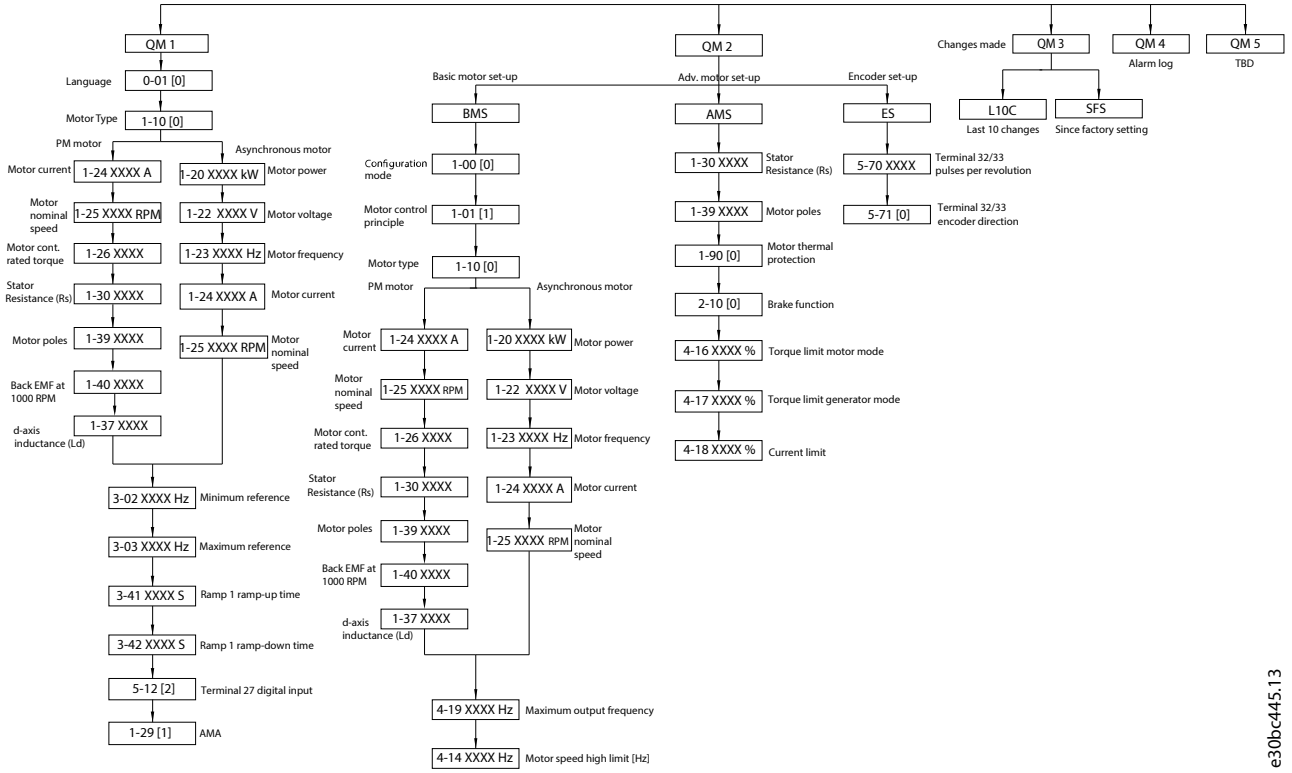


Figure 25: Quick Menu Structure

5.4.5 **Main Menu on NLCP**

5.4.5.1 **Operating Main Menu**

The Main Menu gives access to all parameters.

1. To enter *Main Menu*, press *[Menu]* until the indicator in the display is placed above *Main Menu*.

2. [▲] [▼]: Browse through the parameter groups.

3. Press *[OK]* to select a parameter group.

4. [▲] [▼]: Browse through the parameters in the specific group.

5. Press *[OK]* to select the parameter.

6. [►] and [▲] [▼]: Set/change the parameter value.

7. Press *[OK]* to accept the value.

8. To exit, press either *[Back]* twice (or 3 times for array parameters) to enter *Main Menu*, or press *[Menu]* once to enter *Status*.

5.4.5.2 Continuous Parameters

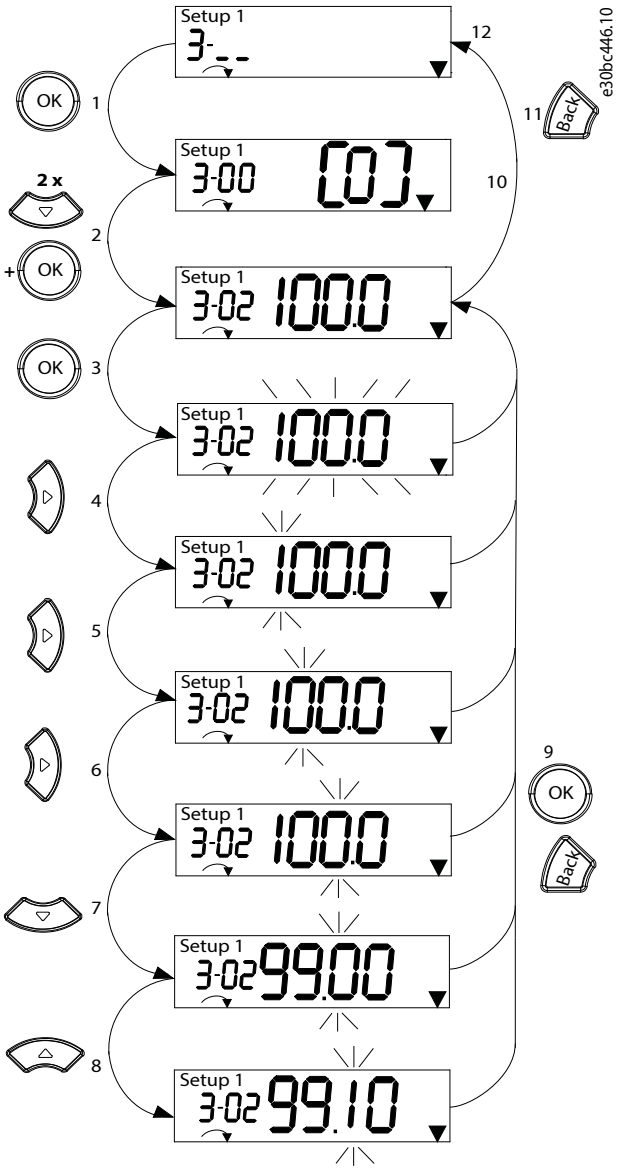


Figure 26: Main Menu Interactions - Continuous Parameters

Table 10: Changing Values in Continuous Parameters

1	*[OK]*: The 1st parameter in the group is shown.
2	Press [▼] repeatedly to move down to the parameter.
3	Press *[OK]* to start editing.
4	[►]: 1st digit flashing (can be edited).
5	[►]: 2nd digit flashing (can be edited).
6	[►]: 3rd digit flashing (can be edited).
7	[▼]: Decreases the parameter value, the decimal point changes automatically.
8	[▲]: Increases the parameter value.
9	*[Back]*: Cancel changes, return to 2. *[OK]*: Accept changes, return to 2.

Table 10: Changing Values in Continuous Parameters (continued)

10	[▲][▼]: Select parameter within the group.
11	*[Back]*: Removes the value and shows the parameter group.
12	[▲][▼]: Select group.

5.4.5.3 Enumerated Parameters

For enumerated parameters, the interaction is similar, but the parameter value is shown in brackets because of the digits limitation (4 large digits) on the NLCP, and the enum can be greater than 99. When the enum value is greater than 99, the LCP can only show the 1st part of the bracket.

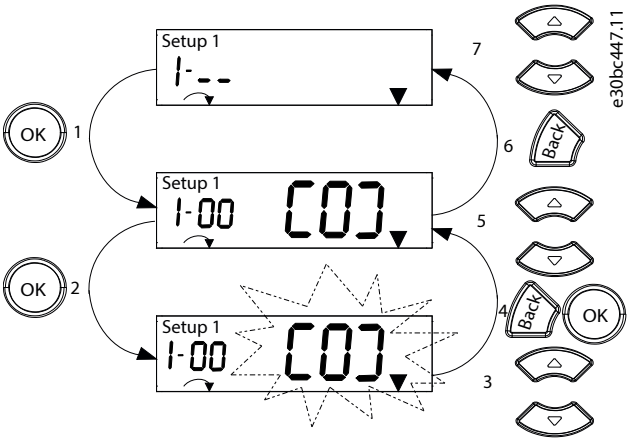


Figure 27: Main Menu Interactions - Enumerated Parameters

Table 11: Changing Values in Enumerated Parameters

1	*[OK]*: The 1st parameter in the group is shown.
2	Press *[OK]* to start editing.
3	[▲][▼]: Change parameter value (flashing).
4	Press [Back] to cancel changes or *[OK]* to accept changes (return to screen 2).
5	[▲][▼]: Select a parameter within the group.
6	*[Back]*: Removes the value and shows the parameter group.
7	[▲][▼]: Select a group.

5.4.5.4 **Array Parameters**

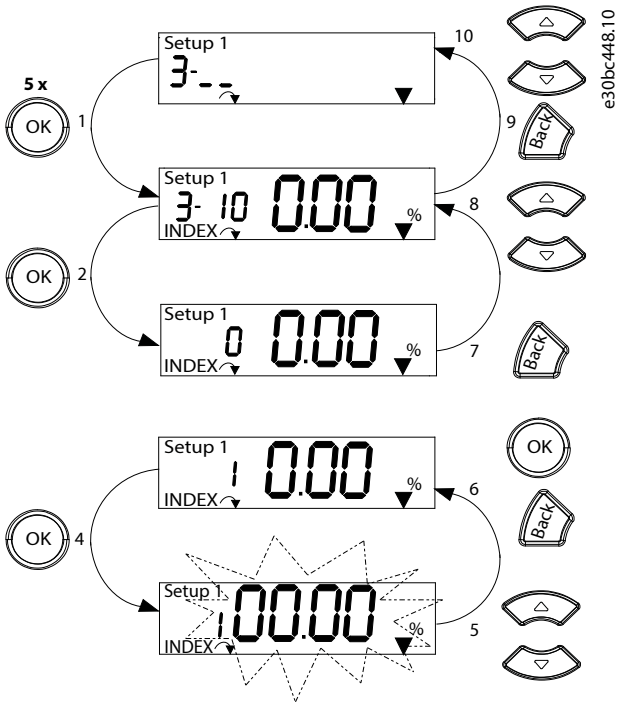


Figure 28: Main Menu Interactions - Array Parameters

Table 12: Changing Values in Array Parameters

1	*[OK]*: Shows parameter numbers and the value in the 1st index.
2	*[OK]*: Index can be selected.
3	[▲][▼]: Select index.
4	*[OK]*: Value can be edited.
5	[▲][▼]: Change parameter value (flashing).
6	[▲][▼]: Change parameter value (flashing). *[OK]*: Accepts changes.
7	*[Back]*: Cancels editing index, selects a new parameter.
8	[▲][▼]: Select parameter within the group.
9	*[Back]*: Removes parameter index value and shows the parameter group.
10	[▲][▼]: Select group.

5.4.6 **Graphical Local Control Panel**

The GLCP is divided into 4 functional groups.

- A. Display area.
- B. Display menu keys.
- C. Navigation keys and indicator lights (LEDs).
- D. Operation keys and reset.

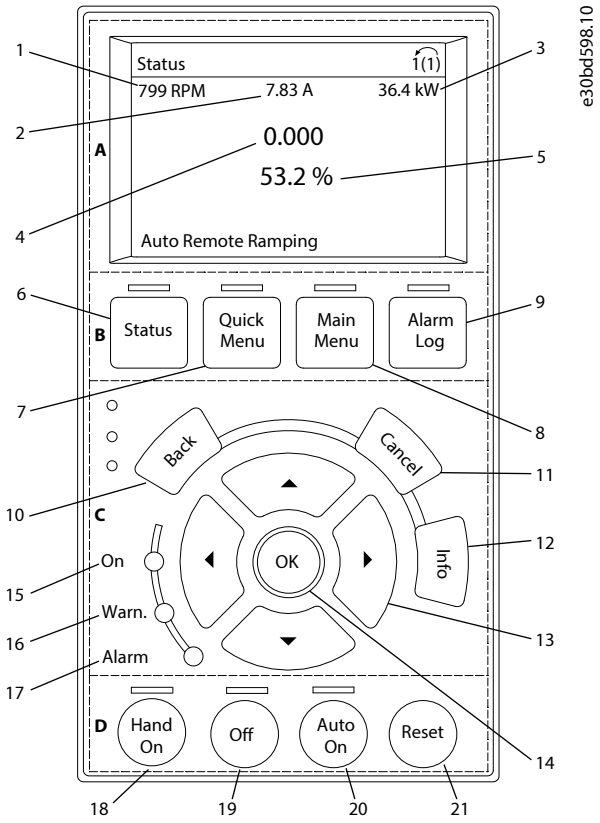


Figure 29: Graphic Local Control Panel (GLCP)

A. Display area

The display area is activated when the drive receives power from the mains voltage, a DC bus terminal or a 24 V DC external supply.

The information shown on the LCP can be customized for user applications. Select options in the *Quick Menu Q3-13 Display Settings*.

Table 13: Legend to Section A

Display	Parameter number	Default setting
1	0-20	***[1602] Reference [%]***
2	0-21	***[1614] Motor Current***
3	0-22	***[1610] Power [kW]***
4	0-23	***[1613] Frequency***
5	0-24	***[1502] kWh Counter***

B. Display menu keys

Menu keys are used for menu access for parameter setup, toggling through status display modes during normal operation, and viewing fault log data.

Table 14: Legend to Section B

Number	Key	Function
6	Status	Shows operational information.
7	Quick Menu	Allows access to programming parameters for initial setup instructions and many detailed application instructions.

Table 14: Legend to Section B (continued)

Number	Key	Function
8	Main Menu	Allows access to all programming parameters.
9	Alarm Log	Shows a list of current warnings, the last 10 alarms, and the maintenance log.

C. Navigation keys and indicator lights (LEDs)

Navigation keys are used for programming functions and moving the display cursor. The navigation keys also provide speed control in local operation. There are also 3 drive status indicator lights in this area.

Table 15: Legend to Section C, Navigation Keys

Number	Key	Function
10	Back	Reverts to the previous step or list in the menu structure.
11	Cancel	Cancels the last change or command as long as the display mode has not changed.
12	Info	Press for a definition of the function being shown.
13	Navigation keys	To move between items in the menu, use the 4 navigation keys.
14	OK	Press to access parameter groups or to enable a selection.

Table 16: Legend to Section C, Indicator Lights (LEDs)

Number	Indicator	Light	Function
15	On	Green	ON turns on when the drive receives power from the mains voltage, a DC bus terminal or a 24 V DC external supply.
16	Warn	Yellow	When warning conditions are met, the yellow WARN LED turns on, and text appears in the display area identifying the problem.
17	Alarm	Red	A fault condition causes the red alarm LED to flash, and an alarm text is shown.

D. Operation keys and reset

Operation keys are at the bottom of the LCP.

Table 17: Legend to Section D

Number	Key	Function
18	Hand On	Starts the drive in hand-on mode. • An external stop signal by control input or serial communication overrides the local hand on.
19	Off	Stops the motor but does not remove power to the drive.
20	Auto On	Puts the system in remote operational mode. • Responds to an external start command by control terminals or serial communication.
21	Reset	Resets the drive manually after a fault has been cleared.

NOTICE

To adjust the display contrast, press *[Status]* and the [▲]/[▼] keys.

5.4.7 Parameter Settings

Establishing the correct programming for applications often requires setting functions in several related parameters.

Programming data is stored internally in the drive.

- For backup, upload data into the LCP memory.
- To download data to another drive, connect the LCP to that unit and download the stored settings.
- Restoring factory default settings does not change data stored in the LCP memory.

5.4.8 Changing Parameter Settings with GLCP

5.4.8.1 Introduction

Access and change parameter settings from the *Quick Menu* or from the *Main Menu*. The *Quick Menu* only gives access to a limited number of parameters.

5.4.8.2 Changing Parameter Settings

1. Press *[Quick Menu]* or *[Main Menu]* on the GLCP.
2. Press [▲] [▼] to browse through the parameter groups, press *[OK]* to select a parameter group.
3. Press [▲] [▼] to browse through the parameters, press *[OK]* to select a parameter.
4. Press [▲] [▼] to change the value of a parameter setting.
5. Press [◄] [►] to shift digit when a decimal parameter is in the editing state.
6. Press *[OK]* to accept the change.
7. Press either *[Back]* twice to enter *Status*, or press *[Main Menu]* once to enter the *Main Menu*.

5.4.8.3 View Changes

Quick Menu Q5 - Changes Made lists all parameters changed from default settings.

- The list only shows parameters which have been changed in the current edit setup.
- Parameters which have been reset to default values are not listed.
- The message *Empty* indicates that no parameters have been changed.

5.4.9 Backing-up/Downloading Parameters

1. Press *[Off]* on GLCP or *[Off/Reset]* on NLCP to stop the motor before uploading or downloading data.
2. Press *[Main Menu]* ***parameter 0-50 LCP Copy*** and press *[OK]*.
3. Select ***[1] All to LCP*** to upload data to the LCP, or select ***[2] All from LCP*** to download data from the LCP.
4. Press *[OK]*. A progress bar shows the uploading or downloading progress.
5. Press *[Hand On]* or *[Auto On]* to return to normal operation.

5.4.10 Restoring Default Settings with LCP

5.4.10.1 Introduction

NOTICE

BACK UP DATA TO LCP

Risk of losing programming, motor data, localization, and monitoring records by restoration of default settings.

- To provide a backup, upload data to the LCP before initialization.

Restoring the default parameter settings is done by initialization of the drive. Initialization is carried out via ***parameter 14-22 Operation Mode*** (recommended) or manually.

Recommended initialization via ***parameter 14-22 Operation Mode*** does not reset the following settings:

- Operating hours.
- Serial communication selections.
- Fault log.
- Alarm log.
- Other monitoring functions.
- ***Parameter 0-03 Regional Settings***.
- ***Parameter 1-06 Clockwise Direction***.

Manual initialization erases all motor, programming, localization, monitoring data, and restores factory default settings. Manual initialization does not reset the following information:

- ***Parameter 0-03 Regional Setting***.
- ***Parameter 1-06 Clockwise Direction***.
- ***Parameter 15-00 Operating hours***.
- ***Parameter 15-03 Power Up's***.
- ***Parameter 15-04 Over Temp's***.
- ***Parameter 15-05 Over Volt's***.

5.4.10.2 Recommended Initialization

1. Select ***parameter 14-22 Operation Mode*** and press *[OK]*.
2. Select ***[2] Initialisation*** and press *[OK]*.
3. Remove power to the unit and wait until the display turns off.
4. Apply power to the unit. Default parameter settings are restored during start-up. This may take slightly longer than normal.
5. ***Alarm 80, Drive initialised*** to default value is shown.
6. Press *[Reset]* to return to operating mode.

5.4.10.3 Manual Initialization

1. Remove power to the unit and wait until the display turns off.
2. Press and hold *[Status]*, *[Main Menu]*, and *[OK]* at the same time on the GLCP, or press *[Menu]* and *[OK]* at the same time on the NLCP while applying power to the unit (approximately 5 s or until a click is heard and the fan starts).
3. Factory default parameter settings are restored during start-up. This may take slightly longer than normal.

5.5 Basic Programming

5.5.1 Asynchronous Motor Setup

5.5.1.1 Setting Up Asynchronous Motor

1. Enter the following motor data in the listed order. Find the information on the motor nameplate.
   a. ***Parameter 1-20 Motor Power***.
   b. ***Parameter 1-22 Motor Voltage***.
   c. ***Parameter 1-23 Motor Frequency***.
   d. ***Parameter 1-24 Motor Current***.

e. ***Parameter 1-25 Motor Nominal Speed***.

2. For optimum performance in VVC+ mode, extra motor data is required to set up the following parameters. The data is found in the motor datasheet (this data is typically not available on the motor nameplate).
   a. ***Parameter 1-30 Stator Resistance (Rs)***.
   b. ***Parameter 1-31 Rotor Resistance (Rr)***.
   c. ***Parameter 1-33 Stator Leakage Reactance (X1)***.
   d. ***Parameter 1-35 Main Reactance (Xh)***.
3. Run a complete AMA using ***parameter 1-29 Automatic Motor Adaption (AMA) [1] Enable Complete AMA*** or enter the parameters manually.

5.5.1.2 Application-specific Adjustment When Running VVC+

VVC+ is the most robust control mode. In most situations, it provides optimum performance without further adjustments. Run a complete AMA for best performance.

5.5.2 PM Motor Set-up in VVC+

5.5.2.1 Initial Programming Steps

1. Set ***parameter 1-10 Motor Construction*** to the following options to activate PM motor operation:
   a. ***[1] PM, non salient SPM***
   b. ***[3] PM, salient IPM***
2. Select ***[0] Open Loop*** in ***parameter 1-00 Configuration Mode.***

5.5.2.2 Programming Motor Data

Prerequisite:

NOTICE

Encoder feedback is not supported for PM motors.

When the initial programming steps are completed, the PM motor-related parameters in ***parameter groups 1-2* Motor Data, 1-3* Adv. Motor Data I***, and ***1-4* Adv. Motor Data II*** are active.

The information is on the motor nameplate and in the motor datasheet.

Program the following parameters in the listed order.

1. ***Parameter 1-24 Motor Current***.
2. ***Parameter 1-26 Motor Cont. Rated Torque***.
3. ***Parameter 1-25 Motor Nominal Speed***.
4. ***Parameter 1-39 Motor Poles***.
5. ***Parameter 1-30 Stator Resistance (Rs)***.

   Enter line-to-common stator winding resistance (Rs). If only line-to-line data is available, divide the line-to-line value by 2 to achieve the line-to-common (starpoint) value.

   It is also possible to measure the value with an ohmmeter, which also takes the resistance of the cable into account. Divide the measured value by 2 and enter the result.

6. ***Parameter 1-37 d-axis Inductance (Ld)***.

   Enter line-to-common direct axis inductance of the PM motor. If only line-to-line data is available, divide the line-to-line value by 2 to achieve the line-to-common (starpoint) value.

It is also possible to measure the value with an inductance meter, which also takes the inductance of the cable into account. Divide the measured value by 2 and enter the result.

7. ***Parameter 1-40 Back EMF at 1000 RPM***.

   Enter line-to-line back EMF of the PM motor at 1000 RPM mechanical speed (RMS value). Back EMF is the voltage generated by a PM motor when no drive is connected and the shaft is turned externally. Back EMF is normally specified for nominal motor speed or for 1000 RPM measured between 2 lines. If the value is not available for a motor speed of 1000 RPM, calculate the correct value as follows:

   For example, if back EMF at 1800 RPM is 320 V, the back EMF at 1000 RPM is:

   Back EMF=(Voltage/ RPM)x1000=(320/1800)x1000=178

   Program this value for ***parameter 1-40 Back EMF*** at 1000 RPM.

5.5.2.3 Testing Motor Operation

1. Start the motor at low speed (100–200 RPM). If the motor does not run, check installation, general programming, and motor data.

5.5.2.4 Parking

This function is the recommended option for applications where the motor is rotating at low speed, for example, windmilling in fan applications. ***Parameter 2-06 Parking Current*** and ***parameter 2-07 Parking Time*** are adjustable. Increase the factory setting of these parameters for applications with high inertia.

Start the motor at nominal speed. If the application does not run well, check the VVC+ PM settings. Recommendations in different applications are shown in Table 18.

Table 18: Recommendations in Different Applications

Application	Settings
Low inertia applications $I_{Load}/I_{Motor}<5^{(1)}$	• Increase the value for ***parameter 1-17 Voltage filter time const.*** by factor 5 to 10. • Reduce the value for ***parameter 1-14 Damping Gain***. • Reduce the value (<100%) for ***parameter 1-66 Min. Current at Low Speed***.
Medium inertia applications $50>I_{Load}/I_{Motor}>5$	Keep calculated values.
High inertia applications $I_{Load}/I_{Motor} > 50$	Increase the values for ***parameter 1-14 Damping Gain***, ***parameter 1-15 Low Speed Filter Time Const.***, and ***parameter 1-16 High Speed Filter Time Const***.
High load at low speed<30% (rated speed)	Increase the value for ***parameter 1-17 Voltage filter time const.*** Increase the value for ***parameter 1-66 Min. Current at Low Speed*** (>100% for longer time can overheat the motor).

1) I_{Load}=The inertia of load. I_{Motor}=The inertia of motor.

If the motor starts oscillating at a certain speed, increase ***parameter 1-14 Damping Gain***. Increase the value in small steps.

Adjust the starting torque in ***parameter 1-66 Min. Current at Low Speed***. 100% provides nominal torque as starting torque.

5.5.3 Automatic Motor Adaptation (AMA)

5.5.3.1 Introduction

It is highly recommended to run AMA because it measures the electrical characteristics of the motor to optimize compatibility between the drive and the motor in VVC+ mode.

- The drive builds a mathematical model of the motor for regulating output motor current, thus enhancing motor performance.
- Some motors are unable to run the complete version of the test. In that case, select ***[2] Enable reduced AMA*** in ***parameter 1-29 Automatic Motor Adaption (AMA)***.
- If warnings or alarms occur, see *chapter List of Warnings and Alarms*.
- Run this procedure on a cold motor for best results.

NOTICE

The AMA function does not cause the motor to run, and it does not harm the motor.

5.5.3.2 Running AMA via LCP

1. By default parameter setting, connect terminals 13 and 27 before running AMA.
2. Enter the Main Menu.
3. Go to ***parameter group 1-** Load and Motor***.
4. Press *[OK]*.
5. Set motor parameters using nameplate data for ***parameter group 1-2* Motor Data***.
6. Set motor cable length in ***parameter 1-42 Motor Cable Length***.
7. Go to ***parameter 1-29 Automatic Motor Adaptation (AMA)***.
8. Press *[OK]*.
9. Select ***[1] Enable complete AMA***.
10. Press *[OK]*.
11. The test runs automatically and indicates when it is complete.
12. Depending on the power size, the AMA takes 3–10 minutes to complete.

5.6 Checking Motor Rotation

Prerequisite: Check the motor rotation before running the drive.

1. Press *[Hand On]*.
2. Press [▲] for positive speed reference.
3. Check that the speed shown is positive.
4. Verify that the wiring between the drive and the motor is correct.
5. Verify that the motor running direction matches the setting in ***parameter 1-06 Clockwise Direction***.
   a. When ***parameter 1-06 Clockwise Direction*** is set to ***[0] Normal*** (default clockwise), verify that the motor turns clockwise and the LCP direction arrow is clockwise.
   b. When ***parameter 1-06 Clockwise Direction*** is set to ***[1] Inverse*** (counterclockwise), verify that the motor turns counterclockwise and the LCP direction arrow is counterclockwise.

5.7 Checking Encoder Rotation

Prerequisite: Only check encoder rotation if encoder feedback is used.

1. Select ***[0] Open Loop*** in ***parameter 1-00 Configuration Mode***.

2. Select *[1] 24 V encoder* in ***parameter 7-00 Speed PID Feedback Source***.
3. Press *[Hand On]*.
4. Press [▲] for positive speed reference (***parameter 1-06 Clockwise Direction*** at ***[0] Normal***).
5. Check in ***parameter 16-57 Feedback [RPM]*** that the feedback is positive.

NOTICE

NEGATIVE FEEDBACK

If the feedback is negative, the encoder connection is wrong.

- Use ***parameter 5-71 Term 32/33 Encoder Direction*** to inverse the direction, or reverse the encoder cables.

5.8 Testing Local-control

1. Press *[Hand On]* to provide a local start command to the drive.
2. Accelerate the drive by pressing [▲] to full speed. Moving the cursor left of the decimal point provides quicker input changes.
3. Note any acceleration problems.
4. Press *[Off]*. Note any deceleration problems.

5.9 System Start-up

The procedure in this section requires user-wiring and application programming to be completed. The following procedure is recommended after application setup is completed.

1. Press *[Auto On]*.
2. Apply an external run command.
3. Adjust the speed reference throughout the speed range.
4. Remove the external run command.
5. Check the sound and vibration levels of the motor to ensure that the system is working as intended.

   If warnings or alarms occur, see *chapter Warning and Alarm Types* for resetting the drive after a trip.

5.10 Memory Module

5.10.1 Memory Module Overview

The VLT® Memory Module MCM is a small memory device containing data such as:

- Firmware for the drive (not including the firmware for communication on the control card).
- PUD file.
- SIVP file.
- Parameter file.

The VLT® Memory Module MCM is an accessory. The drive comes without the memory module installed from the factory. A new memory module can be ordered using the following ordering numbers.

Table 19: Code Number

Description	Code number
VLT® Memory Module MCM 102	132B0359
VLT® Memory Module MCM 103	132B0466

Each memory module has a unique serial number which cannot be modified.

NOTICE

The VLT® Memory Module MCM can be used on the drive together with firmware 1.5 and above.

NOTICE

The VLT® Memory Module MCM does not support copying functional safety-related firmware and parameters.

Select correct options for ***parameter 31-40 Memory Module Function*** before configuring with the memory module.

Table 20: Description of *Parameter 31-40 Memory Module Function*

Parameter 31-40 Memory Module Function	Description
[0] Disabled	Downloading or uploading data function is disabled.
****[1] Only Allow Download***	Only allow downloading data from the memory module to the drive. This is the default setting of ***parameter 31-40 Memory Module Function***.
[2] Only Allow Upload	Only allow uploading data from the drive to the memory module.
[3] Allow Both Download and Upload	If this option is selected, the drive downloads data from memory module first, and then uploads data from the drive to the memory module.

NOTICE

AVOID UNINTENTIONAL OVERWRITING

The default setting of ***parameter 31-40 Memory Module Function*** is ***[1] Only Allow Download***. If there is any update, such as firmware updated by MCT 10 using OSS file, parameter updated by LCP or bus, parameters reset via ***parameter 14-22 Operation Mode***, or 3-finger-reset of the drive, the updated data will be lost after a new power cycle, because the drive downloads data from the memory module again.

- After the data has been downloaded from the memory module to the drive, select ***[0] Disabled*** or ***[2] Only Allow Upload*** in ***parameter 31-40 Memory Module Function*** before the new power cycle.

5.10.2 Synchronizing Drive Data to a New Memory Module (Create Drive Backup)

Prerequisite:

NOTICE

To avoid unintentional overwriting of the data in the memory module, consider to adjust the settings for ***parameter 31-40 Memory Module Function*** before next power cycle according to different operating purpose.

1. Plug a new empty memory module in the drive.
2. Select ***[2] Only Allow Upload*** or ***[3] Allow Both Download and Upload*** in ***parameter 31-40 Memory Module Function***.
3. Power up the drive.
4. Wait until the synchronization is complete, refer to 5.10.8 Transfer Performance and Indications to check the transfer indications on the drive.

5.10.3 Copying Data to Another Drive

Prerequisite:

NOTICE

To avoid unintentional overwriting of the data in the memory module, consider to adjust the settings for ***parameter 31-40 Memory Module Function*** before next power cycle according to different operating purpose.

1. Make sure that the required data is uploaded to the memory module, refer to 5.10.2 Synchronizing Drive Data to a New Memory Module (Create Drive Backup).
2. Unplug the memory module and plug into a new drive.
3. Make sure that ***[1] Only Allow Download*** or ***[3] Allow Both Download and Upload*** is selected in ***parameter 31-40 Memory Module Function*** on the new drive.
4. Power up the new drive.
5. Wait until the download is complete and the data is transferred, refer to 5.10.8 Transfer Performance and Indications to check the transfer indications on the drive.

5.10.4 Copying Data to Multiple Drives

If multiple drives are of same voltage/power, the information of 1 drive can be transferred to the others via 1 memory module.

NOTICE

The data can also be downloaded to the memory module from a PC via the VLT® Memory Module Programmer.

NOTICE

In any of the drives, if an empty memory module is plugged in for backing up data, adjust the settings for ***parameter 31-40 Memory Module Function*** to ***[2] Only Allow Upload*** or ***[3] Allow Both Download and Upload*** before next power cycle.

1. Follow the steps in 5.10.2 Synchronizing Drive Data to a New Memory Module (Create Drive Backup) to upload the data from 1 drive to a memory module.
2. To avoid unintentional uploading of data to the master memory module, make sure that ***[1] Only Allow Download*** is selected in ***parameter 31-40 Memory Module Function*** on the other drives.
3. Unplug the memory module and plug it into a new drive.
4. Power up the new drive.
5. Wait until the download is complete and the data is transferred, refer to 5.10.8 Transfer Performance and Indications to check the transfer indications on the drive.
6. Repeat steps 3–5 for the next drive.

5.10.5 Transferring the Firmware Information

If 2 drives are of same voltage and power size, the firmware information can be transferred from 1 drive to another.

NOTICE

The firmware information can also be downloaded to the memory module from a PC via the VLT® Memory Module Programmer.

1. Follow the steps in 5.10.2 Synchronizing Drive Data to a New Memory Module (Create Drive Backup) to upload the firmware information from 1 drive to a memory module.
2. Follow the steps in 5.10.3 Copying Data to Another Drive to transfer the firmware information to another drive of same voltage and power size.

5.10.6 Backing Up Parameter Changes to Memory Module

1. Plug a new empty memory module in the drive.

2. Select ***[2] Only Allow Upload*** or ***[3] Allow Both Download and Upload*** in ***parameter 31-40 Memory Module Function***.
3. Power up the drive.
4. Wait until the synchronization is complete. Refer to 5.10.8 Transfer Performance and Indications to check the transfer indications on the drive.
5. Any change to parameter settings is automatically synchronized to the memory module.

5.10.7 Erasing Data

The memory module can be erased via setting ***parameter 31-43 Erase_MM*** without a new power cycle.

1. Make sure that the memory module is mounted in the drive.
2. Select ***[1] Erase MM*** in ***parameter 31-43 Erase_MM***.
3. All files in the memory module are erased.
4. ***Parameter 31-43 Erase_MM***setting returns to ***[0] No function***.

5.10.8 Transfer Performance and Indications

The time for transferring different data between the drive and the memory module is different, refer to the following table.

Table 21: Transfer Performance

Data file	Time
Firmware file	• It takes around 2 minutes for uploading data from the drive to the memory module. • It takes around 6 minutes for downloading data from the memory module to the drive.
SIVP file	Around 10 s.
Parameter file [1]	Around 5 s.

1) If a parameter is changed in the drive, to upload the updated parameter, wait at least 5 s before power-down.

Table 22: Transfer Indications

Data file	Indications		
	GLCP	NLCP	On LED[1]
Firmware file	"Synchronizing with Memory Module." is shown during transferring.	No text indication.	The LED flashes slowly during the transfer.
SIVP file			
Parameter file	No text indication.		The LED does not flash.

1) The On LED is lit on the LCP. Refer to 5.4.2 Numerical Local Control Panel and 5.4.6 Graphical Local Control Panel for the On LED's position and functions.

6 Safety Functions

6.1 Introduction

The drive is integrated with Ethernet safety functions according to application needs.

According to EN IEC 61800-5-2, the following 2 safety functions are available within the drive:

- Safe Torque Off (STO): this function prevents force-producing power from being provided to the motor. (Stop category 0 according to EN IEC 60204-1.)
- Safe Stop 1 time controlled (SS1-t): motor decelerates within a specified deceleration time. Safe Torque Off is activated at the end of a deceleration time. (Stop category 1 according to EN IEC 60204-1).

Both of the safety functions fulfill SIL3/SIL CL 3 (according to IEC 61508/61800-5-2/62061) and Category 3/PL e (according to ISO 13849-1) and can be triggered via:

- Digital I/O (terminals 37 and 38, referred at SGND terminal 39).
- Safety fieldbus.

The FSoE communication over EtherCAT is supported by the drive. Communication over FSoE is implemented according to the ETG standards.

To view or download the certificate, search *TÜV Functional safety FC 280* on www.danfoss.com.

⚠ WARNING

DESIGN OF SAFETY SYSTEMS

The designing of safety-related systems requires special knowledge and skills.

- Only qualified persons are allowed to install and set up an advanced safety option board.

⚠ WARNING

USE OF SAFETY FUNCTIONS

The use of safety functions provided by the drive does not in itself ensure safety.

- To make sure that the commissioned system is safe, make an overall risk assessment.
- Safety devices must be correctly incorporated into the entire system. The entire system must be designed in compliance with all relevant standards within the field of industry. (Standards such as EN 12100 Part 1, Part 2, and ISO 14121-1 provide methods for designing safe machinery and making a risk assessment.)

NOTICE

The information in this manual provides guidance on the use of the safety functions that the AC drive provides. This information is in compliance with accepted practice and regulations at the time of writing. However, the product/system designer is responsible for making sure that the system is safe and in compliance with relevant regulations.

NOTICE

The drive must be used in an environment where no conductive dust or contaminants are present.

- To ensure proper protection against contamination, use the drive in at least an IP54 enclosure.

6.2 System Overview

6.2.1 Safety Function Architecture

The safety functions (STO and SS1-t) in the drive can be triggered by control terminals 37 and 38 or safety fieldbus. When the safety function is triggered, the power supply on the high side and low side of the IGBT gate driving circuits is cut off in a defined time limit.

Figure 30 shows the safety architecture which consists of control unit and power unit.

The control unit of the drive consists of:

- Control card.
- Built-in option A (supports PROFINET/POWERLINK/Ethernet IP/EtherCAT fieldbus).
- Built-in safety option B (provides safety sub-functions).

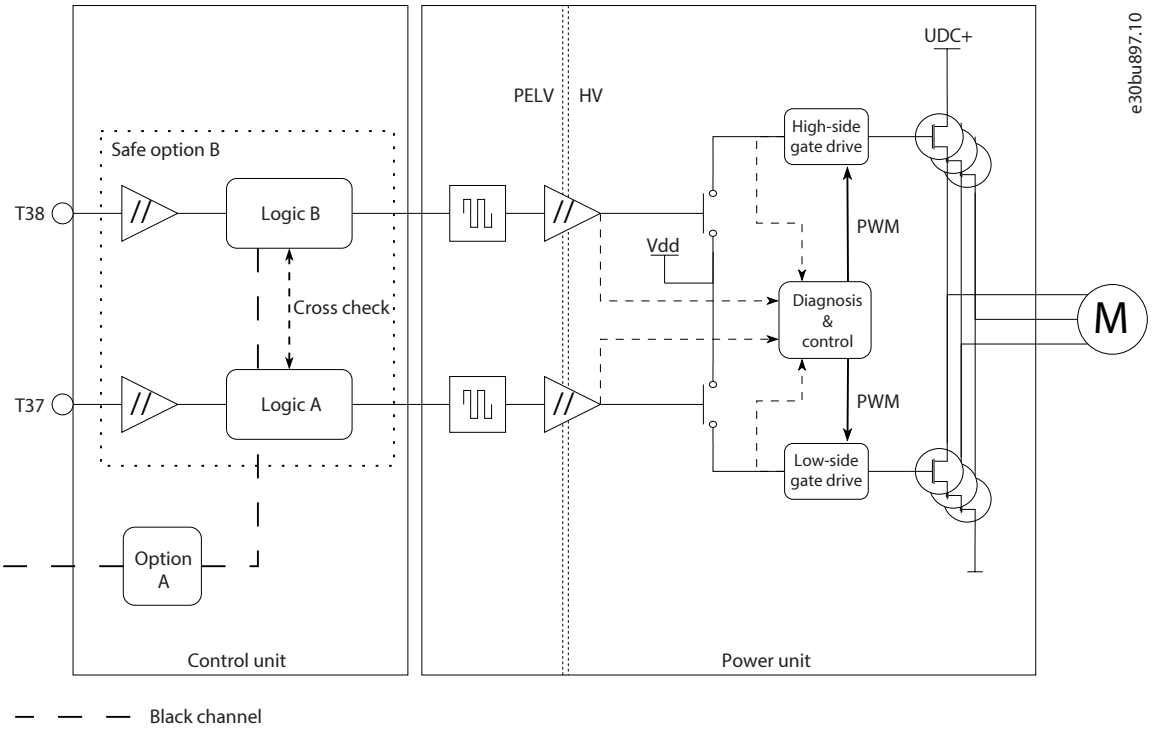


Figure 30: Safety Function Architecture

The safety loop within the drive is a dual-channel based structure. There is 1 dual-channel safety digital input:

- Terminal 37, safe input channel a.
- Terminal 38, safe input channel b.
- Terminal 39, dedicated GND for terminals 37 and 38.

The safety digital input can be configured as STO, SS1-t, or disabled (default) via setting parameters. If disabled, the drive does not react with any signal on terminals 37 or 38. Terminals 37, 38, and 39 are isolated with other inputs of the drive.

There is an RJ45 port for safety fieldbus communication. The safety communication protocol can be enabled or disabled (default) via setting parameters. If disabled, the drive ignores any safety function via fieldbus.

NOTICE

Safety digital input and safety fieldbus protocol are all DISABLED as factory setting.

- Configure the needed safety functions correctly with the MCT 10 tool before use, see *chapter Safety-related Parameters* for details.

NOTICE

Safety components are already mounted within the drive. Disassembling any part of the drive is not allowed.

If both safety digital input and safety fieldbus are enabled, STO or SS1-t can be triggered via both sources. STO has the highest priority. SS1-t can be interrupted by STO from any trigger source.

Table 23: Safety Functions Combination in Drive

FC 280		*Parameter 42-62 Enable FSoE*	
		Disabled*(1)	**Enabled**
Parameter 42-20 Safety Function T37/T38	**Disabled***(1)	No safety function	STO(2) and SS1-t (2)
	STO	STO(3)	STO(4) and SS1-t (2)
	SS1-t	SS1-t (3)	SS1-t (4) and STO(2)

*1) * means default value.*

2) Via fieldbus only.

3) Via digital input only.

4) Via both trigger sources.

6.2.2 Safe State

The safe state of the drive is STO achieved or power off.

6.2.3 Internal and External Fault

Internal fault

The diagnosis mechanism of the drive detects the internal fault inside the drive.

Normally, an internal fault is caused by:

- EMI.
- Random failure of components.
- Harsh environment condition.
- Other systematic errors.

When an internal fault is detected, the drive reports an alarm and switches to the safe state. To reset the drive, clear the alarm or recycle the power supply, see 6.8 Reset Function for details.

External fault

External fault is the fault caused by invalid external input which includes:

- Discrepancy on safety digital input.
- Safety fieldbus communication errors.
- Fieldbus master, for example, a PLC, forces the drive into safe state.

6.2.4 Fault Reaction

When an internal fault is detected, the fault reaction is STO. When an external fault happens, the fault reaction can be defined via setting ***parameter 42-30 External Failure Reaction*** to STO or SS1-t.

⚠ CAUTION

Assess the risk before using SS1-t as external failure reaction.

6.2.5 Recovery from Safe State

6.2.5.1 Recovery from Safe Function Triggered Normally

Restart behavior of safe digital input

When safe function is achieved by the safe digital input (terminals 37 and 38), the reset action to restart the motor depends on the configuration of restart behavior. ***Parameter 42-24 Restart Behavior*** determines whether the drive restarts automatically or waits for a manual reset after the safety function is achieved.

- Automatic reset: when the safety function is achieved, the safety option can run again when the condition that triggered the safety function ceases. This behavior is only valid for the digital input where this reset behavior is defined. For example, if there is an external fault, a manual reset from the reset source is required regardless of the setting in ***parameter 42-24 Restart Behavior***.
- Manual reset: when the safety function is achieved, the drive requires a reset from a reset source before it can run again. The reset source could be the following (refer to 6.12 Safety-related Parameters for more information on ***parameter 42-31 Reset Source*** and its options):
  - The [Reset] key on the LCP.
  - A specified non-safe digital input.
  - The reset command via fieldbus other than FSoE (for example RS485, EtherCAT).

Restart behavior of safe fieldbus

NOTICE

Make sure that the surrounding environment is safe before recovering from safe state.

The drive resets automatically when inactive command received from the host device via safety fieldbus protocol.

6.2.5.2 Recovery from Safety Events

Table 24: Recovery from Safety Events

Safety event index	Safety event	User action required when safe fieldbus is disabled	User action required when safe fieldbus is enabled
1	Customization requested	–	–
2	Customization aborted	Manual reset	–
3	Customization completed	Manual reset	–
4	General reset	Manual reset	–
5	Internal failures	Power cycle	Power cycle
6	External failures	Manual reset	Manual reset
7	SFBC initialized (power up without failure)	Manual reset	–
8	Safe function pending (refer to *Restart behavior of safe digital input* section in 6.2.5.1 Recovery from Safe Function Triggered Normally)	Manual reset	Manual reset
10	In self-test	–	–

6.3 Safety Functions

6.3.1 Safe Torque Off (STO)

6.3.1.1 Overview of Safe Torque Off (STO)

Safe Torque Off (STO) prevents the drive from generating the energy that is required to rotate the motor, thus ensures the safety of the system in emergency situations.

The STO function in the drive is controlled via redundant safety digital input (terminals 37 and 38) or/and safety fieldbus. When STO is activated, the power supply on the high side and low side of the IGBT gate driving circuits is cut off. Figure 31 shows the STO architecture.

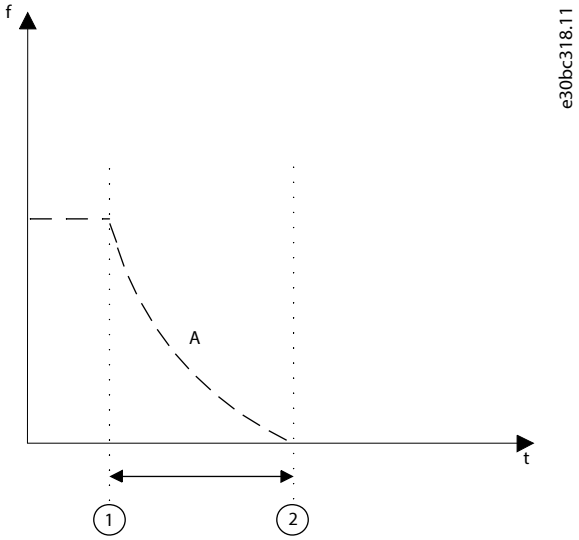


Figure 31: Safe Torque Off

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

6.3.1.2 STO Triggered by DI

To enable safe DI as STO input, set ***parameter 42-20 Safety Function T37/T38*** as ***[0] STO***. Table 25 shows STO statuses based on whether terminals 37 and 38 are energized.

Table 25: STO via DI

Terminal 37	Terminal 38	Torque	Warning/alarm
High	High	Yes	None
Low	Low	No	W68
Low	High	No	W252
High	Low	No	W252

1) Voltage range is 24 V±15%, with terminal 39 as reference.

2) Torque is present only when the drive is running.

3) Open circuit or the voltage is within the range of 0 V ±1.5 V, with terminal 39 as reference.

6.3.1.3 STO Triggered by Fieldbus

To enable safety fieldbus protocol, set ***parameter 42-62 Enable FSoE*** to ***[1] Enabled***. STO control command is sent from the upper device continuously and periodically. The command includes:

- STO inactive
- STO active

Table 26: STO via Fieldbus

STO command	Torque	Warning/alarm
Inactive	Yes[1]	None
Active	No	W68

1) Torque is present only when the drive is running.

6.3.1.4 Exit STO

The STO trigger sources, safe DI and fieldbus, are independent if they are both enabled. To exit the STO state, all of the trigger sources should be turned to inactive:

- *STO inactive* command received on fieldbus.
- Terminals 37 and 38 are *High*.

6.3.1.5 Restart Behavior

Even though the drive has exited STO state, the restart behavior of the motor has 2 modes depending on the setting of ***parameter 42-24 Restart Behavior***:

- If ***parameter 42-24 Restart Behavior*** is set to ***[1] Automatic***, the motor can run again just after an ***On*** command is received.
- If ***parameter 42-24 Restart Behavior*** is set to ***[0] Manual***, the drive needs a ***Reset*** action for acknowledgment, and then the motor can run again after an ***On*** command is received.

⚠ WARNING

For manual restart mode, although the motor cannot run before a reset action after STO state has exited, the motor is no longer safe! Only safe DI and/or safe fieldbus commands are trustable for the remaining safe state.

6.3.2 Safe Stop 1 Time Controlled (SS1-t)

6.3.2.1 Overview of Safe Stop 1 Time Controlled (SS1-t)

For the SS1-t function, the drive decelerates to 0 speed within a defined deceleration time. Meanwhile, the safety components of the drive count down the deceleration time and activate STO after the timer expires.

Features of the safety function

- The safety function SS1-t fulfills Safe Stop 1 time controlled in accordance with EN/IEC 61800-5-2, and also corresponds to Stop category 1 according to EN/IEC 60204-1.
- The drive initiates the motor deceleration and performs the STO function after an application-specific time delay.
- The motor becomes torque-free and removes hazardous movements.

STO is activated immediately when the configured stop delay expires, regardless of speed.

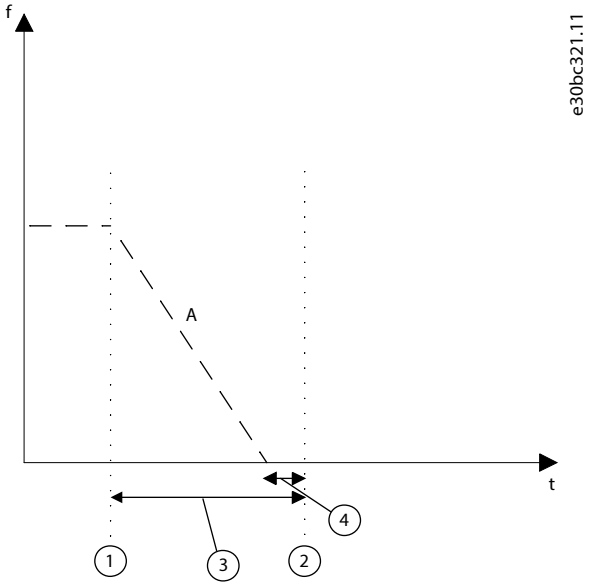


Figure 32: Safe Stop 1 Time Controlled

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

SS1-t function activates a braking ramp defined from a selected time delay in ***parameter 42-42 Delay Time***, which means the braking ramp is linear. Select the value of ***parameter 42-43 Delta T*** (the percentage of delay time), which is a reasonable tolerance before the SS1-t time expires.

⚠ WARNING

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

NOTICE

For SS1-t, ramping down the motor is performed by non-safety components, so it may fail undetected. Therefore, SS1-t cannot be applied if this failure can cause a dangerous situation in the final application.

NOTICE

The SS1-t function does not monitor the reality of the motor's stopping. If any drive's fault occurs before SS1-t time expired, the drive coasts immediately regardless of the motor speed.

- Assess the suitability of SS1-t for end application.

NOTICE

Parameter 42-43 Delta T provides a time margin, the drive should have stopped before entering the time margin. Too much of Delta T can bring a steep ramp down curves, which may cause overcurrent and coast the motor.

6.3.2.2 SS1-t Triggered by DI

To enable safe DI as SS1-t input, set ***parameter 42-20 Safety Function T37/T38*** as ***[9] SS1-t***. The following table shows SS1-t statuses based on whether terminals 37 and 38 are energized.

Table 27: SS1-t via DI

Previous status	Terminal 37	Terminal 38	Status	LCP display
Timing	High[1]	High	Inactive	None
	High=>Low[2]	High=>Low	Timer start	SS1-t[3]
	High=>Low	High	Timer start	W252
	High	High=>Low	Timer start	W252
Timing	High	High	Timing[4]	SS1-t
			Timer stop & reset[5]	None
Timing	Low	X	Timing	SS1-t
	X	Low		
Timer expired	X	X	STO	W68

1) Voltage range is 24 V±15%, with terminal 39 as reference.

2) Open circuit or the voltage within the range of 0 V±1.5 V, with terminal 39 as reference.

*3) When setting **parameter 0-2* LCP Display=[4285]**.*

*4) **Parameter 42-24 Restart Behavior=[0] Manual**.*

*5) **Parameter 42-24 Restart Behavior=[1] Automatic**, and no SS1-t request on fieldbus (inactive command or disabled).*

6.3.2.3 SS1-t Triggered by Fieldbus

To enable safety fieldbus protocol, set ***parameter 42-62 Enable FSoE*** to ***[1] Enabled***. SS1-t control command is sent from the upper device continuously and periodically. The command includes:

- SS1-t inactive
- SS1-t active

Table 28: SS1-t via Fieldbus

Previous status	SS1-t command	Status	LCP display
Inactive	Inactive	Inactive	None
	Inactive=>active	Timer start	SS1-t
Timing	Active	Timing	
	Inactive	Timer stop & reset	None
Timer expired	Active	STO	W68
	Inactive	Inactive	None

1) See the table in 6.5.2.6.2 FSoE Control Word.

*2) When setting **parameter 0-2* LCP Display=[4285]**.*

6.3.2.4 SS1-t Timer Start

If 1 of the following events is detected, SS1-t timer starts immediately:

- Terminal 37 becomes low.
- Terminal 38 becomes low.
- *SS1-t active* command received on fieldbus.

6.3.2.5 SS1-t Timing Quit

When SS1-t timer starts and does not expire, the SS1-t timer can be paused and reset when all of the following conditions are met:

- When ***parameter 42-24 Restart Behavior*** is set to ***[1] Automatic***, terminal 37 and terminal 38 are both high.
- *SS1-t inactive* command received on fieldbus.

6.3.2.6 Safe State of SS1-t

The safe state of SS1-t is STO triggered before timer expires. If any internal fault is detected or external fault happens, the drive triggers STO at any time.

NOTICE

Assess the risk of STO interrupting SS1-t.

6.3.2.7 Timing Precision

The timing precision is:

Lower limit = N × (1−0.1%)

Upper limit = (N+0.05) × (1+0.1%)

N is the set time (set in ***parameter 42-42 Delay Time***), and the unit is seconds.

6.4 Safety Digital Input

6.4.1 Valid Voltage

- The valid voltage range of terminal 39 should be 0 V, PELV.
- The valid voltage range of terminal 37 and 38 should be 0–24 V, PELV, refer to terminal 39.
- If the voltage on terminal 37 or 38 is over 30 V, the drive enters protection mode and triggers STO.
- If the voltage on terminal 37 or 38 is over 60 V, the circuitry of the drive will be damaged.

6.4.2 Debouncing

Some devices, for example safety PLC, generates a test pattern on its output for stuck checking. These test patterns can interrupt the drive. The drive can ignore these test patterns on terminal 37 and 38 if they stay at low level (≤1.8 V) for no longer than 5 ms.

NOTICE

To activate STO (or SS1-t) effectively and stably, keep the 2 channels both at low level for at least 1 s.

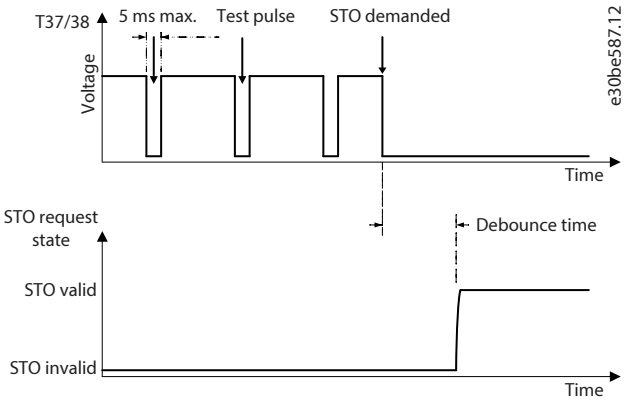


Figure 33: Debouncing

6.4.3 Discrepancy Tolerance

The input signals at the 2 terminals may not always be synchronous. If the discrepancy between the 2 signals is longer than 0.5 s, the STO fault warning (W252) occurs.

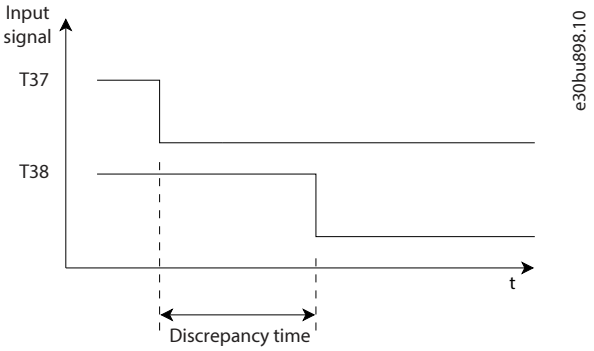


Figure 34: Discrepancy Time

NOTICE

The discrepancy time does not extend the response time of the safety function. The drive activates its safety function when the earlier valid signal arrives.

6.5 Safety Fieldbus

6.5.1 FSoE

FSoE is an additional safety protocol on top of a standard transmission system (EtherCAT). FSoE uses several technologies to ensure the validity and status of the fieldbus communication, making it reliable to use with safety devices.

These measures include:

- Session number for detecting buffering of a complete start-up sequence.
- Sequence number for detecting interchange, repetition, insertion, or loss of whole messages.
- Unique connection identification for safely detecting misrouted messages via a unique address relationship.
- Watchdog monitoring for safely detecting delays not allowed on the communication path.
- Cyclic redundancy checking for data integrity for detecting message corruption from source to sink.

Communication over the non-safe transmission systems is called the "black channel".

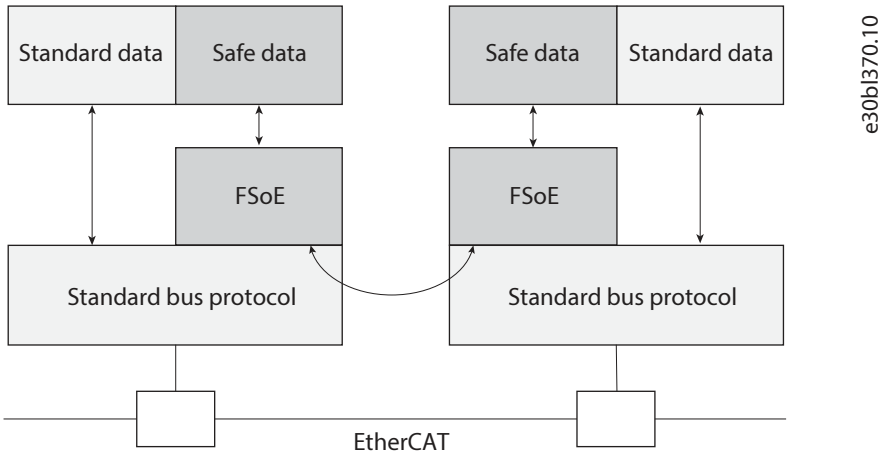


Figure 35: FSoE Communication

6.5.2 FSoE System

6.5.2.1 Overview of FSoE System

The drive can communicate with safety PLC via EtherCAT. The exchanged data includes safety-related data and non-safe process data. For safety-related data, it goes through safety PDU.

6.5.2.2 The Safety PDU

Figure 36 shows the structure of 1 safety PDU embedded in an EtherCAT PDU. The general structure of the Safety PDU is listed in Table 29.

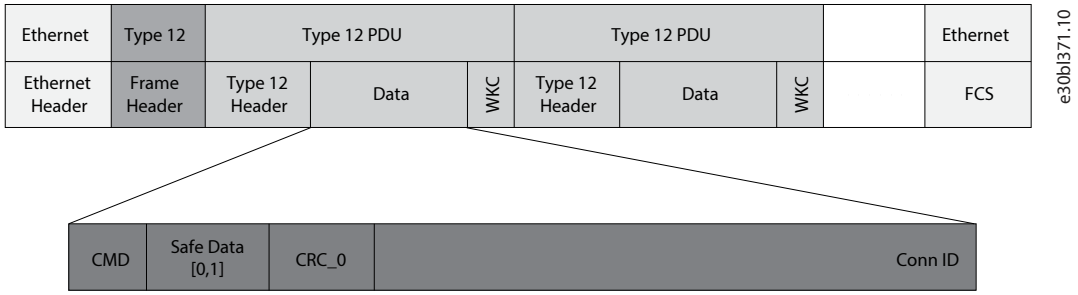


Figure 36: Safety-over-EtherCAT embedded in EtherCAT PDU

Table 29: General Safety PDU

Octet	Name	Description
0	Command	Command
1	SafeData [0]	Safety data, octet 0
2	SafeData [1]	Safety data, octet 1
3	CRC_0_Lo	Low octet (bits 0–7) of the 16-bit CRC_0
4	CRC_0_Hi	High octet (bits 8–15) of the 16-bit CRC_0
5	Conn_Id_Lo	Unique connection ID, low octet
6	Conn_Id_Hi	Unique connection ID, high octet

6.5.2.3 Parameterization for FSoE

When using the FSoE, the protocol requires specific safety parameters. These parameter values must be set to the drive via the MCT 10 safety tool. During start-up, the values are sent to the drive, and the drive checks the values against the values on the drive.

Table 30: Settings in the Safety PLC

Value	Description
FSoE slave address	The value must be the same as the F destination address on FC 280.
Safe data of the safety PDU	The value must be the same as the safety telegram in FC 280. Safe data must be mapped as described in the tables in 6.5.2.6.2 FSoE Control Word and 6.5.2.6.3 FSoE Status Word.

6.5.2.4 FSoE Watchdog Time

The minimum watchdog time has 4 parts:

- DAT = Device Acknowledgment Time. The slave receives a frame, processes it, and prepares a new frame to send.
- Bus = the transfer time of the frame from the AC drive to master.

- HAT = Host Acknowledgment Time. The master receives a frame, processes it, and generates a new frame.
- Bus = the transfer time of the frame from the master to the AC drive.

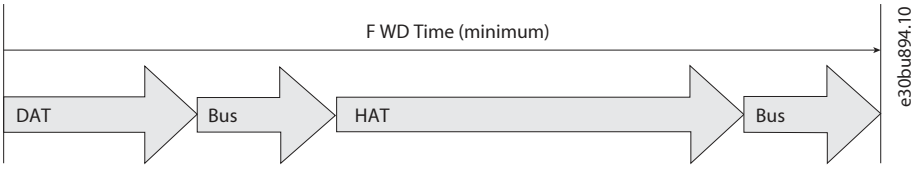


Figure 37: FSoE Watchdog Time

Sometimes, it is difficult to determine the bus transfer time that is used to calculate the watchdog time. For more information on the cycle times, see the user manuals of the specific fieldbus.

The F WD time can be calculated via the following formula:

$$WDTime = DAT + HAT + 2 \times BT$$

Table 31: Description of the Parts of the Watchdog Time

Symbol	Name	Description
DAT	Device Acknowledgment Time	70 ms for the complete AC drive system.
HAT	Host Acknowledgment Time	Application-specific.
BT	Bus Cycle Time	The bus cycle time.

The WD time must have a value that is slightly greater than the sum of DAT, HAT, and 2 times the bus transfer time. It is recommended not to exceed the calculated value by more than 30%. Setting a shorter watchdog time does not have an effect on the safety of a system, but it can cause a fault and make the AC drive trip. For example, if HAT is 4 ms and the EtherCAT cycle time is 4 ms, WD time should be set to:

$$WDTime = (DAT + HAT + 2 \times BT) \times 1.3 = (70ms + 4ms + 2 \times 4ms) \times 1.3 = 110ms$$

NOTICE

If there is extreme electromagnetic interference, the communication systems use retry mechanisms to increase the robustness of the system. Before setting the WD time, it is recommended to find the number of retries of each connection and adjust the minimum watchdog time if necessary.

6.5.2.5 FSoE Safety Function Response Time (SFRT)

FSoE specifies a safety function response time (SFRT), during which the safety system must react to a fault in the system. The SFRT includes all individual delays, including the bus transfer times. All of these elements have minimum and maximum delays, and the actual delay is likely to be somewhere in between these values. For safety reasons, every communication cycle has its own watchdog time $WDTime_i$ after which the safe state is activated if a fault occurs in that communication cycle.

Calculate the safety function response time via the following formula:

$$SFRT = \sum_{i=1}^{n} WCDT_i + \max_{i=1,2.,n} (WDTime_i - WCDT_i)$$

SFRT=Safety Function Response Time

$WCDT_i$=Worst Case Delay Time of entity i

$WDTime_i$=Watchdog Time of entity i. See 6.5.2.4 FSoE Watchdog Time.

Adding the worst case delay times to the components of the safety system gives the total worst case delay time. See Table 32.

Table 32: Time Parameters

Device	Worst case delay time	Watchdog time
The complete AC drive system	120 ms	Recommended 250 ms or larger

6.5.2.6 Safe Data

6.5.2.6.1 Introduction

In a PLC program, address the safety functions using bits while not bytes.

Byte 0 is Safety Drive Profile specification and byte 1 is vendor-specific.

To show the hex values of FSoE status word and FSoE control word on the LCP, use ***parameter 42-83 Safe Status Word*** and ***parameter 42-82 Safe Control Word***. The hex values are used for debugging purpose or transferring the safe control information to a non-safe control environment.

6.5.2.6.2 FSoE Control Word

Table 33: FSoE Control Word

Byte	Bit	Name
Byte 0	0	STO
Byte 0	1	SS1
Byte 0	2–6	Not supported (1)
Byte 0	7	Error Ack
Byte 1	0–7	Not supported (1)

1) Bits that are not supported are set to 0.

Byte 0 Bit 0, STO

- Bit 0.0=0, Safe Torque Off (zero-active).
- Bit 0.0=1, No Safe Torque Off.

Byte 0 Bit 1, SS1

- Bit 0.1=0, Safe Stop 1 (zero-active).
- Bit 0.1=1, No Safe Stop 1.

Byte 0 Bit 7, Error Ack

- When this bit value changes from 1 to 0 (1=>0 edge), an acknowledgment is given to the safety fault buffer. Fault entries in the safety fault buffer are shifted to the last acknowledged fault situation. Faults which are still present or not knowledgeable appear again in the actual fault situation.

6.5.2.6.3 FSoE Status Word

Table 34: FSoE Status Word

Byte	Bit	Name
Byte 0	0	POWER_REMOVED (1)
Byte 0	1	SS1_ACTIVE (2)
Byte 0	2–6	Not supported(3)

Table 34: FSoE Status Word (continued)

Byte	Bit	Name
Byte 0	7	Error
Byte 1	0–7	Not supported[3]

1) If STO is triggered by safe DI or by SS1 timer expired, this bit also indicates "active".

2) If SS1 is triggered by safe DI, this bit also indicates "active".

3) Bits that are not supported are set to 0.

Byte 0 Bit 0, STO

- Bit 0.0=0, Safe Torque Off inactive.
- Bit 0.0=1, Safe Torque Off active (one-active).

Byte 0 Bit 1, SS1

- Bit 0.1=0, Safe Stop 1 inactive.
- Bit 0.1=1, Safe Stop 1 active (one-active).

Byte 0 Bit 7, Error

- Bit 0.7=0, no safety fault.
- Bit 0.7=1, safety fault present.

6.6 Installation

6.6.1 Safe Input Terminals

⚠ WARNING

All short-circuit risks must be eliminated!

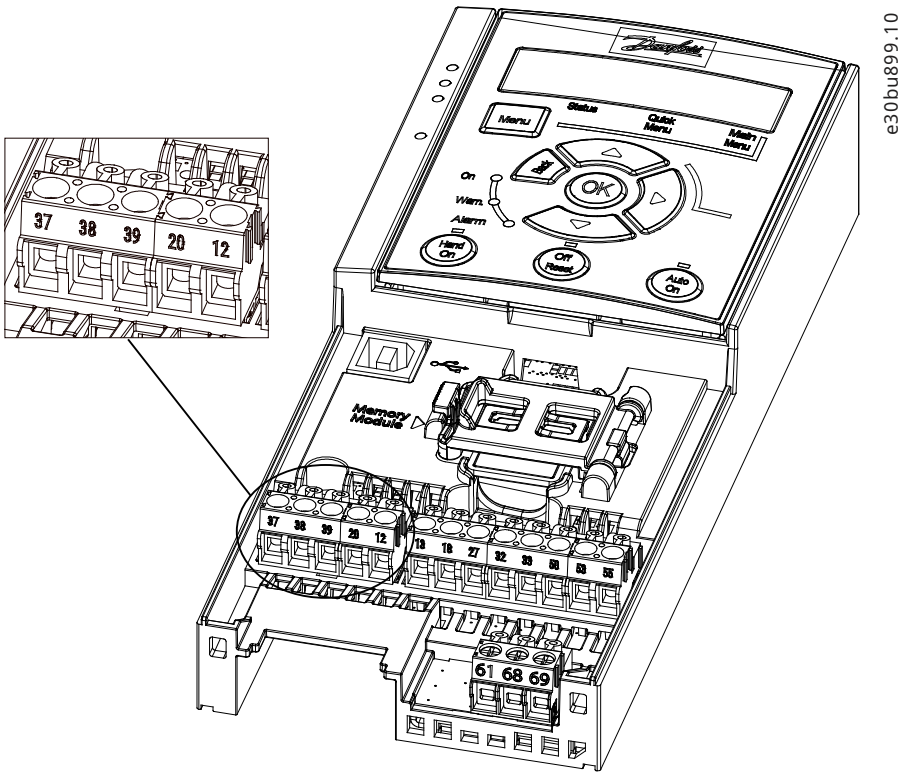


Figure 38: Safe Input Terminals

Table 35: Safe Input Terminals

Terminal	Name	Description
37	SI A	Safe input channel a
38	SI B	Safe input channel b
39	SGND[1]	Safe GND, Ref. 0 V of SI A and SI B
20	GND	Ref. 0 V of 24 V
12	24 V	24 V voltage supply

1) SGND is galvanically isolated with GND.

6.6.2 Jumper for Safety Bypass

If STO/SS1 function needs to be bypassed temporarily, bridge terminals 37-39 according to the Figure 39.

If STO/SS1 function is no longer used or needs to be bypassed for quite a long time, Danfoss recommends to disable the safe input via ***parameter 42-20 Safety Function T37/T38***.

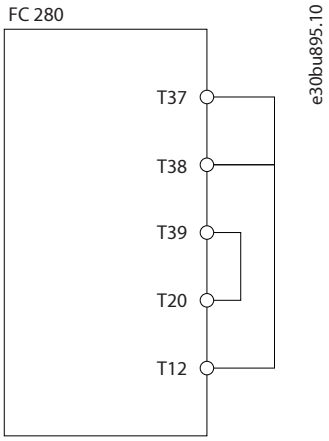


Figure 39: Jumper for Safety Bypass

⚠ WARNING

When the safe digital inputs are bypassed, they no longer provide any safety function.

6.6.3 Connect with Dual-contactor Device

The dual-contactor device includes emergency button, safe relay, and safe PLC with P-P output, and so on.

For applications with an emergency button or other equivalent device in a cabinet, see the connections as shown in Figure 40 and Figure 41.

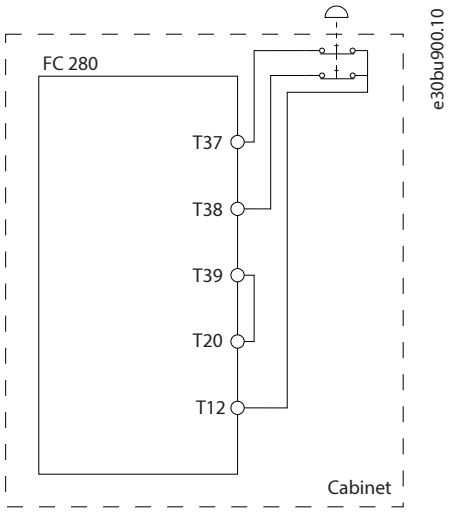


Figure 40: In Cabinet Connection: Use Self 24 V Supply

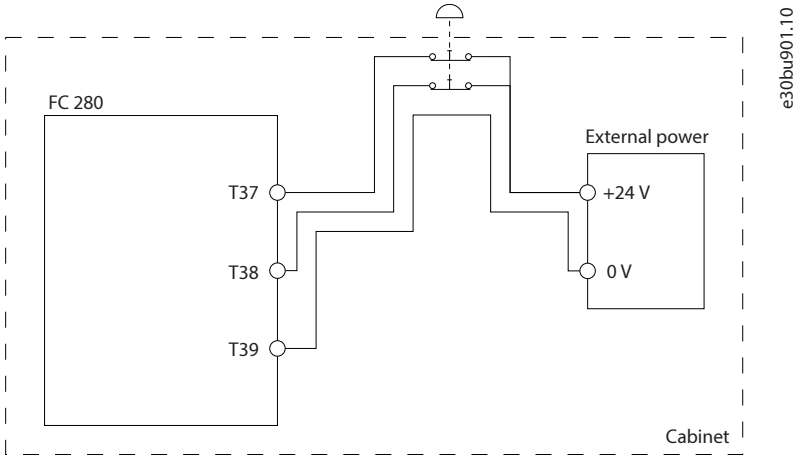


Figure 41: In Cabinet Connection: Use External 24 V Supply

For applications with an emergency button or other equivalent device outside cabinet, see the connection as shown in Figure 42.

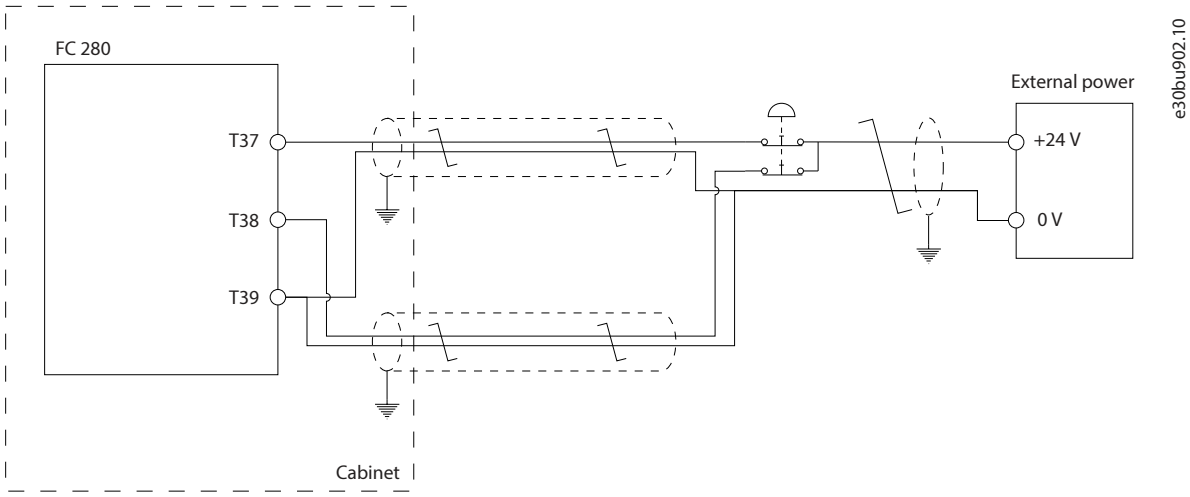


Figure 42: Outside Cabinet Connection

NOTICE

For outside cabinet connection or inside cabinet connection with cable length>20 m (65.6 ft), the cables must be shielded.

6.6.4 Connect with P-M Mode

For some safe PLC, P-M mode outputs are provided. This kind of output disconnects both high-side and low-side branches.

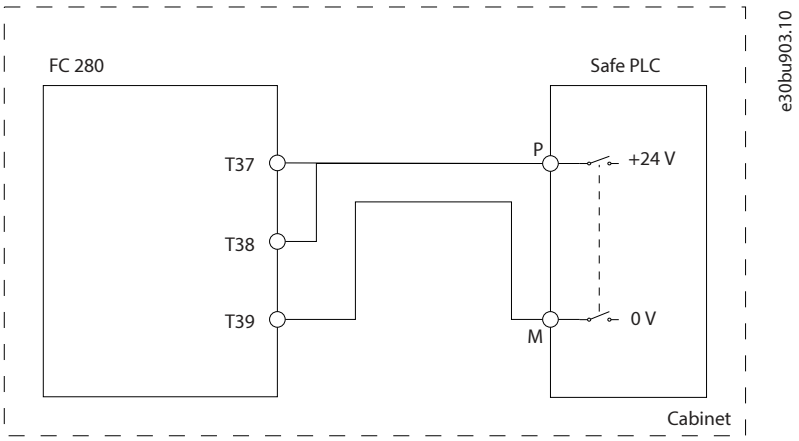


Figure 43: Connect with P-M Mode PLC: In Cabinet

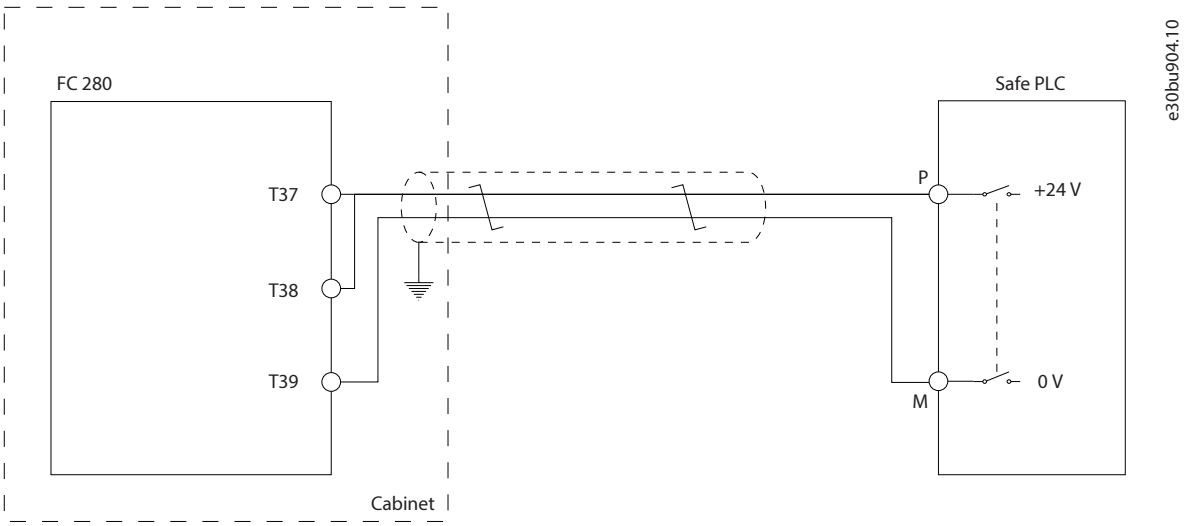


Figure 44: Connect with P-M Mode PLC: Outside Cabinet

⚠ WARNING

For P-M mode connection, T39 must NOT be connected with OTHER reference potential, for example, T20, T55, PE, or other 0 V of PLC.

6.6.5 Daisy Chain Connection

Daisy chain is recommended when several drives are connected in parallel. See the Figure 45 and Figure 46.

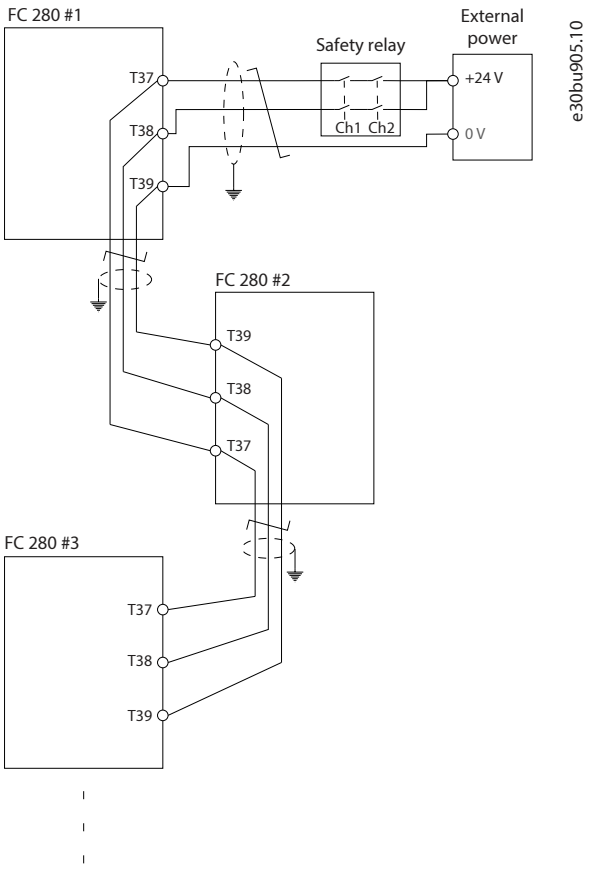


Figure 45: Daisy Chain with 2 Output Safety Relays

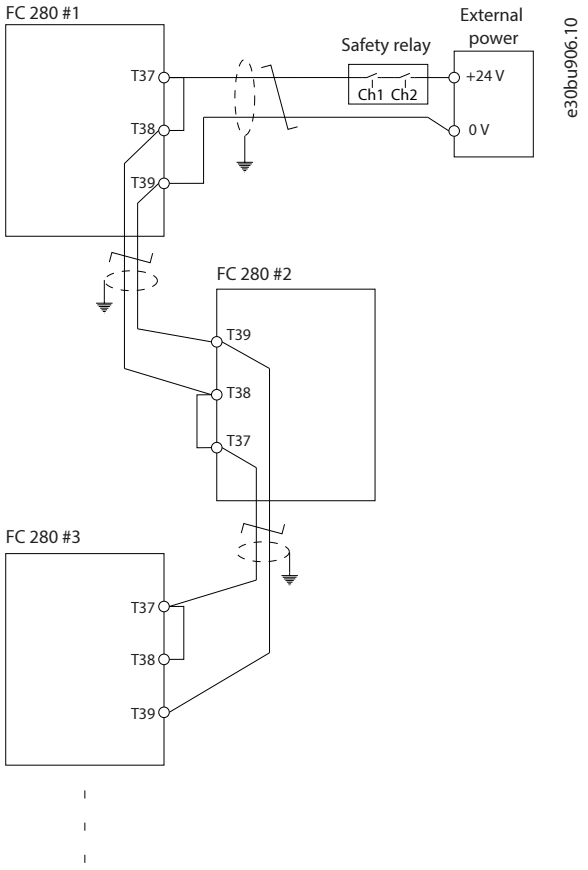


Figure 46: Daisy Chain with Single Output Safety Relay

NOTICE

The total cable length for daisy chain shall not exceed 20 m (65.6 ft).

6.7 Configuration

6.7.1 Configuration with MCT 10

6.7.1.1 Safety Functions Configuration

Safety-related parameters must be configured via a PC with the MCT 10 tool and can also be copied between drives with the LCP or a memory module.

Use the VLT® Motion Control Tool MCT 10 Safe Plug-in to configure the safety functions and to enable the FSoE communication. 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 for the safety functions.

NOTICE

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

Downloading the configuration to safety option:

- On single-drive systems, via the RS485/USB interface on the drive.

- On networked systems, via the RS485 or fieldbus interface on the MCT 10 Safe Plug-in. The control system passes the configuration to the respective safety option.
- The feasibility of the configuration is checked when it is downloaded. Further information on configuration and setting parameters for the safety functions is available in the online help for the MCT 10 Safe Plug-in and in the *VLT® Motion Control Tool MCT 10 Operating Guide*.

The safety option is configured with the commissioning software VLT® Motion Control Tool MCT 10 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:

- Safe Input.
- Safe Stop 1.
- Parameters.
- Status.

The menu items are described in detail in the *VLT® Motion Control Tool MCT 10 Operating Guide*. The menu item *Status* shows the following:

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

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

6.7.1.2 Commissioning the Safety Option

This procedure describes the example of the safety option commissioning procedure with VLT® Motion Control Tool MCT 10.

NOTICE

If any errors occur while changing the password or after the approval step, the *Safety* plug-in shows a notification with the error description.

NOTICE

If STO is inactive (the drive is operational) when starting the customization process, the *Safety* plug-in shows the *Confirmation Required* dialog box. This dialog box prompts to confirm that STO is activated during the commissioning:

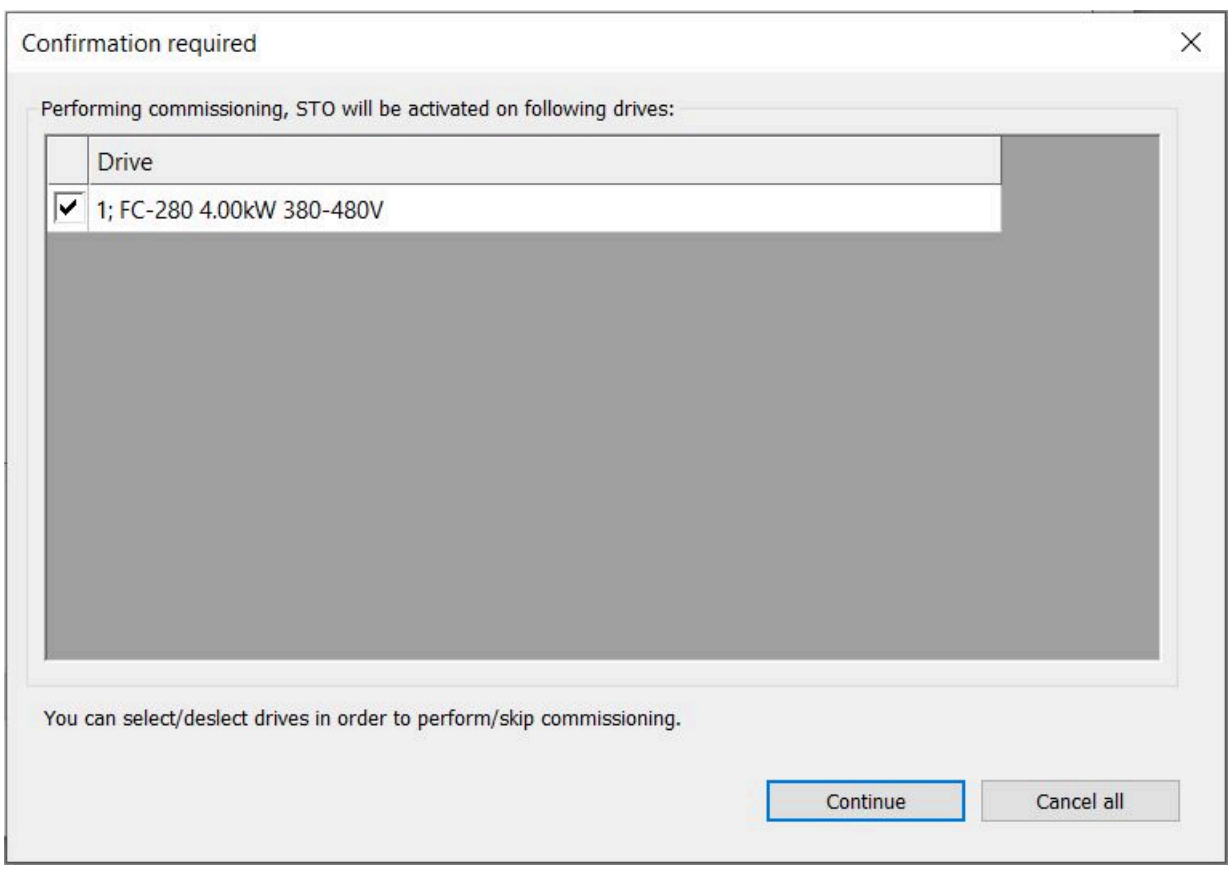
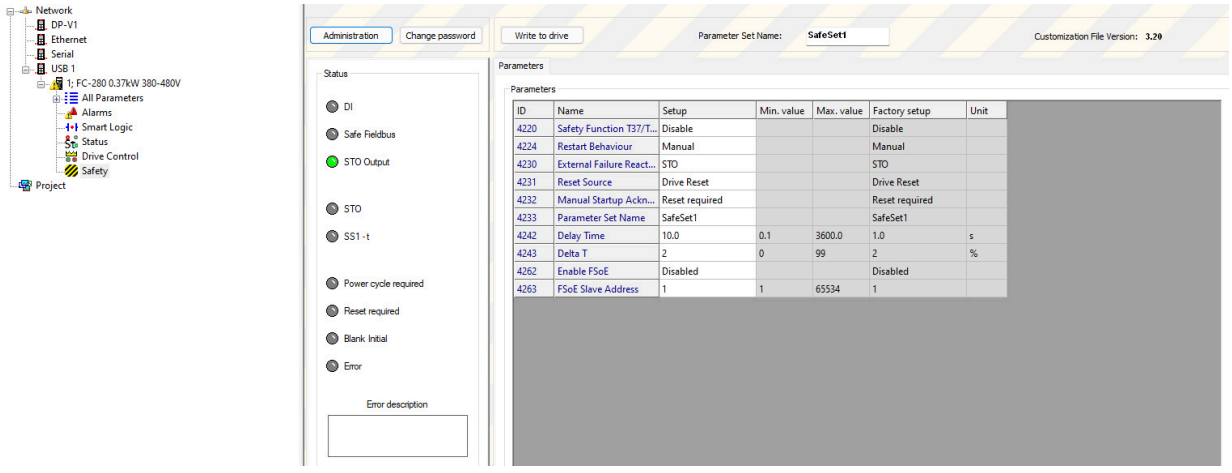


Figure 47: Confirmation Required Dialog Box

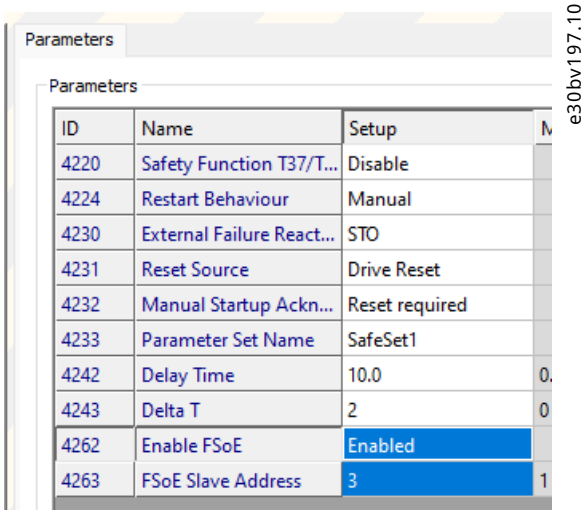
NOTICE

- Ensure that the drive enters a safe state before configuration.
- Ensure that the written parameters are correct.

1. In MCT 10, establish a connection between the PC and the drive.
2. In MCT 10, select the *Safety* plug-in.

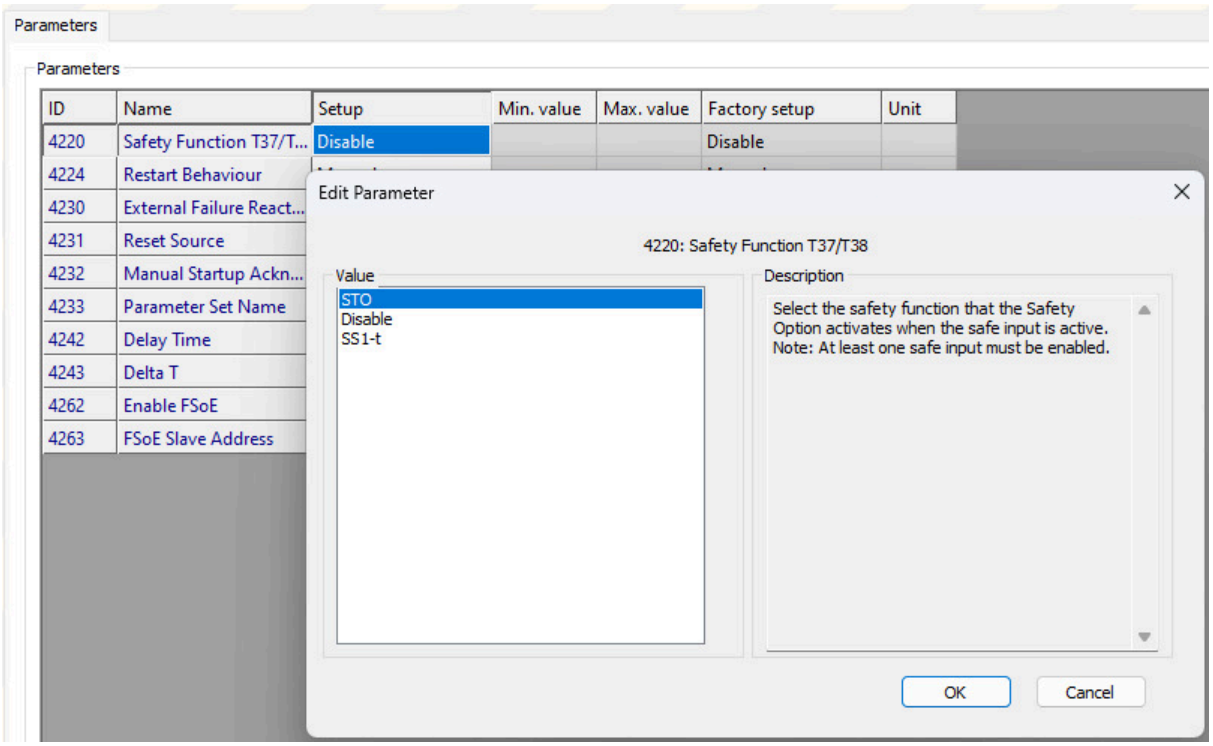


3. In *Parameters* view, double-click and select *Enabled* for *Enable FSoE*, then enter the *FSoE Slave Address*.



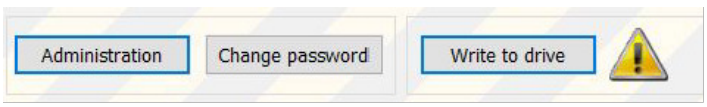
e30bv197.10

4. In *Parameters* view, select the appropriate safe function.



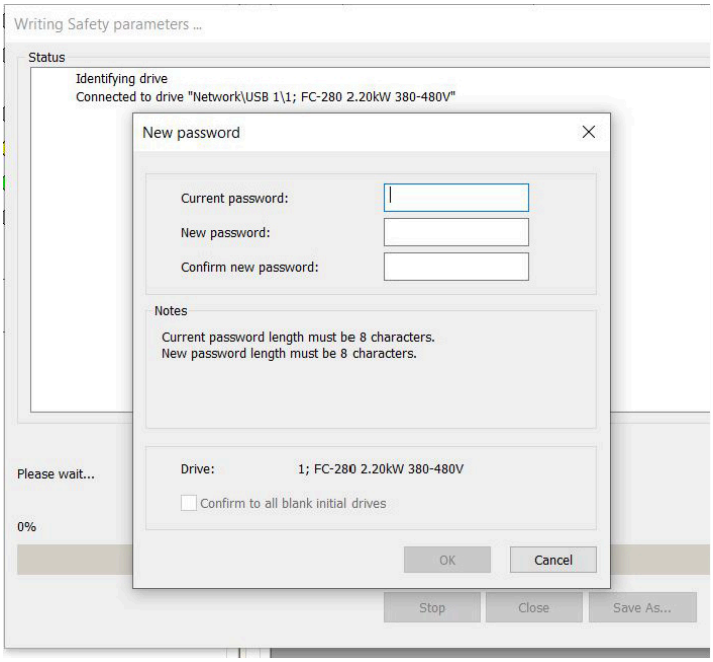
e30bv198.10

5. Select other application-specific settings.
6. In the *Safety* plug-in, click *Write to drive*.

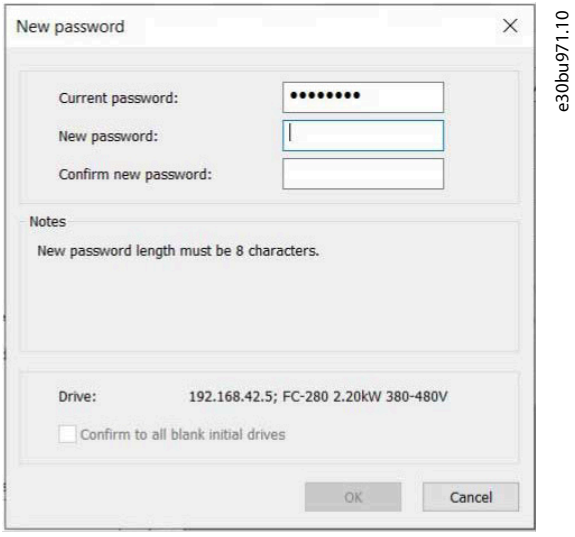


e30bu959.10

7. If the safety option is in a blank initial state, it prompts to change the password.
   a. In the *New password* dialog box, enter the current password *12345678*, which is the default password.

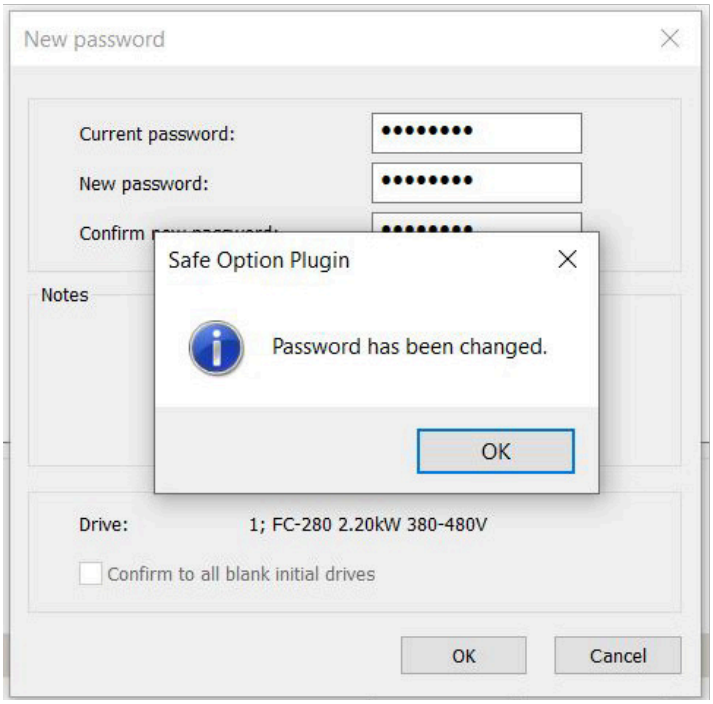


b. Enter the new password.



c. Click *OK*.

d. The *Safety* plug-in shows the confirmation message, click *OK*.



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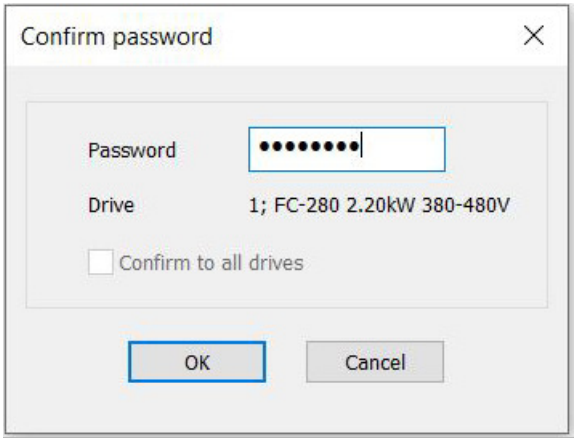
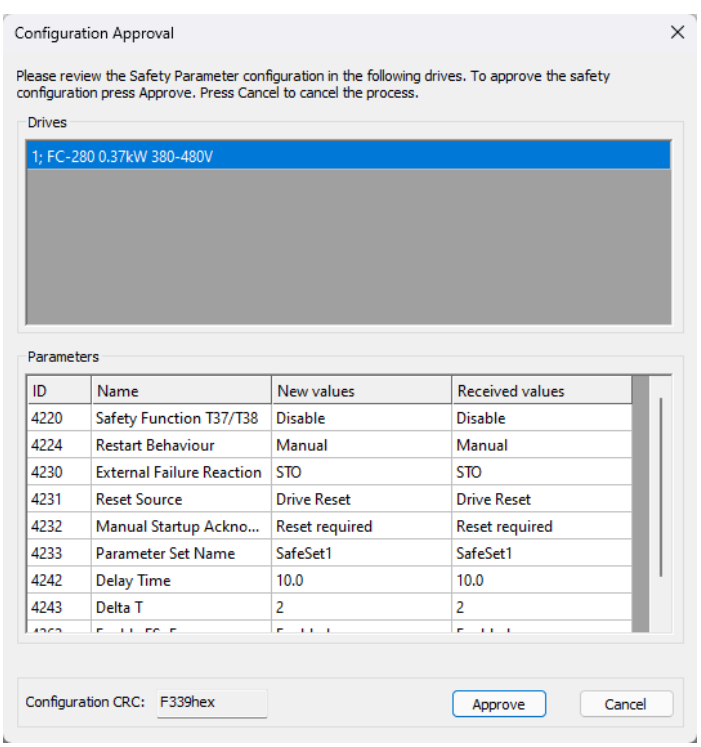
8. In the *Confirm password* dialog box, enter the password and click *OK*.



e30bu962.10

9. In the *Configuration Approval* dialog box, verify the safety configuration.



e30bv199.10

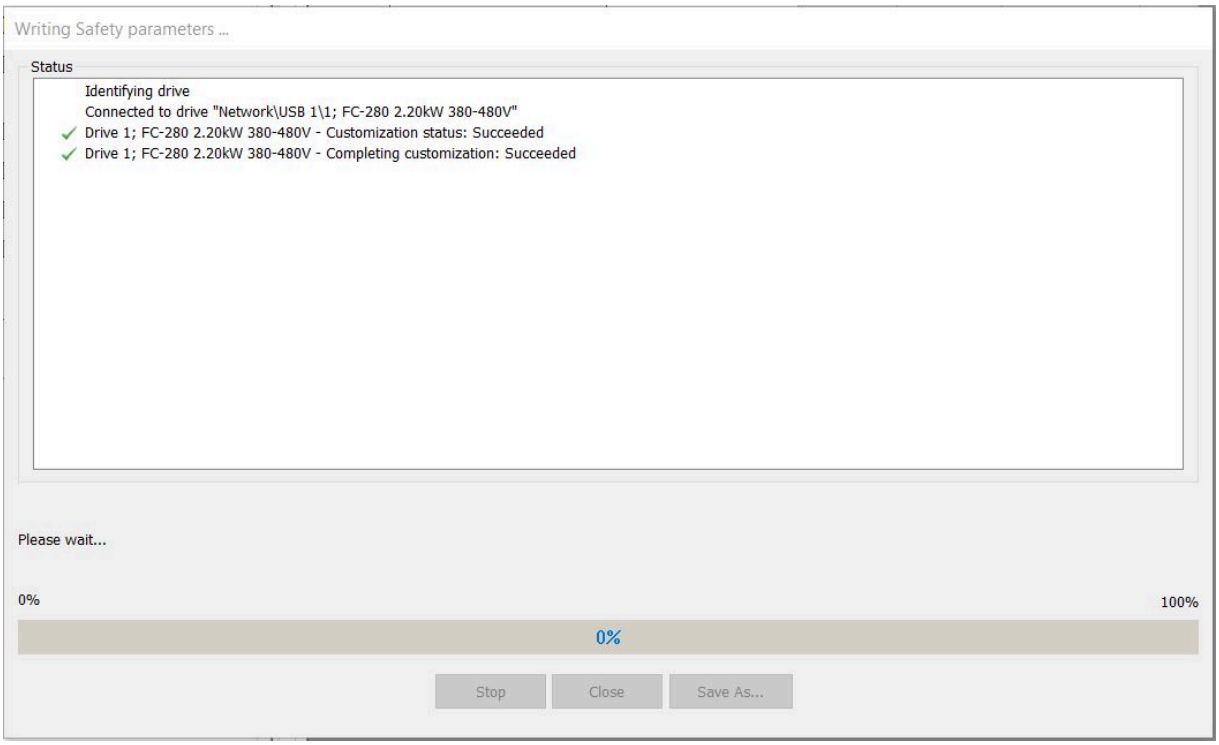
NOTICE

- If the safety fieldbus is disabled (***parameter 42-62 Enable FSoE*** is set to ***[0] Disabled***) and ***parameter 42-32 Manual Startup Acknowledge*** is set to ***[0] Direct restart***, the device is ready for mission after start-up, no manual acknowledgment is needed. This configuration is applicable for non-safety application.
- If the safety digital input is enabled (***parameter 42-20 Safety Function T37/T38*** is set to ***[0] STO*** or ***[9] SS1-t***), ***parameter 42-32 Manual Startup Acknowledge*** should not be set to ***[0] Direct restart*** unless the integrator has performed a risk assessment and implemented required safety measures to avoid unexpected risk due to direct restart.
- If the safety fieldbus is enabled, there is no difference no matter which option is selected in ***parameter 42-32 Manual Startup Acknowledge***.

– Click *Cancel* to abort the customization process and revert to the previous safety option state.

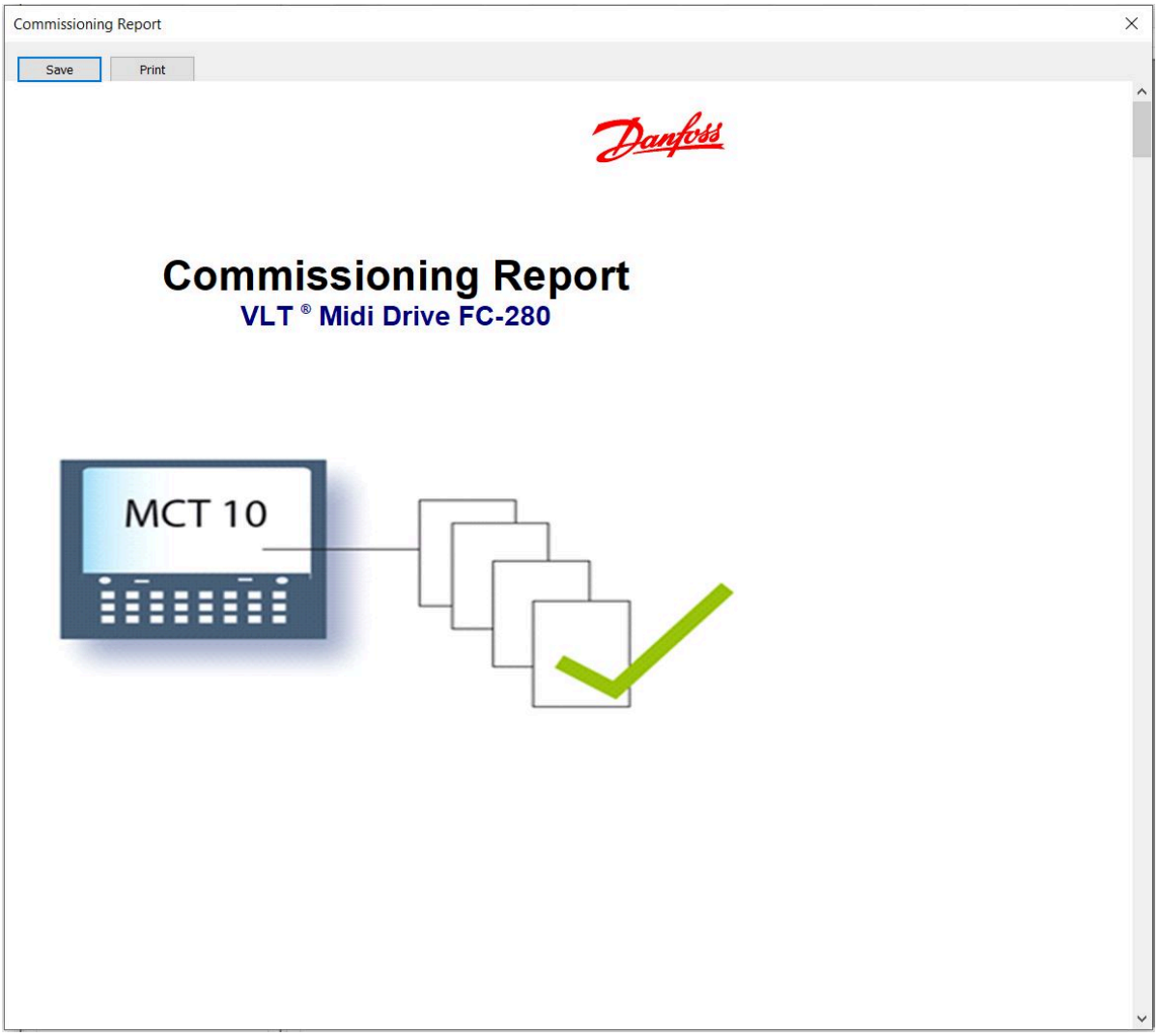
– Click *Approve* to start writing the safety parameters.

10. The MCT 10 opens the *Writing Safety parameters...* dialog box. When the progress bar reaches 100%, the safety parameters are written.



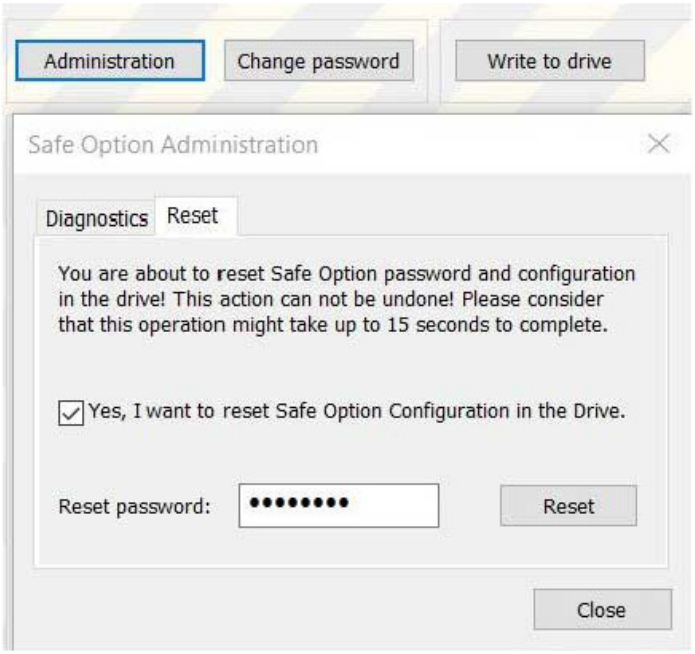
e30bu964.10

11. The MCT 10 generates and opens the commissioning report.



e30bu965.10

12. Save and print the commissioning report which is required for future maintenance.
13. Close the commissioning report dialog box and the *Writing Safety parameters...* dialog box.
14. The safety option customization is now complete. A reset may be required depending on the safety option configuration.



6.7.1.3 Password Protection

6.7.1.3.1 Password Protection Overview

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

The 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 the password may lead to safety issues.

NOTICE

No password is required to access the commissioning parameters of the safety option. The password is required when writing the parameters to the option via the *Write to Drive* feature.

The password must consist of 8 characters and is case-sensitive. Alphanumeric characters and symbols are also valid for the password. Use the *Change Password* menu item to change the safety option parameter password.

6.7.1.3.2 Resetting the Password

If the password is forgotten, the password can be reset using MCT 10.

NOTICE

Resetting the password resets all option parameters to factory default.

1. In MCT 10, click *Administration*.
2. In the *Reset* tab, select *Yes, I want to reset Safety Option configuration in the drive*.
3. Enter the default password (12345678).

4. Click *Reset*.
5. On the prompt that appears, click *Yes*.
6. Change the safety option password.

6.7.1.4 Retrieving Safety Option Status

6.7.1.4.1 Introduction

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

Configure the following 2 options in ***parameter 8-13 Configurable Status Word STW***:

- Configure ***[91] Safe Opt. Reset. req*** to indicate that a reset of the safety option is required.
- Configure ***[90] Safe Function active*** to indicate that a safe function is active.

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

NOTICE

Parameter 42-80 Safe Option Status only shows the active safety function.

6.7.1.4.2 Status Bits for Safety Option Status

Table 36: Status Bits for Safety Option Status

Bit	Description	State
00	Normal_up	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.
01	PUST	Bit 01, power up self test. Bit 01=0, safety option is not in PUST state. Bit 01=1, safety option is in PUST state.
02	STO active	Bit 02, Safe Torque Off. Bit 02=0, Safe Torque Off is not active. Bit 02=1, Safe Torque Off is active.
03	SS1-t active	Bit 03, Safe Stop 1. Bit 03=0, Safe Stop 1 is not active. Bit 03=1, Safe Stop 1 is active.
04–07	Reserved	–
08	Safe output status	Bit 08, safe output status. Bit 08=0, safe output at 24 V. Bit 08=1, safe output at 0 V.
09	Safe option initialized	Bit 09, safe option initialized. Bit 09=0, not in safe option initialized state. Bit 09=1, in safe option initialized state.
10	Safe fieldbus acknowledge request	Bit 10, safe fieldbus acknowledge request. Bit 10=0, no operator acknowledgement requested. Bit 10=1, operator acknowledgement from safe PLC requested.

Table 36: Status Bits for Safety Option Status (continued)

Bit	Description	State
11	Int_failure	Bit 11, internal failure. Bit 11=0, no internal failure is active. Bit 11=1, an internal failure is active.
12	Reset required	Bit 12, reset. Bit 12=0, no safety option reset is required. Bit 12=1, a safety option reset is required.
13	Pending fail safe state	Bit 13, pending fail safe state. Bit 13=0, no pending fail safe state. Bit 13=1, the safety option is in this state at each power-up.
14	Ext_fail ure	Bit 14, external failure. Bit 14=0, no external failure is active. Bit 14=1, external failure is active.
15	Safe function pending	Bit 15, safe function pending. Bit 15=0, no safe function is pending. Bit 15=1, a safe function is pending.
16	General reset	Bit 16, general reset. Bit 16=0, no change in state. Bit 16=1, a general reset is done.
17	Customization_confirmed	Bit 17, customization confirmed. Bit 17=0, no change in state. Bit 17=1, customization confirmed by user.
18	Customization_aborted	Bit 18, customization aborted. Bit 18=0, no change in state. Bit 18=1, customization aborted by user.
19	Customization_requested	Bit 19, customization requested. Bit 19=0, no change in state. Bit 19=1, customization is requested by user.
20	Reserved	–
21	PUST warning	Bit 21, power up self test warning. Bit 21=0, no change in state. Bit 21=1, a power up self test warning is issued.
22–23	Reserved	–
24–31	Error code	These bits indicate reasons for internal or external errors. For more information, see the error codes.

6.7.1.4.3 Status Bits for Safety Option Status 2

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

Table 37: Status Bits for Safety Option Status 2

Bit	Description	State
0 1	DI safety status	00: inactive 01: active 10: pending 11: error
2–3	Reserved	–
4	Blank initial state	0: inactive 1: active
5 6 7	Safe fieldbus support	0: no safe fieldbus supported 1: PROFIsafe supported 2: FSoE supported 3: CIP Safey supported 4: openSAFETY supported
8	Safe function status on safe fieldbus	0: deactivated 1: activated, safe fieldbus communication is established.
9	Safe fieldbus communication established	0: not established 1: established
10–31	Reserved	–

6.7.1.5 Copying Safe Parameter Setup

To copy the safe parameter setup to another drive, see the following steps:

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

6.7.1.6 Password Protection LCP Copy and Safe Parameter Mismatch

Optionally, a password protection can be used for the function LCP copy (see Table 38) and if there is a parameter mismatch (see Table 39). Password protection can be enabled/disabled in ***parameter 0-69 Password Protection of Safety Parameters***. The password is set in ***parameter 0-68 Safety Parameters Password***. Default password is 300.

Table 38: LCP Copy Messages

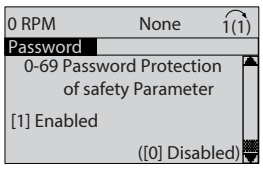
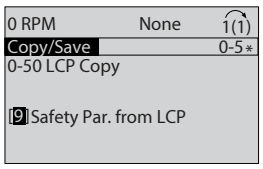
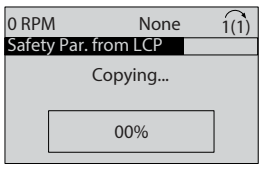
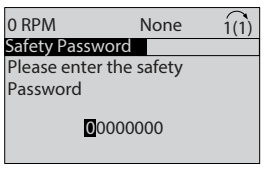
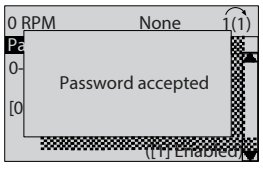
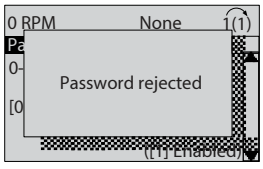
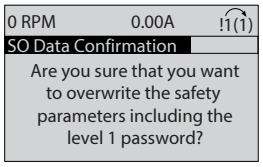
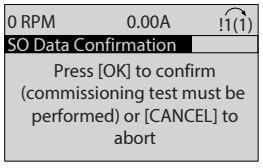
Message	Description
 e30bd114.11	The password protection of the safety parameters is enabled.
 e30bd116.11	Copying the safety parameters from the LCP into the drive is selected.
 e30bd117.11	The safety parameters get copied from the LCP into the drive.
 e30bd118.11	If password protection is enabled in ***parameter 0-69 Password Protection of Safety Parameters***, enter the correct LCP-copy/parameter mismatch password (***parameter 0-68 Safety Parameters Password***).
 e30bd119.11	If the entered password is correct, this overlay message is shown for some seconds.
 e30bd123.11	If the entered password is wrong, this overlay message is shown for some seconds. Then the password can be entered again.
 e30bd120.11  e30bd121.11	Decision box for continuing overwriting the existing data or to abort the procedure.

Table 38: LCP Copy Messages (continued)

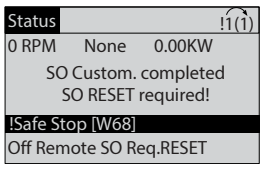
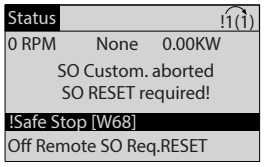
Message	Description
 e30bd122.11	Press [OK] to complete the customization of the safety option. A reset is required to finalize this procedure.
 e30bd124.11	Press [Cancel] to abort the customization of the safety option. A reset is required to finalize this procedure.

Table 39: Mismatch Between Safety Parameters in the Safety Option and in the Drive

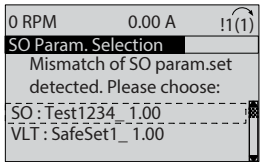
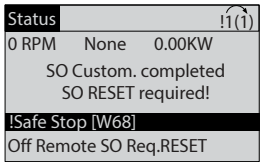
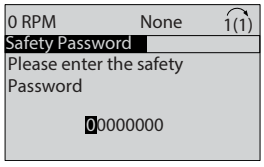
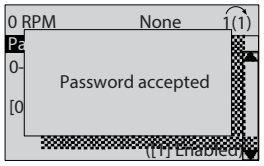
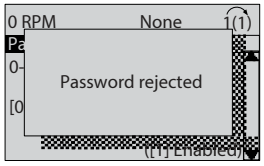
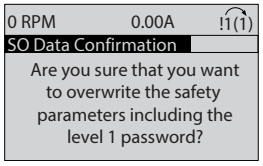
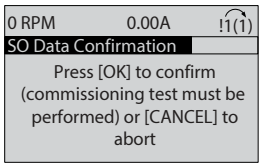
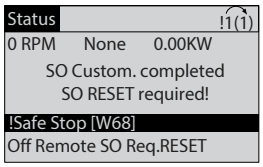
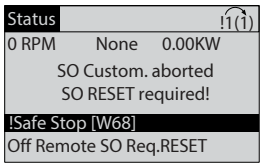
Message	Description
 e30bd115.11	Whenever there is a mismatch of safety parameters within the safety option and the drive, this selection form is shown on the LCP. Select between the *Safety data on safe option* or the *Safety data on drive* valid data.
 e30bd122.11	If selecting [SO:…], the customization of the safety option is completed and a reset is required to finalize this procedure.
 e30bd118.11	If selecting [VLT:…] and the password protection in ***parameter 0-69 Password Protection of Safety Parameters*** is enabled, enter the correct LCP-copy/parameter mismatch password (***parameter 0-68 Safety Parameters Password***).
 e30bd119.11	If the entered password is correct, this overlay message is shown for some seconds.
 e30bd123.11	If the entered password is wrong, this overlay message is shown for some seconds. Then the password can be entered again.

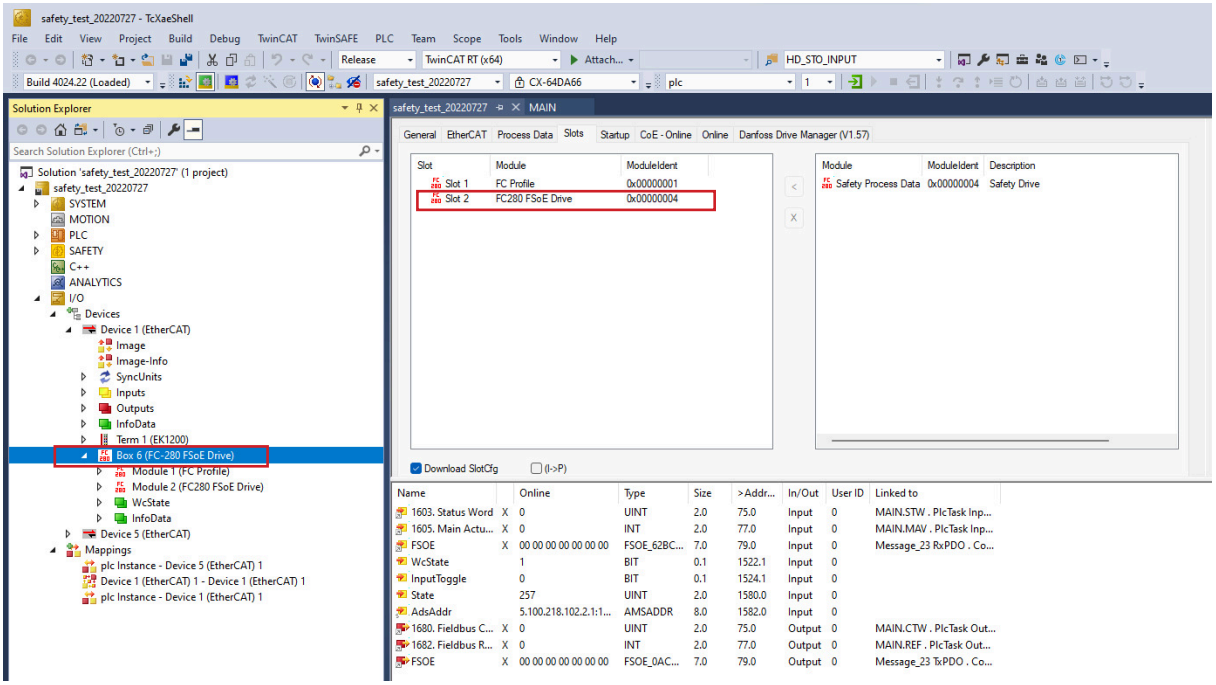
Table 39: Mismatch Between Safety Parameters in the Safety Option and in the Drive (continued)

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

6.7.2 Configuring FSoE with TWinCAT3

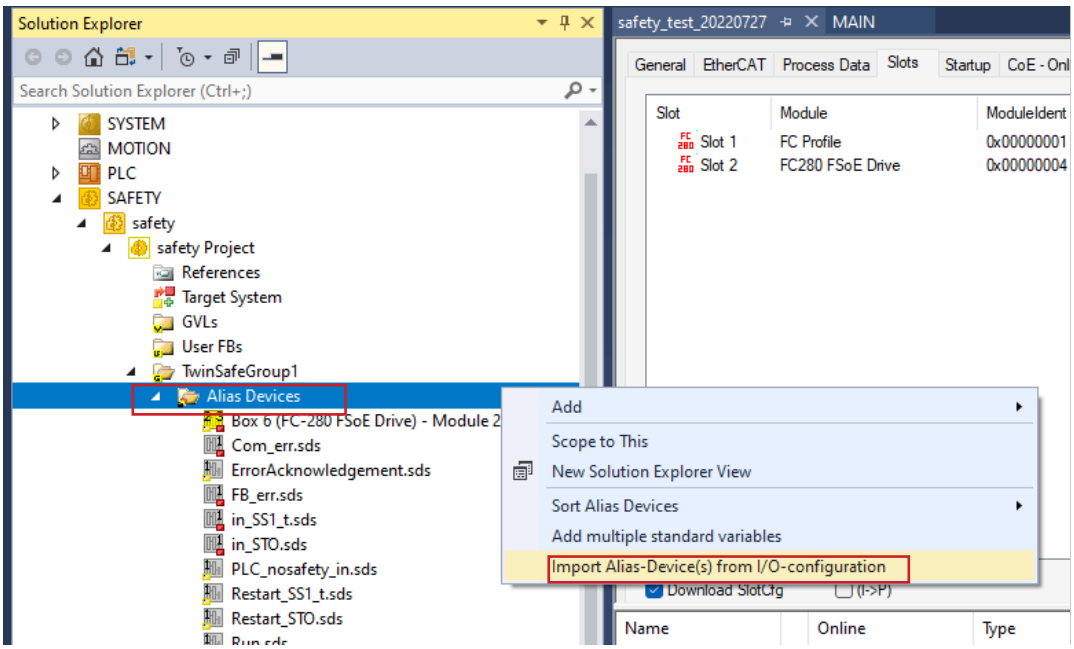
This section explains how to configure FSoE communication between VLT® Midi Drive FC 280 and other device with TWinCAT3.

1. Connect the PLC and the drive.
2. Scan the devices.
3. Find the FC 280 FSoE drive, and add *ModuleIdent 0x00000004* to *Slot 2*.



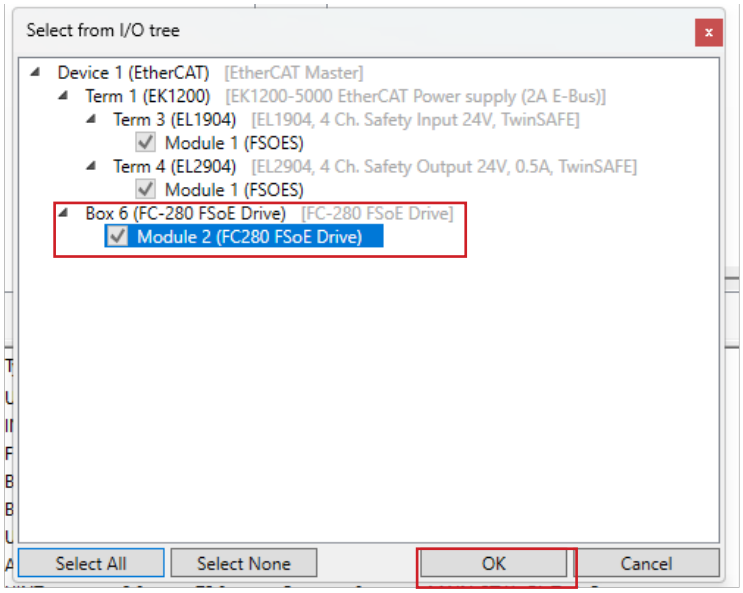
e30bv200.10

4. Right click *Alias Devices*, and click *Import Alias-Device(s) from I/O-configuration*.



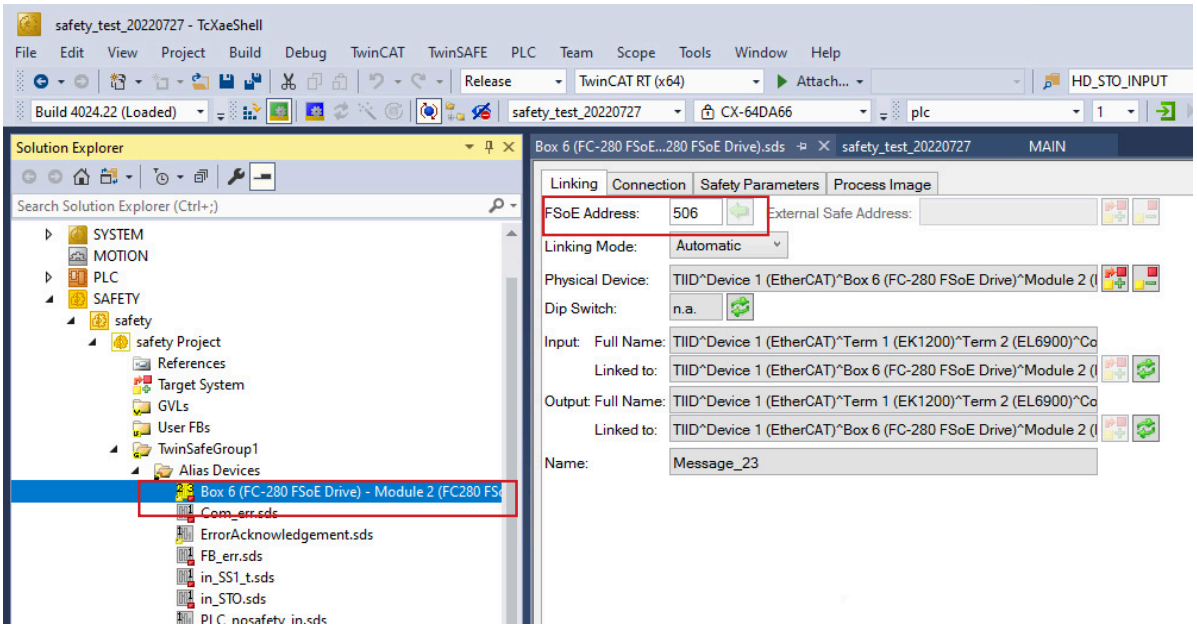
e30bv201.10

5. Click *Box 11 (FC-280 FSoE Drive)* and select *Module 2 (Safety Process Data)*, and then click *OK*.



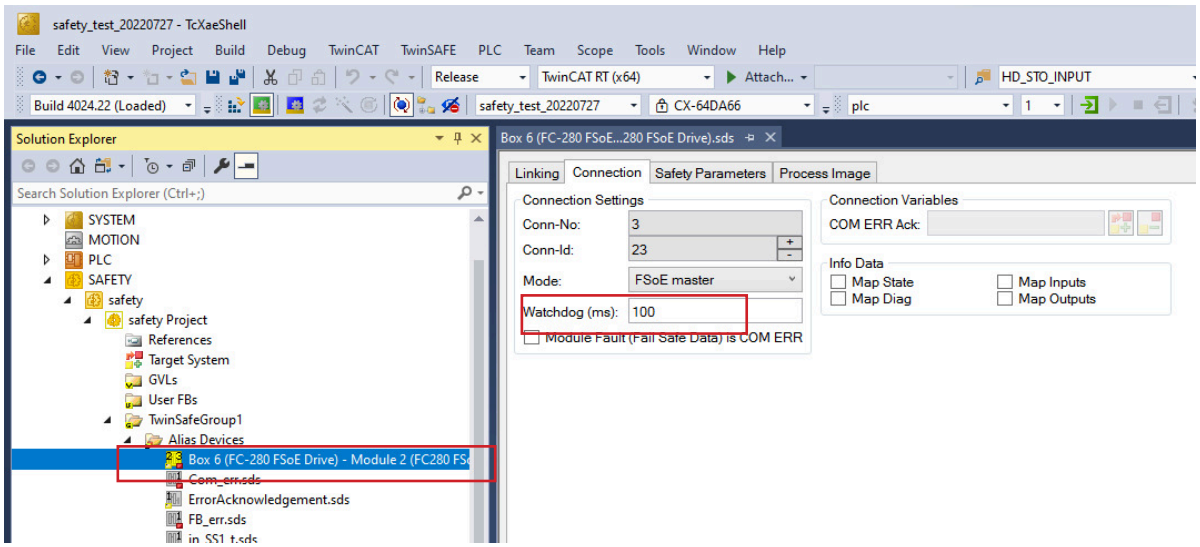
e30bv202.10

6. Set the *FSoE Address* and synchronize the modification value of ***parameter 42-62 Enable FSoE***.



e30bv203.10

7. Modify the watchdog time.



e30bv204.10

6.8 Reset Function

When the safety function is activated, reset the safety option. Depending on the configuration, the following sources can reset the safety option:

- The [Reset] key on the LCP or the digital input of the drive.
- The reset signal via the safe fieldbus.

Parameter 42-24 Restart Behavior determines whether the safety option restarts automatically or waits for a manual reset after the safety function was activated:

- Manual reset behavior - when the safety function is activated, the safety option requires a reset from a reset source before it can run again.

- Automatic reset behavior - when the safety function is activated, the safety option can run again when the condition that triggered the safety function ceases. This behavior is only valid for the digital input where this reset behavior is defined. For instance, if there is an external error, a manual reset from the reset source is required regardless of the setting in ***Parameter 42-24 Restart Behavior***.

For more information, read the description of ***parameter 42-31 Reset Source***.

NOTICE

The default restart behavior is set to *Manual*. Before switching to *Automatic*, ensure to follow the requirements of the integrator risk assessment.

6.9 Commissioning and Validation

6.9.1 Safety Guidelines

NOTICE

Always perform a commissioning test after installation, maintenance, retrofit, and reconfiguration.

When commissioning/recommissioning:

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

⚠ CAUTION

ELECTROSTATIC DISCHARGE

Electrostatic discharge can damage components.

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

⚠ WARNING

RISK OF ELECTROCUTION

- Never wire the electrical connections on the drive 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 other chapters of this operating guide for further information of the drive. Refer to VLT® Motion Control Tool MCT 10 Operating Guide for further information on the Safe Plug-in.

6.9.2 Commissioning Requirements

The procedure requires installation of MCT 10 setup software, version 5.90 or later, and a successful connection to VLT® Midi Drive FC 280 with built-in safety option.

- 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.
- Ensure that the device number (serial number and order number) of the safety option on the drive matches the device number of the safety option in the MCT 10 safe plug-in.

- Ensure that the drive is ready for commissioning.

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

- VLT® Motion Control Tool MCT 10 set-up software (licensed version).
- USB or fieldbus connection or RS485 interface adaptor for connecting the control card of the drive with the PC.

If RS485 is used, the protocol for serial communication needs to be set to ***[0] FC-MC*** in ***parameter 8-30 Protocol*** (only accessible through the LCP). When setting up the option for the first time, ensure to have a commissioning report at hand, see further information in VLT® Motion Control Tool MCT 10 Operating Guide.

NOTICE

Only LCP software version 7.0 or newer is supported.

6.9.3 Commissioning Test

6.9.3.1 Introduction

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 tests for the configured safety functions are described in the commissioning report generated by the MCT 10 safe plug-in.

The commissioning test must be performed in the following cases:

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

The commissioning test for systems with safety functions is focused on:

- Validating the functionality of safety monitoring and stop functions configured in the drive system.
- Correct selection of the safety option parameter values.
- Examining the response of specific monitoring functions to the explicit input of values outside tolerance limits.

Perform the commissioning test on the basis of the risk analysis. Adhere to all applicable standards and regulations.

Ensure that the following preconditions are met:

- The drive is wired properly. For more information about wiring, see the *chapter Installation*.
- All safety equipment such as protective monitoring devices, light barriers, or emergency stop switches are connected and ready for operation.
- All motor parameters and command parameters are set correctly in the drive.

6.9.3.2 Performing the Commissioning Test

1. Use MCT 10 set-up software to generate the commissioning test report.
2. Follow the test sequence in the report to ensure proper functioning of the safety option.
3. Document each individual step of the test.
4. Note the checksum of the safety option parameters in the records.
5. Do not release the system unless it has successfully passed all individual steps of the test.
6. Restart the drive and check that the motor runs normally.

6.9.4 Commissioning Test Report

After some operations, for example LCP copy of safe parameters, a commissioning test is required. Follow and approve the test sequence according to the commissioning test report.

Table 40: Commissioning Test Report: Safe Torque Off

Safety functions	Test procedure	Approved ✓
STO	1. Check the STO circuit connections against the circuit diagram. STO function must be inactive: • Via digital input. • Via FSoE.	
	2. Power on, manual acknowledgment is required if configured. No safety faults and alarms.	
	3. Run the drive.	
	4. Ensure that the correct drive is running.	
	5. Trigger STO while the drive is running.	
	6. Check the following: • The drive coasts to zero speed. • The motor is braked and stopped by the mechanical brake (if available and configured). • ***Warning 68 Safe Torque Off*** is shown.	
	7. Deactivate STO.	
	8. Check the following: • Depending on the configuration, *Safety Func. Pending* is shown. • STO inactive.	
	9. Restart the drive and check that the motor runs normally.	
	10. Ensure that the STO function is safe and accepted to operate.	
	11. Document and sign the commissioning test report.	

Table 41: Commissioning Test Report: Safe Stop 1 Time Controlled

Safety functions	Test procedure	Approved ✓
SS1-t	1. Check the SS1-t circuit connections against the circuit diagram. SS1-t function must be inactive: • Via digital input. • Via FSoE.	
	2. Power on, manual acknowledgment is required if configured. No safety faults and alarms.	
	3. Run the drive.	
	4. Ensure that the correct drive is running.	
	5. Trigger SS1-t while the drive is running.	
	6. Check the following: • The drive coasts to zero speed after the specified waiting time has elapsed. • The motor is braked and stopped by the mechanical brake (if available and configured). • ***Warning 68 Safe Torque Off*** is shown.	
	7. Deactivate SS1-t.	
	8. Check the following: • Depending on the configuration, *Safety Func. Pending* is shown. • SS1-t inactive.	
	9. Restart the drive and check that the motor runs normally.	
	10. Ensure that the SS1-t function is safe and accepted to operate.	
	11. Document and sign the commissioning test report.	

6.10 Operation and Maintenance

6.10.1 Safe Operation

⚠ WARNING

UNINTENDED BEHAVIOR

Numerous stored data or settings determine the behavior of the drive system. Unsuitable settings or data may trigger unexpected movements or responses to signals and disable monitoring functions. Failure to follow these instructions can result in death, serious injury, or equipment damage.

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

Prerequisites for normal operation:

- Commissioning is complete.
- The safety option contains the configuration data.
- The safety functions have been tested.

During operation:

- The safety option monitors any pulse changes at its safe inputs.
- The safety option executes safety functions according to the configuration.

6.10.2 Firmware Update and Modification

NOTICE

Contact Danfoss for advice on the firmware update.

⚠ CAUTION

FIRMWARE MODIFICATIONS IN SAFE OPTION

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

6.10.3 Troubleshooting

Table 42: List of Fault Conditions

Fault code	Description	Reason	Action
1–32	Internal fault	An internal fault is detected by diagnosis.	Repower, if irrecoverable, contact Danfoss service support.
89	Invalid command	FSoE communicate error.	Check the configuration of FSoE.
90	Unknown command	FSoE communicate error.	Check the configuration of FSoE.
91	Invalid connection ID	FSoE communicate error.	Check the configuration of FSoE.
92	Invalid CRC	FSoE communicate error.	Check the configuration of FSoE.
93	Watchdog expired	FSoE communicate error.	Check the configuration of FSoE.
94	Invalid slave address	FSoE communicate error.	Check the configuration of FSoE.
95	Invalid data	FSoE communicate error.	Check the configuration of FSoE.
96	Invalid size of communication parameters	FSoE communicate error.	Check the configuration of FSoE.
97	Invalid communication parameters	FSoE communicate error.	Check the configuration of FSoE.
98	Invalid length of application parameters	FSoE communicate error.	Check the configuration of FSoE.

Table 42: List of Fault Conditions (continued)

Fault code	Description	Reason	Action
99	Invalid application parameters (it is acceptable that the drive cannot report this error if the safety application parameters are not allowed.)	FSoE communicate error.	Check the configuration of FSoE.
113	DI discrepancy	One of the safety inputs fails.	Check the connection of T37 and T38 and the device connected on them.

6.11 Safety Technical Data

6.11.1 Condition and Assumption

The Failure Modes, Effects, and Diagnostic Analysis (FMEDA) is performed based on the following assumptions:

- VLT® Midi Drive FC 280 takes 20% of the total failure budget for an SIL3 safety loop.
- Failure rates are based on the Siemens SN29500 database.
- Failure rates are constant; wear-out mechanisms are not included.
- For each channel, the safety-related components are considered to be of type B with a hardware fault tolerance of 0.
- The stress levels are average for an industrial environment and the working temperature of components is up to 85 °C (185 °F).
- A safe error (for example output in safe state) is repaired within 8 hours.
- No torque output is the safe state.

6.11.2 Safety Technical Data

Table 43: Safety Functions via Digital Input (T37/T38)

Safety standards	E/E/PE	IEC 61508
	Machinery system	ISO 13849-1
	Drive	IEC 61800-5-2
Safety functions	STO SS1-t	IEC 61800-5-2

Table 43: Safety Functions via Digital Input (T37/T38) (continued)

Safety performance	**ISO 13849-1**	
	Category	Cat.3
	Diagnostic coverage (DC)	90%<DC_{avg}<99% (medium)
	Mean time to dangerous failure ($MTTF_D$)	350 years (high)
	Performance level	PL e
	IEC 61508/IEC 61800-5-2	
	Safety Integrity Level SIL Claim Limit (SIL CL)	SIL3
	Probability of dangerous failure on demand (PFD_{avg})(1)	$2.5x10^{-4}$
	Probability of dangerous failure per hour (PFH)	9.0 FIT(2)
	Safe failure fraction (SFF)	For dual-channel parts: >93%
		For single-channel parts: >99%
	Hardware fault tolerance (HFT)	For dual-channel parts: HFT=1
		For single-channel parts: HFT=0
	Failure rates of 1oo1 part	$\lambda_S=9.3x10^{-7}$
		$\lambda_D=2.0x10^{-8}$
		$\lambda_{DD}=1.9x10^{-8}$
		$\lambda_{DU}=1.3x10^{-9}$
	Failure rates of 1oo2 part	$\lambda_S=4.6x10^{-7}$
		$\lambda_D=3.1x10^{-7}$
		$\lambda_{DD}=2.9x10^{-7}$
		$\lambda_{DU}=2.4x10^{-8}$
	Proof test interval (PTI)	20 years
	Mission time	20 years
	Common cause failure (CCF)	β=5%; β_D=2%
	Diagnostic test interval (DTI)	<10 minutes
	Systematic capability	SC 3
	Operation mode	Low/High/Continuous demand mode
STO reaction time	Input to output response time(3)	≤110 ms

1) PFD_{avg} is not suitable for the drive due to the fact that it is assumed to be working in high or continuous mode in IEC 61800-5-2. Here, PFD_{avg} is for reference purposes only.

2) 1 FIT=1/(10^9 hour).

3) STO reaction time via digital input is the amount of time from an input signal condition triggers the STO until the torque is removed from the motor interface.

Table 44: Safety Functions via Safety Fieldbus

Safety standards	E/E/PE	IEC 61508
	Machinery system	ISO 13849-1
	Drive	IEC 61800-5-2
	Safety fieldbus	IEC 61784-3-12

Table 44: Safety Functions via Safety Fieldbus (continued)

Safety functions	STO SS1-t	IEC 61800-5-2
Safety performance	**ISO 13849-1**	
	Category	Cat.3
	Diagnostic coverage (DC)	90%<DC_{avg}<99% (medium)
	Mean time to dangerous failure ($MTTF_D$)	350 years (high)
	Performance level	PL e
	IEC 61508/IEC 61800-5-2	
	Safety Integrity Level SIL Claim Limit (SIL CL)	SIL3
	Probability of dangerous failure per hour (PFH)	9.0 FIT[1]
	Probability of dangerous failure on demand (PFD_{avg})	$2.5x10^{-4}$
	Safe failure fraction (SFF)	For dual-channel parts: >93%
		For single-channel parts: >99%
	Hardware fault tolerance (HFT)	For dual-channel parts: HFT=1
		For single-channel parts: HFT=0
	Failure rates of 1oo1 part	$\lambda_S=9.3x10^{-7}$
		$\lambda_D=2.0x10^{-8}$
		$\lambda_{DD}=1.9x10^{-8}$
		$\lambda_{DU}=1.3x10^{-9}$
	Failure rates of 1oo2 part	$\lambda_S=4.6x10^{-7}$
		$\lambda_D=3.1x10^{-7}$
		$\lambda_{DD}=2.9x10^{-7}$
		$\lambda_{DU}=2.4x10^{-8}$
	Proof test interval (PTI)	20 years
	Mission time	20 years
	Common cause failure (CCF)	β=5%; β_D=2%
	Diagnostic test interval (DTI)	<10 minutes
	Systematic capability	SC 3
	Operation mode	Low/High/Continuous demand mode
STO reaction time	Drive worst case delay time (WCDT)	≤70 ms
	Bus delay time (BT)	≤4 ms
	Input to output response time[2]	≤120 ms

1) 1 FIT=1/(10^9 hour).

2) STO reaction time via digital input is the amount of time from an input signal condition triggers the STO until the torque is removed from the motor interface.

6.12 Safety-related Parameters

Table 45: Safety Related Parameters

Parameter	Option/range	Default	Usage	Conversion index	Data type
Parameter 42-20 Safety Function T37/ T38	***[0] STO*** ***[5] Disable*** ***[9] SS1-t***	***[5] Disable***	Select the safety function when the safe input is active.	–	u_int8
Parameter 42-24 Restart Behavior	***[0] Manual*** ***[1] Automatic***	***[0] Manual***	Select whether the safety option restarts automatically or waits for a manual reset after the safety function was activated via a digital input.	–	u_int8
Parameter 42-30 External Failure Reaction	***[0] STO*** ***[3] SS1-t***	***[0] STO***	Select which safety function is executed if there is an external failure.	–	u_int8
Parameter 42-31 Reset Source	***[0] Drive Reset*** ***[1] Drive Safe Reset***	***[0] Drive Reset***	Select the source that triggers the safety option reset. The reset sources of ***[0] Drive Reset*** are: • The *[Reset]* key on the LCP. • Digital input. • Reset signal via a fieldbus. If there is an active alarm on the drive, the 1st the drive, and the 2nd safety option, the reset sources of ***[1] Drive Safe Reset*** are: • Digital input (Select ***[100] Safe Option Reset*** on 1 of the digital inputs for this source type to work). • The reset signal via a fieldbus. (For the fieldbus reset to work, set ***parameter 8-14 Configurable Control Word CTW*** to ***[3] Safe Option Reset***.)	–	u_int8
Parameter 42-32 Manual Startup Acknowledge	***[0] Direct restart*** ***[1] Reset required***	***[0] Direct restart***	When safety fieldbus is disabled, select whether a reset (manual acknowledge) is needed before starting the safety function after the drive powers up.	–	u_int8
Parameter 42-33 Parameter Set Name	–	SafeSet1	Enter the name of the safety parameter set (8 characters). Use this parameter to identify the safety configurations.	–	Visible String
Parameter 42-35 S-CRC Value	–	–	The CRC value of safe parameter set.	–	u_int16
Parameter 42-36 Level 1 Password	–	12345678	Password for safe parameter set to avoid unauthorized modification.	–	Visible String
Parameter 42-42 Delay Time	0.1–3600.0 s	10.0 s	Time until STO is activated.	-1	u_int16

Table 45: Safety Related Parameters (continued)

Parameter	Option/range	Default	Usage	Conversion index	Data type
Parameter 42-43 Delta T	0–99%	2%	The value subtracts from the time in ***parameter 42-42 Delay Time*** to get the motor to stop before the timer expires.	0	u_int8
Parameter 42-62 Enable FSoE	***[0] Disabled*** ***[1] Enabled***	***[0] Disabled***	Enable/disable the FSoE function.	–	u_int8
Parameter 42-63 Destination Address	1–65534	1	FSoE slave address of the drive.	–	u_int16
Parameter 42-80 Safe Option Status	0-0xFFFFFFFF	0	Shows the status word 1 of the safety option as a hexadecimal value. Refer to Table 46.	0	u_int32
Parameter 42-81 Safe Option Status 2	0-0x7FFFFFFF	0	Shows the status 2 word of the safety option as a hexadecimal value. Refer to Table 47.	0	u_int32
Parameter 42-82 Safe Control Word	0-0xFFFFFFFF	0	Shows the safe control word as a hexadecimal value.	–	u_int32
Parameter 42-83 Safe Status Word	0-0xFFFFFFFF	0	Shows the safe status word as a hexadecimal value.	–	u_int32
Parameter 42-85 Active Safe Func.	***[0] STO*** ***[9] SS1-t*** ***[10] None***	***[10] None***	Shows the currently active safety function. Use ***parameter 0-20 Display Line 1.1 Small*** to ***parameter 0-22 Display Line 1.3 Small*** to show the function on the LCP.	–	u_int8
Parameter 42-86 Safe Option Info	–	0	Shows the information about the safety option. Use ***parameter 0-23 Display Line 2 Large*** and ***parameter 0-24 Display Line 3 Large*** to show the function on the LCP large display line.	0	Visible String
Parameter 42-88 Supported Customization File Version	0.00–99.99	2.00	Shows the maximum supported configuration file version. 0.00 means the maximum version supported by the safe system (the drive with the safety option). 1.00 means the maximum version supported by the safety option. 2.00 means the maximum version supported by the control card.	-2	u_int16
Parameter 42-89 Customization File Version	0.00–99.99	2.00	Shows the currently used customization file version.	-2	u_int16

Table 46: Status Word 1

Bit	Name	Description
0	Normal up	0: Safety function, fail-safe reaction is active or pending or warning is active. 1: Normal operation.
1	PUST	0: SFBC is not in the PUST state. 1: SFBC in PUST state.
2	STO active	0: STO is not active. 1: STO is active.
3	SS1-t active	0: SS1-t is not active. 1: SS1-t is active.
4–7	Reserved	–
8	Safe output status	The safe output status of SFBC (from SFBC to PU). 0: Safe output deactivated. 1: Safe output activated.
9	SFBC initialized	0: Not in the SFBC initialized state. 1: In SFBC initialized state.
10	Safe fieldbus acknowledge request	Indicating if the PROFIsafe PLC is requesting the operator acknowledge or not. 0: No operator acknowledgment requested. 1: Operator acknowledgment requested from safe PLC.
11	Internal failure	0: No internal failure is active. 1: An internal failure is active.
12	Reset Required	0: No SFBC reset is required. 1: An SFBC reset is required.
13	Pending fail safe state	0: No pending fail safe state. 1: In pending fail safe state.
14	External failure	0: No external failure is active. 1: An external failure is active.
15	Safe function pending	0: No safe function is pending. 1: A safe function is pending.
16	General reset	0: No change in state. 1: A General Reset is done.
17	Customization confirmed	0: No change in state. 1: Customization confirmed.
18	Customization aborted	0: No change in state. 1: Customization aborted.
19	Customization requested	0: No change in state. 1: Customization is requested.
20	Reserved	–
21	PUST warning	0: No change in state. 1: A power-up selftest warning is issued.

Table 46: Status Word 1 (continued)

Bit	Name	Description
22–23	Reserved	–
24–31	Error code	This is the internal or external error codes. 8 bits can indicate 256 different errors. Refer to 6.10.3 Troubleshooting for the definition of the error codes.

Table 47: Status Word 2

Bit	Name	Description
0–1	DI safety status	00: Inactive 01: Active 10: Pending 11: Error
2–3	Reserved	–
4	Blank initial state	0: Inactive 1: Active
5–7	Safe fieldbus support	0: No safe fieldbus supported. 1: PROFIsafe supported. 2: FSoE supported. 3: CIP safety supported. 4: openSAFETY supported.
8	Safe function status on safe fieldbus	0: Deactivated. 1: Activated, safe fieldbus communication is established.
9	Safe fieldbus communication established	0: Not established. 1: Established.
10–31	Reserved	–

7 Application Examples

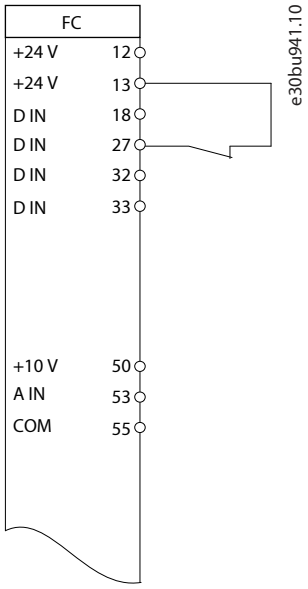
7.1 Introduction

The examples in this section are intended as a quick reference for common applications.

- Parameter settings are the regional default values unless otherwise indicated (selected in ***parameter 0-03 Regional Settings***).
- Parameters associated with the terminals and their settings are shown next to the drawings.
- Required switch settings for analog terminals 53 or 54 are also shown.

7.2 AMA

Table 48: AMA with T27 Connected

<table>
<tr>
<td> 
</td>
<td>
<table>
<tr><td colspan="2">Parameters</td></tr>
<tr><td>Function</td><td>Setting</td></tr>
<tr><td>Parameter 1-29 Automatic Motor Adaptation (AMA)</td><td>[1] Enable complete AMA</td></tr>
<tr><td>Parameter 5-12 Terminal 27 Digital Input</td><td>*[2] Coast inverse</td></tr>
<tr><td colspan="2">*=Default value</td></tr>
<tr><td colspan="2">Notes/comments:
Set parameter group 1-2* Motor Data according to motor specifications.

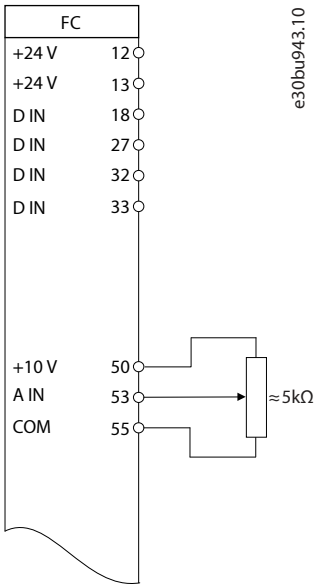
NOTICE
If terminals 13 and 27 are not connected, set parameter 5-12 Terminal 27 Digital Input to [0] No operation.</td></tr>
</table>
</td>
</tr>
</table>

7.3 Speed

Table 49: Analog Speed Reference (Voltage)

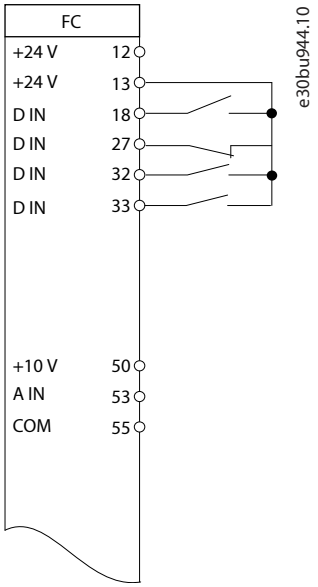
	Parameters	
	Function	**Setting**
	Parameter 6-10 Terminal 53 Low Voltage	*0.07 V
	Parameter 6-11 Terminal 53 High Voltage	*10 V
	Parameter 6-14 Terminal 53 Low Ref./Feedb. Value	0
	Parameter 6-15 Terminal 53 High Ref./Feedb. Value	50
	Parameter 6-19 Terminal 53 mode	***[1] Voltage***
	*=Default value	
	Notes/comments:	

Table 50: Speed Reference (Using a Manual Potentiometer)



Parameters	
Function	**Setting**
Parameter 6-10 Terminal 53 Low Voltage	*0.07 V
Parameter 6-11 Terminal 53 High Voltage	*10 V
Parameter 6-14 Terminal 53 Low Ref./Feedb. Value	0
Parameter 6-15 Terminal 53 High Ref./Feedb. Value	50
Parameter 6-19 Terminal 53 mode	***[1] Voltage***
*=Default value	
Notes/comments:	

Table 51: Speed Up/Speed Down



Parameters	
Function	**Setting**
Parameter 5-10 Terminal 18 Digital Input	****[8] Start***
Parameter 5-12 Terminal 27 Digital Input	***[19] Freeze Reference***
Parameter 5-13 Terminal 29 Digital Input	***[21] Speed Up***
Parameter 5-14 Terminal 32 Digital Input	***[22] Speed Down***
*=Default value	
Notes/comments:	

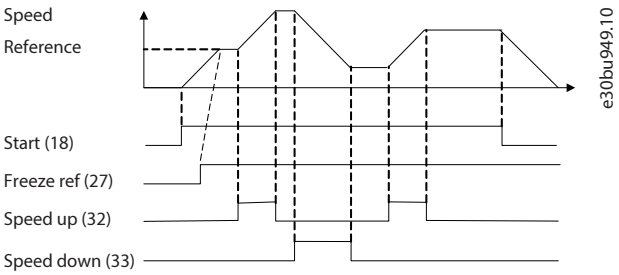
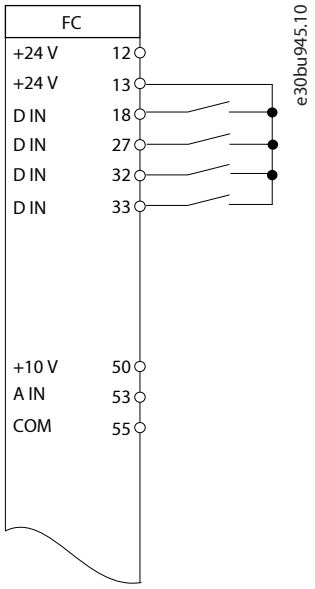


Figure 48: Speed Up/Speed Down

7.4 Start/Stop

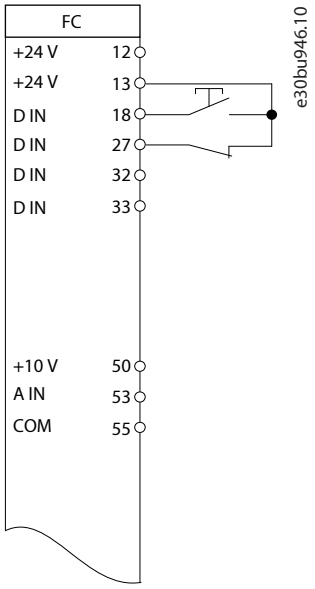
Table 52: Start/Stop with Reversing and 4 Preset Speeds



Parameters	
Function	**Setting**
Parameter 5-10 Terminal 18 Digital Input	*[8] Start*
Parameter 5-12 Terminal 27 Digital Input	*[10] Reversing*
Parameter 5-14 Terminal 32 Digital Input	*[16] Preset ref bit 0*
Parameter 5-15 Terminal 33 Digital Input	*[17] Preset ref bit 1*
Parameter 3-10 Preset Reference	
Preset ref. 0	25%
Preset ref. 1	50%
Preset ref. 2	75%
Preset ref. 3	100%
*=Default value	
Notes/comments:	

7.5 External Alarm Reset

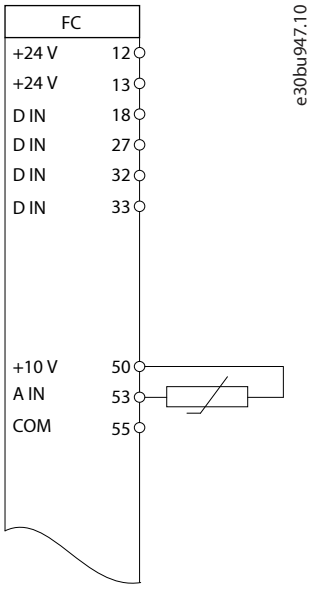
Table 53: External Alarm Reset



Parameters	
Function	**Setting**
Parameter 5-10 Terminal 18 Digital Input	*[1] Reset*
*=Default value	
Notes/comments:	

7.6 Motor Thermistor

Table 54: Motor Thermistor



Parameters	
Function	**Setting**
Parameter 1-90 Motor Thermal Protection	***[2] Thermistor trip***
Parameter 1-93 Thermistor Source	***[1] Analog input 53***
Parameter 6-19 Terminal 53 mode	***[1] Voltage***
*=Default value	

Notes/comments:

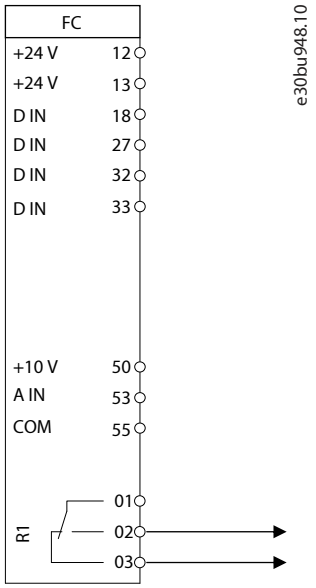
If only a warning is needed, set ***parameter 1-90 Motor Thermal Protection*** to ***[1] Thermistor warning***.

NOTICE

To meet PELV insulation requirements, use reinforced or double insulation on the thermistors.

7.7 SLC

Table 55: Using SLC to Set a Relay



Parameters	
Function	**Setting**
Parameter 4-30 Motor Feedback Loss Function	***[1] Warning***
Parameter 4-31 Motor Feedback Speed Error	50
Parameter 4-32 Motor Feedback Loss Timeout	5 s
Parameter 7-00 Speed PID Feedback Source	***[1] 24 V encoder***
Parameter 5-70 Term 32/33 Pulses Per Revolution	*1024
Parameter 13-00 SL Controller Mode	***[1] On***
Parameter 13-01 Start Event	***[19] Warning***
Parameter 13-02 Stop Event	***[44] Reset key***
Parameter 13-10 Comparator Operand	***[21] Warning no.***
Parameter 13-11 Comparator Operator	****[1] ≈***
Parameter 13-12 Comparator Value	61
Parameter 13-51 SL Controller Event	***[22] Comparator 0***
Parameter 13-52 SL Controller Action	***[32] Set digital out A low***
Parameter 5-40 Function Relay	***[80] SL digital output A***
*=Default value	
Notes/comments: If the limit in the feedback monitor is exceeded, ***warning 61, feedback monitor*** is issued. The SLC monitors ***warning 61, feedback monitor***. If ***warning 61, feedback monitor*** becomes true, relay 1 is triggered. External equipment could indicate that service is required. If the feedback error goes below the limit again within 5 s, the drive continues, and the warning disappears. Relay 1 persists until *[Off/Reset]* is pressed.	

8 Maintenance, Diagnostics, and Troubleshooting

8.1 Preventive Maintenance Recommendations

Generally, all technical equipment, including Danfoss AC drives, need a minimum level of preventive maintenance. To ensure trouble-free operation and long life of the drive, regular maintenance is recommended. It is also recommended as a good service practice to record a maintenance log with counter values, date, and time describing the maintenance and service actions.

Danfoss recommends the following inspections and service intervals for air-cooled drives/systems.

NOTICE

The service schedule for part replacements can vary depending on operating conditions. Under specific conditions, the combination of stressful operation and environmental conditions work together to reduce the lifetime of the components significantly. These conditions can include, for example, extreme temperature, dust, high humidity, hours of use, corrosive environment, and loading.

For operation in stressful conditions, Danfoss offers the DrivePro® Preventive Maintenance service. DrivePro® services extend the lifetime and increase the performance of the product with scheduled maintenance including customized part replacements. DrivePro® services are tailored to the specific application and operating conditions.

Table 56: Maintenance Schedule for Air-cooled Drives

Component	Inspection interval[1]	Service schedule[2]	Preventive maintenance actions
Installation			
Visual inspection	1 year	–	Check for the unusual, for example, for signs of overheating, aging, corrosion, and for dusty and damaged components.
Auxiliary equipment	1 year	According to manufacturer recommendations	Inspect equipment, switchgear, relays, disconnects, or fuses/circuit breakers. Examine the operation and condition for possible causes of operational faults or defects. The continuity check on fuses must be performed by trained service personnel.
EMC consideration	1 year	–	Inspect the wiring regarding the electromagnetic capability and the separation distance between control wiring and power cables.
Cable routing	1 year	–	Check for parallel routing of motor cables, mains wiring, and signal wiring. Avoid parallel routing. Avoid routing cables through free air without support. Check for aging and wearing of the cable insulation.
Control wiring	1 year	–	Check for tightness, damaged or crimped wires, or ribbon wires. Terminate the connections correctly with solid crimped ends. The use of shielded cables and grounded EMC plate, or a twisted pair is recommended.
Clearances	1 year	–	Check that the external clearances for proper airflow for cooling follow the requirements for the frame and product type. For clearances, refer to the local design regulations.
Sealing	1 year	–	Check that the sealing of the enclosure, the covers, and the cabinet doors are in good condition.
Corrosive environments	1 year	–	Conductive dust and aggressive gases, such as sulphide, chloride, and salt mist, can damage the electrical and mechanical components. Air filters do not remove airborne corrosive chemicals. Act based on the findings.

Table 56: Maintenance Schedule for Air-cooled Drives (continued)

Component	Inspection interval[1]	Service schedule[2]	Preventive maintenance actions
Drive			
Programming	1 year	–	Check that the AC drive parameter settings are correct according to the motor, drive application, and I/O configuration. Only trained service personnel are allowed to perform this action.
Control panel	1 year	–	Check that the display pixels are intact. Check the event log for warnings and faults. Repetitive events are a sign of potential issues. If necessary, contact a local service center.
Drive cooling capacity	1 year	–	Check for blockages or constrictions in the air passages of the cooling channel. The heat sinks must be free of dust and condensation.
Cleaning and filters	1 year	–	Clean the interior of the enclosure annually, and more frequently if necessary. The amount of dust in the filter or inside the enclosure is an indicator for when the next cleaning or filter replacement is required.
Fans	1 year	3–10 years	Inspect the condition and operational status of all cooling fans. With the power off, the fan axis should feel tight, and spinning the fan with a finger, the rotation should be almost silent and not have abnormal rotation resistance. When in RUN mode, fan vibration, excessive or strange noise is a sign of the bearings wearing, and the fan must be replaced.
Grounding	1 year	–	The drive system requires a dedicated ground wire connecting the drive, the output filter, and the motor to the building ground. Check that the ground connections are tight and free of paint or oxidation. Daisy-chain connections are not allowed. If applicable, braided straps are recommended.
Power cables and wiring	1 year	–	Check for loose connections, aging, insulation condition, and proper torque to the drive connections. Check for proper rating of fuses and continuity check. Observe if there are any signs of operation in a demanding environment. For example, discoloration of the fuse housing can be a sign of condensation or high temperatures.
Vibration	1 year	–	Check for abnormal vibration or noise coming from the drive to ensure that the environment is stable for electronic components.
Spare parts			
Spare parts	1 year	2 years	Stock spares in their original boxes in a dry and clean environment. Avoid hot storage areas. Electrolytic capacitors require reforming as stated in the service schedule. The reforming must be performed by trained service personnel.
Exchange units and units stored for long periods before commissioning	1 year	2 years	Visually inspect for signs of damage, water, high humidity, corrosion, and dust within the visual field of view without disassembly. The exchange units with mounted electrolytic capacitors require reforming as stated in the service schedule. The reforming must be performed by trained service personnel.

1) Defined as the time after the commissioning/startup or the time from the previous inspection.

2) Defined as the time after the commissioning/startup or the time from the previous service schedule actions.

8.2 Warning and Alarm Types

Warnings

A warning is issued when an alarm condition is impending, or when an abnormal operating condition is present and may result in the drive issuing an alarm. A warning clears by itself when the abnormal condition ceases.

Alarms

An alarm indicates a fault that requires immediate attention. The fault always triggers a trip or a trip lock. Reset the system after an alarm.

Trip

An alarm is issued when the drive is tripped, meaning that the drive suspends operation to prevent damage to the drive or system. The motor coasts to a stop. The drive logic continues to operate and monitor the drive status. After the fault condition is remedied, the drive can be reset. It is then ready to start operation again.

Trip lock

Input power is cycled. The motor coasts to a stop. The drive continues to monitor the drive status. Remove input power to the drive, correct the cause of the fault, and reset the drive.

Resetting the drive after a trip/trip lock

A trip can be reset in any of 4 ways:

- Press [Reset] on the LCP.
- Digital reset input command.
- Serial communication reset input command.
- Auto reset.

8.3 Warning and Alarm Displays

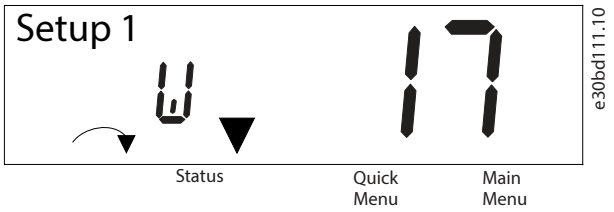


Figure 49: Warning Display

An alarm or trip lock alarm shows in the display along with the alarm number.

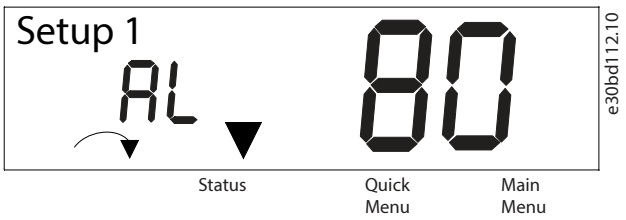


Figure 50: Alarm/Trip Lock Alarm

In addition to the text and alarm code on the drive display, there are 3 status indicator lights. The warning indicator light is yellow during a warning. The alarm indicator light is red and flashing during an alarm.

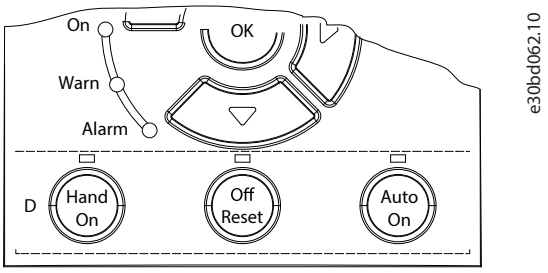


Figure 51: Status Indicator Lights

8.4 List of Warning and Alarms

8.4.1 Warning and Alarm Code List

An (X) marked in the following table indicates that the warning or alarm has occurred.

Table 57: Warnings and Alarms Code List

Number	Description	Warning	Alarm	Trip lock	Cause
2	Live zero error	X	X	–	Signal on terminal 53 or 54 is less than 50% of value set in ***parameter 6-10 Terminal 53 Low Voltage***, ***parameter 6-12 Terminal 53 Low Current***, ***parameter 6-20 Terminal 54 Low Voltage***, and ***parameter 6-22 Terminal 54 Low Current***.
3	No motor	X	–	–	No motor has been connected to the output of the drive.
4	Mains phase loss (1)	X	X	X	Missing phase on the supply side, or the voltage imbalance is too high. Check the supply voltage.
7	DC overvoltage (1)	X	X	–	DC-link voltage exceeds the limit.
8	DC undervoltage (1)	X	X	–	DC-link voltage drops below the voltage warning low limit.
9	Inverter overloaded	X	–	–	More than 100% load for too long.
10	Motor ETR overtemperature	X	X	–	Motor is too hot due to more than 100% load for too long.
11	Motor thermistor overtemperature	X	X	–	Thermistor or thermistor connection is disconnected, or the motor is too hot.
12	Torque limit	X	X	–	Torque exceeds value set in either ***parameter 4-16 Torque Limit Motor Mode*** or ***parameter 4-17 Torque Limit Generator Mode***.
13	Overcurrent	X	X	X	Inverter peak current limit is exceeded. If this alarm occurs on power-up, check whether power cables are mistakenly connected to the motor terminals.
14	Ground fault	–	X	X	Discharge from output phases to ground.
16	Short circuit	–	X	X	Short circuit in motor or on motor terminals.
17	Control word timeout	X	X	–	No communication to the drive.
25	Brake resistor short-circuited	–	X	X	Brake resistor is short-circuited, thus the brake function is disconnected.
26	Brake overload	X	X	–	The power transmitted to the brake resistor over the last 120 s exceeds the limit. Possible corrections: Decrease brake energy via lower speed or longer ramp time.

Table 57: Warnings and Alarms Code List (continued)

Number	Description	Warning	Alarm	Trip lock	Cause
27	Brake IGBT/Brake chopper short-circuited	–	X	X	Brake transistor is short-circuited, thus the brake function is disconnected.
28	Brake check	–	X	–	Brake resistor is not connected/working.
30	U phase loss	–	X	X	Motor phase U is missing. Check the phase.
31	V phase loss	–	X	X	Motor phase V is missing. Check the phase.
32	W phase loss	–	X	X	Motor phase W is missing. Check the phase.
34	Fieldbus fault	X	X	–	Fieldbus communication issues have occurred.
35	Option fault	–	X	–	Fieldbus detects internal faults.
36	Mains failure	X	X	–	This warning/alarm is only active if the supply voltage to the drive is less than the value set in ***parameter 14-11 Mains Fault Voltage Level***, and ***parameter 14-10 Mains Failure*** is NOT set to ***[0] No Function***.
38	Internal fault	–	X	X	Contact the local supplier.
40	Overload T27	X	–	–	Check the load connected to terminal 27 or remove short-circuit connection.
46	Gate drive voltage fault	–	X	X	–
47	24 V supply low	X	X	X	24 V DC may be overloaded.
49	Speed limit	–	X	–	The motor speed is below the specified limit in ***parameter 1-87 Trip Speed Low [Hz]***.
50	AMA calibration failed	–	X	–	A calibration error has occurred.
51	AMA check U_{nom} and I_{nom}	–	X	–	Wrong setting for motor voltage and/or motor current.
52	AMA low I_{nom}	–	X	–	Motor current is too low. Check the settings.
53	AMA big motor	–	X	–	The power size of the motor is too large for the AMA to operate.
54	AMA small motor	–	X	–	The power size of the motor is too small for the AMA to operate.
55	AMA parameter range	–	X	–	The parameter values of the motor are outside of the acceptable range. AMA does not run.
56	AMA interrupt	–	X	–	The AMA is interrupted.
57	AMA timeout	–	X	–	–
58	AMA internal	–	X	–	Contact local supplier.
59	Current limit	X	X	–	Drive overload.
60	External Interlock	–	X	–	External interlock has been activated.
61	Encoder loss	X	X	–	–
63	Mechanical brake low	–	X	–	Actual motor current has not exceeded release brake current within start delay time window.

Table 57: Warnings and Alarms Code List (continued)

Number	Description	Warning	Alarm	Trip lock	Cause
65	Control card temp	X	X	X	The cutout temperature of the control card has exceeded the upper limit.
67	Option change	–	X	–	A new option is detected or a mounted option is removed.
68	Safe Torque Off [2]	X	X	–	STO is activated. If STO is in manual restart mode (default), to resume normal operation, apply 24 V DC to terminals 37 and 38, and initiate a reset signal (via fieldbus, digital I/O, or *[Reset]*/*[Off Reset]* key). If STO is in automatic restart mode, applying 24 V DC to terminals 37 and 38 automatically resumes the drive to normal operation.
69	Power card temp	X	X	X	The cutout temperature of the power card has exceeded the upper limit.
80	Drive initialized to default value	–	X	–	All parameter settings are initialized to default settings.
87	Auto DC brake	X	–	–	Occurs in IT mains when the drive coasts, and the DC voltage is higher than 830 V for 400 V units and 425 V for 200 V units. The motor consumes energy on the DC link. This function can be enabled/disabled in ***parameter 0-07 Auto DC Braking***.
88	Option detection	–	X	X	The option is removed successfully.
95	Broken belt	X	X	–	–
99	Locked rotor	–	X	–	Rotor is blocked.
120	Position control fault	–	X	–	–
126	Motor rotating	–	X	–	PM motor is rotating when AMA is performed.
127	Back EMF too high	X	–	–	The back EMF of PM motor is too high before starting.
188	STO internal fault [2]	–	X	–	24 V DC supply is connected to only 1 of the 2 STO terminals (37 and 38), or a failure in STO channels is detected. Ensure that both terminals are powered by a 24 V DC supply, and that the discrepancy between the signals at the 2 terminals is less than 0.5 s. If the fault still occurs, contact the local supplier.
nw run	Not while running	–	–	–	Parameters can only be changed when the motor is stopped.
Err.	A wrong password was entered	–	–	–	Occurs when using a wrong password for changing a password-protected parameter.

1) These faults may be caused by mains distortions. Installing a Danfoss line filter may rectify this problem.

*2) This alarm cannot be reset via **parameter 14-20 Reset Mode** automatically.*

8.4.2 Alarm Words, Warning Words, and Extended Status Words

For diagnosis, read out the alarm words, warning words, and extended status words.

Table 58: Description of Alarm Word, Warning Word, and Extended Status Word

Bit	Hex	Dec	Alarm word	Alarm word 2	Alarm word 3	Warning word	Warning word 2	Extended status word	Extended status word 2
0	00000001	1	Brake check	Reserved	STO function fault	Reserved	Reserved	Ramping	Off
1	00000002	2	Pwr. card temp	Gate drive voltage fault	MM alarm	Pwr. card temp	Reserved	AMA tuning	Hand/Auto
2	00000004	4	Earth fault	Reserved	Reserved	Reserved	Reserved	Start CW/CCW	PROFIBUS OFF1 active
3	00000008	8	Ctrl. card temp	Reserved	Reserved	Ctrl. card temp	Reserved	Slowdown	PROFIBUS OFF2 active
4	00000010	16	Ctrl. word TO	Reserved	Reserved	Ctrl. word TO	Reserved	Catch up	PROFIBUS OFF3 active
5	00000020	32	Overcurrent	Reserved	Reserved	Overcurrent	Reserved	Feedback high	Reserved
6	00000040	64	Torque limit	Reserved	Reserved	Torque limit	Reserved	Feedback low	Reserved
7	00000080	128	Motor Th. over	Reserved	Reserved	Motor Th. over	Reserved	Output current high	Control ready
8	00000100	256	Motor ETR over	Broken belt	Reserved	Motor ETR over	Broken belt	Output current Low	Drive ready
9	00000200	512	Inverter overld.	Reserved	Reserved	Inverter overld.	Reserved	Output freq. high	Quick stop
10	00000400	1024	DC undervolt.	Start failed	Reserved	DC undervolt.	Reserved	Output freq. Low	DC brake
11	00000800	2048	DC overvolt.	Speed limit	Reserved	DC overvolt.	Reserved	Brake check OK	Stop
12	00001000	4096	Short circuit	External interlock	Reserved	Reserved	Reserved	Braking max	Reserved
13	00002000	8192	Reserved	Reserved	Reserved	Reserved	Reserved	Braking	Freeze output request
14	00004000	16384	Mains ph. loss	Reserved	Reserved	Mains ph. loss	Reserved	Reserved	Freeze output
15	00008000	32768	AMA not OK	Reserved	Reserved	No motor	Auto DC brake	OVC active	Jog request
16	00010000	65536	Live zero error	Reserved	Reserved	Live zero error	Reserved	AC brake	Jog
17	00020000	131072	Internal fault	Reserved	Reserved	Reserved	Reserved	Reserved	Start request
18	00040000	262144	Brake overload	Reserved	Reserved	Brake resistor power limit	Reserved	Reserved	Start

Table 58: Description of Alarm Word, Warning Word, and Extended Status Word (continued)

Bit	Hex	Dec	Alarm word	Alarm word 2	Alarm word 3	Warning word	Warning word 2	Extended status word	Extended status word 2
19	00080000	524288	U phase loss	Reserved	Reserved	Reserved	Reserved	Reference high	Reserved
20	00100000	1048576	V phase loss	Option detection	Reserved	Reserved	Overload T27	Reference Low	Start delay
21	00200000	2097152	W phase loss	Option fault	Reserved	Reserved	Reserved	Reserved	Sleep
22	00400000	4194304	Fieldbus fault	Locked rotor	Reserved	Fieldbus fault	Memory module	Reserved	Sleep boost
23	00800000	8388608	24 V supply low	Position ctrl. fault	Reserved	24 V supply low	Reserved	Reserved	Running
24	01000000	16777216	Mains failure	Reserved	Reserved	Mains failure	Reserved	Reserved	Bypass
25	02000000	33554432	Reserved	Current limit	Reserved	Current limit	Reserved	Reserved	Reserved
26	04000000	67108864	Brake resistor	Reserved	Reserved	Reserved	Reserved	Reserved	External interlock
27	08000000	134217728	Brake IGBT	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved
28	10000000	268435456	Option change	Reserved	Reserved	Encoder loss	Reserved	Reserved	FlyStart active
29	20000000	536870912	Drive initialized	Encoder loss	Reserved	Reserved	Back EMF too high	Reserved	Heat sink clean warning
30	40000000	1073741824	Safe Torque Off	Reserved	Reserved	Safe Torque Off	Reserved	Reserved	Reserved
31	80000000	2147483648	Mech. brake low	Reserved	Reserved	Reserved	Reserved	Database busy	Reserved

8.4.3 Troubleshooting

Table 59: Troubleshooting

Symptom	Possible cause	Test	Solution
Motor not running	LCP stop	Check if [Off] has been pressed.	Press [Auto On] or [Hand On] (depending on operating mode) to run the motor.
	Missing start signal (standby)	Check ***parameter 5-10 Terminal 18 Digital Input*** of correct setting for terminal 18 (use default setting).	Apply a valid start signal to start the motor.
	Motor coast signal active (coasting)	Check ***parameter 5-12 Terminal 27 Digital Input*** for correct setting of terminal 27 (use default setting).	Apply 24 V on terminal 27 or program this terminal to ***[0] No operation***.
	Wrong reference signal source	Check the following: • Is the reference signal local, remote, or bus reference? • Is preset reference active? • Is terminal connection correct? • Is the scaling of terminals correct? • Is the reference signal available?	• Program correct settings. • Set preset reference active in ***parameter group 3-1* References***. • Check for correct wiring. • Check scaling of terminals. • Check reference signal.
Motor is running in the wrong direction	Motor rotation limit	Check that ***parameter 4-10 Motor Speed Direction*** is programmed correctly.	Program correct settings.
	Active reversing signal	Check if a reversing command is programmed for the terminal in ***parameter group 5-1* Digital inputs***.	Deactivate reversing signal.
	Wrong motor phase connection	Change ***parameter 1-06 Clockwise Direction***.	–
Motor is not reaching maximum speed	Frequency limits are set incorrectly	Check output limits in ***parameter 4-14 Motor Speed High Limit [Hz]*** and ***parameter 4-19 Max Output Frequency.***	Program correct limits.
	Reference input signal not scaled correctly	Check reference input signal scaling in ***parameter group 6-** Analog I/O Mode*** and ***parameter group 3-1* References***.	Program correct settings.

Table 59: Troubleshooting (continued)

Symptom	Possible cause	Test	Solution
Motor speed is unstable	Possible incorrect parameter settings	Check the settings of all motor parameters, including all motor compensation settings. For closed-loop operation, check PID settings.	Check settings in ***parameter group 6-** Analog I/O Mode***.
Motor runs roughly	Possible overmagnetization	Check for incorrect motor settings in all motor parameters.	Check motor settings in ***parameter groups 1-2* Motor data***, ***1-3* Adv motor data***, and ***1-5* Load indep. setting***.
Motor does not brake	Possible incorrect settings in the brake parameters. Possible too short ramp-down times.	Check brake parameters. Check ramp time settings.	Check ***parameter groups 2-0* DC brake*** and ***3-0* Reference limits***.
Open power fuses or circuit breaker trip	Phase-to-phase short	Motor or panel has a short phase-to-phase. Check motor and panel phase for shorts.	Eliminate any shorts detected.
	Motor overload	Motor is overloaded for the application.	Perform the start-up test and verify that motor current is within specifications. If motor current is exceeding nameplate full load current, the motor may run only with reduced load. Review the specifications for the application.
	Loose connections	Perform pre-start-up check for loose connections.	Tighten loose connections.
Mains current imbalance greater than 3%	Problem with mains power (see ***Alarm 4, Mains phase loss*** description)	Rotate input power leads into the drive 1 position: A to B, B to C, C to A.	If the imbalanced leg follows the wire, it is a power problem. Check mains supply.
	Problem with the drive unit	Rotate input power leads into the drive 1 position: A to B, B to C, C to A.	If the imbalanced leg stays on same input terminal, it is a problem with the unit. Contact the supplier.
Motor current imbalance greater than 3%	Problem with motor or motor wiring	Rotate output motor cables 1 position: U to V, V to W, W to U.	If the imbalanced leg follows the wire, the problem is in the motor or motor wiring. Check motor and motor wiring.
	Problem with the drive unit	Rotate output motor cables 1 position: U to V, V to W, W to U.	If the imbalanced leg stays on same output terminal, it is a problem with the unit. Contact the supplier.

Table 59: Troubleshooting (continued)

Symptom	Possible cause	Test	Solution
Acoustic noise or vibration (for example a fan blade is making noise or vibrations at certain frequencies)	Resonances, for example, in the motor/fan system	Bypass critical frequencies by using parameters in ***parameter group 4-6* Speed Bypass***.	Check if noise and/or vibration have been reduced to an acceptable limit.
		Turn off overmodulation in ***parameter 14-03 Overmodulation***.	
		Increase resonance damping in ***parameter 1-64 Resonance Damping***.	

9 Specification

9.1 Electrical Data

Table 60: Mains Supply 3x380–480 V AC

Drive	PK37	PK55	PK75	P1K1	P1K5	P2K2	P3K0
Typical shaft output [kW]	0.37	0.55	0.75	1.1	1.5	2.2	3.0
Typical shaft output [hp]	0.5	0.75	1.0	1.5	2.0	3.0	4.0
Enclosure protection rating IP20 (IP21/Type 1 as option)	K1	K1	K1	K1	K1	K1	K2
Output current							
Shaft output [kW]	0.37	0.55	0.75	1.1	1.5	2.2	3
Continuous (3x380–440 V) [A]	1.2	1.7	2.2	3	3.7	5.3	7.2
Continuous (3x441–480 V) [A]	1.1	1.6	2.1	2.8	3.4	4.8	6.3
Intermittent (60 s overload) [A]	1.9	2.7	3.5	4.8	5.9	8.5	11.5
Continuous kVA (400 V AC) [kVA]	0.9	1.2	1.5	2.1	2.6	3.7	5.0
Continuous kVA (480 V AC) [kVA]	0.9	1.3	1.7	2.5	2.8	4.0	5.2
Maximum input current							
Continuous (3x380–440 V) [A]	1.2	1.6	2.1	2.6	3.5	4.7	6.3
Continuous (3x441–480 V) [A]	1.0	1.2	1.8	2.0	2.9	3.9	4.3
Intermittent (60 s overload) [A]	1.9	2.6	3.4	4.2	5.6	7.5	10.1
More specifications							
Maximum cable cross-section (mains, motor, brake, and load sharing) [mm^2 (AWG)]	4 (12)						
Estimated power loss at rated maximum load [W][(1)]	20.9	25.2	30	40	52.9	74	94.8
Weight, enclosure protection rating IP20 [kg (lb)]	2.3 (5.1)	2.3 (5.1)	2.3 (5.1)	2.3 (5.1)	2.3 (5.1)	2.5 (5.5)	3.6 (7.9)
Weight, enclosure protection rating IP21 [kg (lb)]	4.0 (8.8)	4.0 (8.8)	4.0 (8.8)	4.0 (8.8)	4.0 (8.8)	4.0 (8.8)	5.5 (12.1)
Efficiency [%][(2)]	96.0	96.6	96.8	97.2	97.0	97.5	98.0

1) The typical power loss is at nominal load conditions and expected to be within ±15% (tolerance relates to variety in voltage and cable conditions). Values are based on a typical motor efficiency (IE2/IE3 border line). Motors with lower efficiency add to the power loss in the drive, and motors with high efficiency reduce power loss. Applies to dimensioning of drive cooling. If the switching frequency is higher than the default setting, the power losses sometimes rise. LCP and typical control card power consumptions are included. Further options and customer load sometimes add up to 30 W to the losses (though typically only 4 W extra for a fully loaded control card or fieldbus). For power loss data according to EN 50598-2, refer to https://ecosmart.mydrive.danfoss.com/.

2) Measured using 50 m (164 ft) shielded motor cables at rated load and rated frequency. For energy efficiency class, see chapter Ambient Conditions. For part load losses, see https://ecosmart.mydrive.danfoss.com/.

Table 61: Mains Supply 3x380–480 V AC

Drive	P4K0	P5K5	P7K5	P11K	P15K	P18K	P22K
Typical shaft output [kW]	4.0	5.5	7.5	11	15	18.5	22
Typical shaft output [hp]	5.5	7.5	10	15	20	25	30

Table 61: Mains Supply 3x380–480 V AC (continued)

Drive	P4K0	P5K5	P7K5	P11K	P15K	P18K	P22K
Enclosure protection rating IP20 (IP21/ Type 1 as option)	K2	K2	K3	K4	K4	K5	K5
Output current							
Shaft output	4	5.5	7.5	11	15	18.5	22
Continuous (3x380–440 V) [A]	9	12	15.5	23	31	37	42.5
Continuous (3x441–480 V) [A]	8.2	11	14	21	27	34	40
Intermittent (60 s overload) [A]	14.4	19.2	24.8	34.5	46.5	55.5	63.8
Continuous kVA (400 V AC) [kVA]	6.2	8.3	10.7	15.9	21.5	25.6	29.5
Continuous kVA (480 V AC) [kVA]	6.8	9.1	11.6	17.5	22.4	28.3	33.3
Maximum input current							
Continuous (3x380–440 V) [A]	8.3	11.2	15.1	22.1	29.9	35.2	41.5
Continuous (3x441–480 V) [A]	6.8	9.4	12.6	18.4	24.7	29.3	34.6
Intermittent (60 s overload) [A]	13.3	17.9	24.2	33.2	44.9	52.8	62.3
More specifications							
Maximum cable cross-section (mains, motor, brake, and load sharing) [mm^2 (AWG)]	4 (12)			16 (6)			
Estimated power loss at rated maximum load [W](1)	115.5	157.5	192.8	289.5	393.4	402.8	467.5
Weight enclosure protection rating IP20 [kg (lb)]	3.6 (7.9)	3.6 (7.9)	4.1 (9.0)	9.4 (20.7)	9.5 (20.9)	12.3 (27.1)	12.5 (27.6)
Weight enclosure protection rating IP21 [kg (lb)]	5.5 (12.1)	5.5 (12.1)	6.5 (14.3)	10.5 (23.1)	10.5 (23.1)	14.0 (30.9)	14.0 (30.9)
Efficiency [%](2)	98.0	97.8	97.7	98.0	98.1	98.0	98.0

1) The typical power loss is at nominal load conditions and expected to be within ±15% (tolerance relates to variety in voltage and cable conditions). Values are based on a typical motor efficiency (IE2/IE3 border line). Motors with lower efficiency add to the power loss in the drive, and motors with high efficiency reduce power loss. Applies to dimensioning of drive cooling. If the switching frequency is higher than the default setting, the power losses sometimes rise. LCP and typical control card power consumptions are included. Further options and customer load sometimes add up to 30 W to the losses (though typically only 4 W extra for a fully loaded control card or fieldbus). For power loss data according to EN 50598-2, refer to https://ecosmart.mydrive.danfoss.com/.

2) Measured using 50 m (164 ft) shielded motor cables at rated load and rated frequency. For energy efficiency class, see chapter Ambient Conditions. For part load losses, see https://ecosmart.mydrive.danfoss.com/.

Table 62: Mains Supply 3x200–240 V AC

Drive	PK37	PK55	PK75	P1K1	P1K5	P2K2	P3K7
Typical shaft output [kW]	0.37	0.55	0.75	1.1	1.5	2.2	3.7
Typical shaft output [hp]	0.5	0.75	1.0	1.5	2.0	3.0	5.0
Enclosure protection rating IP20 (IP21/Type 1 as option)	K1	K1	K1	K1	K1	K2	K3
Output current							
Continuous (3x200–240 V) [A]	2.2	3.2	4.2	6	6.8	9.6	15.2
Intermittent (60 s overload) [A]	3.5	5.1	6.7	9.6	10.9	15.4	24.3
Continuous kVA (230 V AC) [kVA]	0.9	1.3	1.7	2.4	2.7	3.8	6.1

Table 62: Mains Supply 3x200–240 V AC (continued)

Drive	PK37	PK55	PK75	P1K1	P1K5	P2K2	P3K7
Maximum input current							
Continuous (3x200–240 V) [A]	1.8	2.7	3.4	4.7	6.3	8.8	14.3
Intermittent (60 s overload) [A]	2.9	4.3	5.4	7.5	10.1	14.1	22.9
More specifications							
Maximum cable cross-section (mains, motor, brake, and load sharing) [mm^2 (AWG)]	4 (12)						
Estimated power loss at rated maximum load [W](1)	29.4	38.5	51.1	60.7	76.1	96.1	147.5
Weight enclosure protection rating IP20 [kg (lb)]	2.3 (5.1)	2.3 (5.1)	2.3 (5.1)	2.3 (5.1)	2.3 (5.1)	2.5 (5.5)	3.6 (7.9)
Weight enclosure protection rating IP21 [kg (lb)]	4.0 (8.8)	4.0 (8.8)	4.0 (8.8)	4.0 (8.8)	4.0 (8.8)	5.5 (12.1)	6.5 (14.3)
Efficiency [%](2)	96.4	96.6	96.3	96.6	96.5	96.7	96.7

1) The typical power loss is at nominal load conditions and expected to be within ±15% (tolerance relates to variety in voltage and cable conditions). Values are based on a typical motor efficiency (IE2/IE3 border line). Motors with lower efficiency add to the power loss in the drive, and motors with high efficiency reduce power loss. Applies to dimensioning of drive cooling. If the switching frequency is higher than the default setting, the power losses sometimes rise. LCP and typical control card power consumptions are included. Further options and customer load sometimes add up to 30 W to the losses (though typically only 4 W extra for a fully loaded control card or fieldbus). For power loss data according to EN 50598-2, refer to https://ecosmart.mydrive.danfoss.com/.

2) Measured using 50 m (164 ft) shielded motor cables at rated load and rated frequency. For energy efficiency class, see chapter Ambient Conditions. For part load losses, see https://ecosmart.mydrive.danfoss.com/.

Table 63: Mains Supply 1x200–240 V AC

Drive	PK37	PK55	PK75	P1K1	P1K5	P2K2
Typical shaft output [kW]	0.37	0.55	0.75	1.1	1.5	2.2
Typical shaft output [hp]	0.5	0.75	1.0	1.5	2.0	3.0
Enclosure protection rating IP20 (IP21/Type 1 as option)	K1	K1	K1	K1	K1	K2
Output current						
Continuous (3x200–240 V) [A]	2.2	3.2	4.2	6	6.8	9.6
Intermittent (60 s overload) [A]	3.5	5.1	6.7	9.6	10.9	15.4
Continuous kVA (230 V AC) [kVA]	0.9	1.3	1.7	2.4	2.7	3.8
Maximum input current						
Continuous (1x200–240 V) [A]	2.9	4.4	5.5	7.7	10.4	14.4
Intermittent (60 s overload) [A]	4.6	7.0	8.8	12.3	16.6	23.0
More specifications						
Maximum cable cross-section (mains and motor) [mm^2 (AWG)]	4 (12)					
Estimated power loss at rated maximum load [W](1)	37.7	46.2	56.2	76.8	97.5	121.6
Weight enclosure protection rating IP20 [kg (lb)]	2.3 (5.1)	2.3 (5.1)	2.3 (5.1)	2.3 (5.1)	2.3 (5.1)	2.5 (5.5)

Table 63: Mains Supply 1x200–240 V AC (continued)

Drive	PK37	PK55	PK75	P1K1	P1K5	P2K2
Weight enclosure protection rating IP21 [kg (lb)]	4.0 (8.8)	4.0 (8.8)	4.0 (8.8)	4.0 (8.8)	4.0 (8.8)	5.5 (12.1)
Efficiency [%][2]	94.4	95.1	95.1	95.3	95.0	95.4

1) *The typical power loss is at nominal load conditions and expected to be within ±15% (tolerance relates to variety in voltage and cable conditions). Values are based on a typical motor efficiency (IE2/IE3 border line). Motors with lower efficiency add to the power loss in the drive, and motors with high efficiency reduce power loss. Applies to dimensioning of drive cooling. If the switching frequency is higher than the default setting, the power losses sometimes rise. LCP and typical control card power consumptions are included. Further options and customer load sometimes add up to 30 W to the losses (though typically only 4 W extra for a fully loaded control card or fieldbus). For power loss data according to EN 50598-2, refer to https://ecosmart.mydrive.danfoss.com/.*

2) *Measured using 50 m (164 ft) shielded motor cables at rated load and rated frequency. For energy efficiency class, see chapter Ambient Conditions. For part load losses, see https://ecosmart.mydrive.danfoss.com/.*

9.2 Mains Supply

Supply terminals	(L1/N, L2/L, L3)
Supply voltage	380–480 V: -15% (-25%)[1] to +10%
Supply voltage	200–240 V: -15% (-25%)[1] to +10%
Supply frequency	50/60 Hz ±5%
Maximum imbalance temporary between mains phases	3.0% of rated supply voltage
True power factor (λ)	≥0.9 nominal at rated load
Displacement power factor (cos Φ)	Near unity (>0.98)
Switching on input supply (L1/N, L2/L, L3) (power-ups) ≤7.5 kW (10 hp)	Maximum 2 times/minute
Switching on input supply (L1/N, L2/L, L3) (power-ups) 11–22 kW (15–30 hp)	Maximum 1 time/minute

1) *The drive can run at -25% input voltage with reduced performance. The maximum output power of the drive is 75% if input voltage is -25%, and 85% if input voltage is -15%. Full torque cannot be expected at mains voltage lower than 10% below the lowest rated supply voltage of the drive.*

9.3 Motor Output and Motor Data

9.3.1 Motor Output (U, V, W)

Output voltage	0–100% of supply voltage
Output frequency	0–500 Hz
Output frequency in VVC$^+$ mode	0–200 Hz
Switching on output	Unlimited
Ramp time	0.01–3600 s

9.3.2 Torque Characteristics

Starting torque (constant torque)	Maximum 160% for 60 s[1]
Overload torque (constant torque)	Maximum 160% for 60 s[1]
Starting current	Maximum 200% for 1 s

Torque rise time in VVC$^+$ (independent of f_{sw})	Maximum 50 ms

1) Percentage relates to the nominal torque. It is 150% for 11–22 kW (15–30 hp) drives.

9.4 Ambient Conditions

Enclosure protection rating, drive	IP20 (IP21/Type 1 as option)
Enclosure protection rating, conversion kit	IP21/Type 1
Vibration test, all enclosure sizes	1.14 g
Relative humidity	5–95% (IEC 721-3-3; Class 3K3 (non-condensing) during operation)
Ambient temperature (at DPWM switching mode)	
- with derating	Maximum 55 °C (131 °F)[1), 2), 3)]
- at full continuous output current	Maximum 45 °C (113 °F)[4)]
Minimum ambient temperature during full-scale operation	0 °C (32 °F)
Minimum ambient temperature at reduced performance	-10 °C (14 °F)
Temperature during storage/transport	-25 to +65/70 °C (-13 to +149/158 °F)
Maximum altitude above sea level without derating	1000 m (3280 ft)
Maximum altitude above sea level with derating	3000 m (9843 ft)
EMC standards, emission	EN 61800-3, EN 61000-3-2, EN 61000-3-3, EN 61000-3-11, EN 61000-3-12, EN 61000-6-3/4, EN 55011
EMC standards, immunity	EN 61800-3, EN 61000-6-1/2, EN 61000-4-2, EN 61000-4-3, EN 61000-4-4, EN 61000-4-5, EN 61000-4-6, EN 61800-5-2
Energy efficiency class	IE2

1) Refer to chapter Special Conditions in the design guide for:

- Derating for high ambient temperature;
- Derating for high altitude.

2) To prevent control card overtemperature on PROFIBUS, PROFINET, EtherNet/IP, EtherCAT, and POWERLINK variants of VLT® Midi Drive FC 280, avoid full digital/analog I/O load at ambient temperature higher than 45 °C (113 °F).

3) Ambient temperature for K1S2 with derating is maximum 50 °C (122 °F).

4) Ambient temperature for K1S2 at full constant output current is maximum 40 °C (104 °F).

5) Determined according to EN 50598-2 at:

- Rated load;
- 90% rated frequency;
- Switching frequency factory setting;
- Switching pattern factory setting;
- Open type: Surrounding air temperature 45 °C (113 °F);
- Type 1 (NEMA kit): Ambient temperature 45 °C (113 °F).

9.5 Cable Specifications

Maximum motor cable length, shielded	50 m (164 ft)
Maximum motor cable length, unshielded	75 m (246 ft)
Maximum cross-section of control terminals, flexible/rigid wire	2.5 mm^2/14 AWG
Minimum cross-section to control terminals	0.55 mm^2/30 AWG
Maximum STO input cable length, unshielded	20 m (66 ft)

For power cables cross-sections, see the tables in 9.1 Electrical Data. When complying with EN 55011 1A and EN 55011 1B, the motor cable must in certain instances be reduced. See *chapter EMC Emission* in the design guide for more details.

9.6 Control Input/Output and Control Data

9.6.1 Digital Inputs

Terminal number	18, 27[1], 32, 33
Logic	PNP or NPN
Voltage level	0–24 V DC
Voltage level, logic 0 PNP	< 5 V DC
Voltage level, logic 1 PNP	> 10 V DC
Voltage level, logic 0 NPN	> 19 V DC
Voltage level, logic 1 NPN	< 14 V DC
Maximum voltage on input	28 V DC
Pulse frequency range	4–32 kHz
(Duty cycle) minimum pulse width	4.5 ms
Input resistance, R_i	Approximately 4 kΩ

1) Terminals 27 can also be programmed as output.

9.6.2 Safety Inputs

Terminal number	37, 38, 39[1]
Voltage level	0–24 V DC
Voltage level, de-energized	< 1.8 V DC
Voltage level, energized	> 20 V DC
Maximum voltage on input	30 V DC
Minimum current for disabling STO (each pin)	6 mA
Debouncing time	≤ 5 ms
Discrepancy tolerance	≤ 0.5 s

1) Terminal 39 is the common ground of safety input, which is galvanically isolated from analog/digital input or output.

Refer to *chapter 6 Safe Functions* for more details about safety inputs.

9.6.3 Analog Inputs

Number of analog inputs	1
Terminal number	53[1]
Modes	Voltage or current
Mode select	Software
Voltage level	0–10 V
Input resistance, R_i	Approximately 10 kΩ
Maximum voltage	-15 to +20 V

Current level	0/4 to 20 mA (scaleable)
Input resistance, R_i	Approximately 200 Ω
Maximum current	30 mA
Resolution for analog inputs	11 bit
Accuracy of analog inputs	Maximum error 0.5% of full scale
Bandwidth	100 Hz

1) Terminal 53 supports only voltage mode and can also be used as digital input.

The analog inputs are galvanically isolated from the supply voltage (PELV) and other high-voltage terminals.

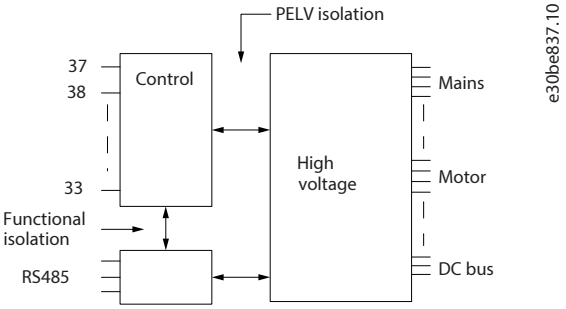


Figure 52: Galvanic Isolation

NOTICE

HIGH ALTITUDE

For installation at altitudes above 2000 m (6562 ft), contact Danfoss hotline regarding PELV.

9.6.4 Pulse Inputs

Programmable pulse inputs	1
Terminal number pulse	33
Maximum frequency at terminal 33	32 kHz (push-pull driven)
Maximum frequency at terminal 33	5 kHz (open collector)
Minimum frequency at terminal 33	4 Hz
Voltage level	See the section on digital input
Maximum voltage on input	28 V DC
Input resistance, R_i	Approximately 4 kΩ
Pulse input accuracy	Maximum error: 0.1% of full scale

9.6.5 Digital Outputs

Programmable digital/pulse outputs	1
Terminal number	27(1)
Voltage level at digital/frequency output	0–24 V
Maximum output current (sink or source)	40 mA
Maximum load at frequency output	1 kΩ

Maximum capacitive load at frequency output	10 nF
Minimum output frequency at frequency output	4 Hz
Maximum output frequency at frequency output	32 kHz
Accuracy of frequency output	Maximum error: 0.1% of full-scale
Resolution of frequency output	10 bit

1) Terminal 27 can also be programmed as input.

The digital output is galvanically isolated from the supply voltage (PELV) and other high-voltage terminals.

9.6.6 Control Card, 24 V DC Output

Terminal number	12, 13
Maximum load	100 mA

The 24 V DC supply is galvanically isolated from the supply voltage (PELV). However, the supply has the same potential as the analog and digital inputs and outputs.

9.6.7 Control Card, +10 V DC Output

Terminal number	50
Output voltage	10.5 V ±0.5 V
Maximum load	15 mA

The 10 V DC supply is galvanically isolated from the supply voltage (PELV) and other high-voltage terminals.

9.6.8 Control Card, RS485 Serial Communication

Terminal number	68 (P, TX+, RX+), 69 (N, TX-, RX-)
Terminal number 61	Common for terminals 68 and 69

The RS485 serial communication circuit is galvanically isolated from the supply voltage (PELV). It is used in production, and not recommended for fieldbus application.

9.6.9 Control Card, USB Serial Communication

USB standard	1.1 (full speed)
USB plug	USB type B plug

Connection to the PC is carried out via a standard host/device USB cable.

The USB connection is galvanically isolated from the supply voltage (PELV) and other high-voltage terminals.

The USB ground connection is not galvanically isolated from protective earth. Use only an isolated laptop as PC connection to the USB connector on the drive.

9.6.10 Relay Outputs

Programmable relay outputs	1
Relay 01	01–03 (NC), 01–02 (NO)
Maximum terminal load (AC-1)[1] on 01–02 (NO) (resistive load)	250 V AC, 3 A
Maximum terminal load (AC-15)[1] on 01–02 (NO) (inductive load @ cosφ 0.4)	250 V AC, 0.2 A
Maximum terminal load (DC-1)[1] on 01–02 (NO) (resistive load)	30 V DC, 2 A
Maximum terminal load (DC-13)[1] on 01–02 (NO) (inductive load)	24 V DC, 0.1 A
Maximum terminal load (AC-1)[1] on 01–03 (NC) (resistive load)	250 V AC, 3 A
Maximum terminal load (AC-15)[1] on 01–03 (NC) (inductive load @ cosφ 0.4)	250 V AC, 0.2 A
Maximum terminal load (DC-1)[1] on 01–03 (NC) (resistive load)	30 V DC, 2 A
Minimum terminal load on 01–03 (NC), 01–02 (NO)	24 V DC 10 mA, 24 V AC 20 mA

1) IEC 60947 parts 4 and 5.

The relay contacts are galvanically isolated from the rest of the circuit by reinforced isolation.

9.6.11 Control Card Performance

Scan interval	1 ms

9.6.12 Control Characteristics

Resolution of output frequency at 0–500 Hz	±0.003 Hz
System response time (terminals 18, 27, 32, and 33)	≤2 ms
Speed control range (open loop)	1:100 of synchronous speed
Speed accuracy (open loop)	±0.5% of nominal speed
Speed accuracy (closed loop)	±0.1% of nominal speed

All control characteristics are based on a 4-pole asynchronous motor.

9.7 Connection Tightening Torques

Make sure to use the right torques when tightening all electrical connections. Too low or too high torque sometimes causes electrical connection problems. To ensure that correct torques are applied, use a torque wrench. Recommended slot screwdriver type is SZS 0.6x3.5 mm.

Table 64: Tightening Torques

Enclosure size	Power [kW (hp)]	Torque [Nm (in-lb)]						
		Mains	Motor	DC connection	Brake	Ground	Control	Relay
K1	0.37–2.2 (0.5–3.0)	0.8 (7.1)	0.8 (7.1)	0.8 (7.1)	0.8 (7.1)	1.6 (14.2)	0.4 (3.5)	0.5 (4.4)
K2	3.0–5.5 (4.0–7.5)	0.8 (7.1)	0.8 (7.1)	0.8 (7.1)	0.8 (7.1)	1.6 (14.2)	0.4 (3.5)	0.5 (4.4)
K3	7.5 (10)	0.8 (7.1)	0.8 (7.1)	0.8 (7.1)	0.8 (7.1)	1.6 (14.2)	0.4 (3.5)	0.5 (4.4)
K4	11–15 (15–20)	1.2 (10.6)	1.2 (10.6)	1.2 (10.6)	1.2 (10.6)	1.6 (14.2)	0.4 (3.5)	0.5 (4.4)
K5	18.5–22 (25–30)	1.2 (10.6)	1.2 (10.6)	1.2 (10.6)	1.2 (10.6)	1.6 (14.2)	0.4 (3.5)	0.5 (4.4)

9.8 Fuses and Circuit Breakers

9.8.1 Introduction

Use fuses and/or circuit breakers on the supply side to protect service personnel and equipment from injuries and damage if there is component breakdown inside the drive (first fault).

Branch circuit protection

Protect all branch circuits in an installation, switchgear, and machines against short circuit and overcurrent according to national/international regulations.

NOTICE

Integral solid-state short-circuit protection does not provide branch circuit protection. Provide branch circuit protection in accordance with the national and local rules and regulations.

⚠ WARNING

PERSONAL INJURY AND EQUIPMENT DAMAGE RISK

Malfunction or failing to follow the recommendations may result in personal risk and damage to the drive and other equipment.

- Select fuses according to recommendations. Possible damages can be limited to be inside the drive.

9.8.2 Recommendation of Fuses

NOTICE

EQUIPMENT DAMAGE

Failure to follow the protection recommendations can result in damage to the drive.

- Using fuses and/or circuit breakers is mandatory to ensure compliance with IEC 60364 for CE.

Danfoss recommends using the fuses and circuit breakers in the following tables to ensure compliance with UL 508C or IEC 61800-5-1. For non-UL applications, design circuit breakers for protection in a circuit capable of delivering a maximum of 50000 A_{rms} (symmetrical), 240 V/400 V maximum. The drive short-circuit current rating (SCCR) is suitable for use on a circuit capable of delivering not more than 100000 A_{rms}, 240 V/480 V maximum when protected by Class T fuses.

The following tables list the recommended fuses that have been tested.

Table 65: Non-UL Fuse and Circuit Breaker

Enclosure size		Power [kW (hp)]	Non-UL fuse	Non-UL circuit breaker (Eaton)
3-phase 380–480 V	K1	0.37 (0.5)	gG-10	PKZM0-16
		0.55–0.75 (0.75–1.0)		
		1.1–1.5 (1.5–2.0)	gG-20	
		2.2 (3.0)		
	K2	3.0–5.5 (4.0–7.5)	gG-25	PKZM0-20
	K3	7.5 (10)		PKZM0-25
	K4	11–15 (15–20)	gG-50	–
	K5	18.5–22 (25–30)	gG-80	–
3-phase 200–240 V	K1	0.37 (0.5)	gG-10	PKZM0-16
		0.55 (0.75)	gG-20	
		0.75 (1.0)		
		1.1 (1.5)		
		1.5 (2.0)		
	K2	2.2 (3.0)	gG-25	PKZM0-20
	K3	3.7 (5.0)		PKZM0-25
Single-phase 200–240 V	K1	0.37 (0.5)	gG-10	PKZM0-16
		0.55 (0.75)	gG-20	
		0.75 (1.0)		
		1.1 (1.5)		
		1.5 (2.0)		
	K2	2.2 (3.0)	gG-25	PKZM0-20

Table 66: UL fuse

Enclosure size		Power [kW (hp)]	Bussmann E4273						Littelfuse E81895	MERSEN E163267/ E2137	MERSEN E163267/ E2138
			Class RK1	Class J	Class T	Class CC	Class CC	Class CC	Class RK1	Class CC	Class RK1
3-phase 380–480 V	K1	0.37–0.75 (0.5–1.0)	KTS-R-6	JKS-6	JJS-6	FNQ-R-6	KTK-R-6	LP-CC-6	KLSR-6	ATM-R6	A6K-6R
		1.1–1.5 (1.5–2.0)	KTS-R-10	JKS-10	JJS-10	FNQ-R-10	KTK-R-10	LP-CC-10	KLSR-10	ATM-R10	A6K-10R
		2.2 (3.0)	KTS-R-15	JKS-15	JJS-15	FNQ-R-15	KTK-R-15	LP-CC-15	KLSR-15	ATM-R15	A6K-15R
	K2–K3	3.0–7.5 (4.0–10)	KTS-R-25	JKS-25	JJS-25	FNQ-R-25	KTK-R-25	LP-CC-25	KLSR-25	ATM-R25	A6K-25R
	K4	11–15 (15–20)	KTS-R-50	JKS-50	JJS-50	–	–	–	KLSR-50	–	A6K-50R
	K5	18.5–22 (25–30)	–	JKS-80	JJS-80	–	–	–	–	–	–
3-phase 200–240 V	K1	0.37 (0.5)	KTN-R-6	JKS-6	JJN-6	FNQ-R-6	KTK-R-6	LP-CC-6	KLNR-6	ATM-R6	A2K-6R
		0.55 (0.75)	KTN-R-10	JKS-10	JJN-10	FNQ-R-10	KTK-R-10	LP-CC-10	KLNR-10	ATM-R10	A2K-10R
		0.75 (1.0)	KTN-R-15	JKS-15	JJN-15	FNQ-R-15	KTK-R-15	LP-CC-15	KLNR-15	ATM-R15	A2K-15R
		1.1–1.5 (1.5–2.0)	KTN-R-20	JKS-20	JJN-20	FNQ-R-20	KTK-R-20	LP-CC-20	KLNR-20	ATM-R20	A2K-20R
	K2–K3	2.2–3.7 (3.0–5.0)	KTN-R-25	JKS-25	JJN-25	–	–	–	KLNR-25	ATM-R25	A2K-25R
Single-phase 200–240 V	K1	0.37 (0.5)	KTN-R-6	JKS-6	JJN-6	FNQ-R-6	KTK-R-6	LP-CC-6	KLNR-6	ATM-R6	A2K-6R
		0.55 (0.75)	KTN-R-10	JKS-10	JJN-10	FNQ-R-10	KTK-R-10	LP-CC-10	KLNR-10	ATM-R10	A2K-10R
		0.75 (1.0)	KTN-R-15	JKS-15	JJN-15	FNQ-R-15	KTK-R-15	LP-CC-15	KLNR-15	ATM-R15	A2K-15R
		1.1–1.5 (1.5–2.0)	KTN-R-20	JKS-20	JJN-20	FNQ-R-20	KTK-R-20	LP-CC-20	KLNR-20	ATM-R20	A2K-20R
	K2	2.2 (3.0)	KTN-R-25	JKS-25	JJN-25	–	–	–	KLNR-25	ATM-R25	A2K-25R

9.9 Enclosure Sizes, Power Ratings, and Dimensions

Table 67: Enclosure Sizes, Power Ratings, and Dimensions

	Enclosure size	K1						K2			K3	K4		K5	
Power size [kW (hp)]	Single-phase 200–240 V	0.37 (0.5)	0.55 (0.75)	0.75 (1.0)	1.1 (1.5)	1.5 (2.0)		2.2 (3.0)			–	–		–	
	3-phase 200–240 V	0.37 (0.5)	0.55 (0.75)	0.75 (1.0)	1.1 (1.5)	1.5 (2.0)		2.2 (3.0)			3.7 (5.0)	–		–	
	3-phase 380–480 V	0.37 (0.5)	0.55 (0.75)	0.75 (1.0)	1.1 (1.5)	1.5 (2.0)	2.2 (3.0)	3 (4.0)	4 (5.5)	5.5 (7.5)	7.5 (10)	11 (15)	15 (20)	18.5 (25)	22 (30)
Dimensions [mm (in)]	**FC 280 IP20**														
	Height A1	210 (8.3)						272.5 (10.7)			272.5 (10.7)	317.5 (12.5)		410 (16.1)	
	Height A2	278 (10.9)						340 (13.4)			341.5 (13.4)	379.5 (14.9)		474 (18.7)	
	Width B	75 (3.0)						90 (3.5)			115 (4.5)	133 (5.2)		150 (5.9)	
	Depth C	171 (6.7)						171 (6.7)			171 (6.7)	248 (9.8)		248 (9.8)	
	FC 280 with IP21/UL/Type 1 kit														
	Height A	338.5 (13.3)						395 (15.6)			395 (15.6)	425 (16.7)		520 (20.5)	
	Width B	100 (3.9)						115 (4.5)			130 (5.1)	153 (6.0)		170 (6.7)	
	Depth C	183 (7.2)						183 (7.2)			183 (7.2)	260 (10.2)		260 (10.2)	
	FC 280 with bottom cable entry cover (w/o top cover)														
	Height A	294 (11.6)						356 (14)			357 (14.1)	391 (15.4)		486 (19.1)	
	Width B	75 (3.0)						90 (3.5)			115 (4.5)	133 (5.2)		150 (5.9)	
	Depth C	171 (6.7)						171 (6.7)			171 (6.7)	248 (9.8)		248 (9.8)	
Weight [kg (lb)]	IP20	2.5 (5.5)						3.6 (7.9)			4.6 (10.1)	8.2 (18.1)		11.5 (25.4)	
	IP21	4.0 (8.8)						5.5 (12.1)			6.5 (14.3)	10.5 (23.1)		14.0 (30.9)	

Table 67: Enclosure Sizes, Power Ratings, and Dimensions (continued)

	Enclosure size	K1	K2	K3	K4	K5
Mounting holes [mm (in)]	a	198 (7.8)	260 (10.2)	260 (10.2)	297.5 (11.7)	390 (15.4)
	b	60 (2.4)	70 (2.8)	90 (3.5)	105 (4.1)	120 (4.7)
	c	5 (0.2)	6.4 (0.25)	6.5 (0.26)	8 (0.32)	7.8 (0.31)
	d	9 (0.35)	11 (0.43)	11 (0.43)	12.4 (0.49)	12.6 (0.5)
	e	4.5 (0.18)	5.5 (0.22)	5.5 (0.22)	6.8 (0.27)	7 (0.28)
	f	7.3 (0.29)	8.1 (0.32)	9.2 (0.36)	11 (0.43)	11.2 (0.44)

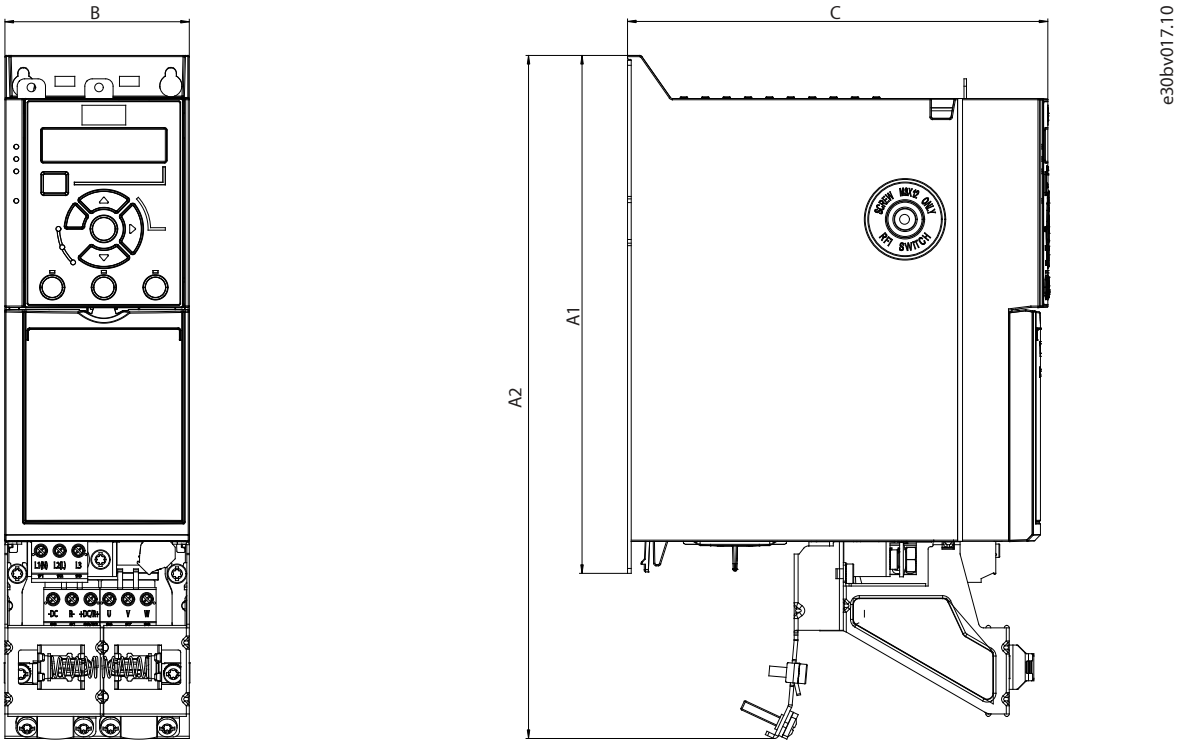


Figure 53: Standard with Decoupling Plate

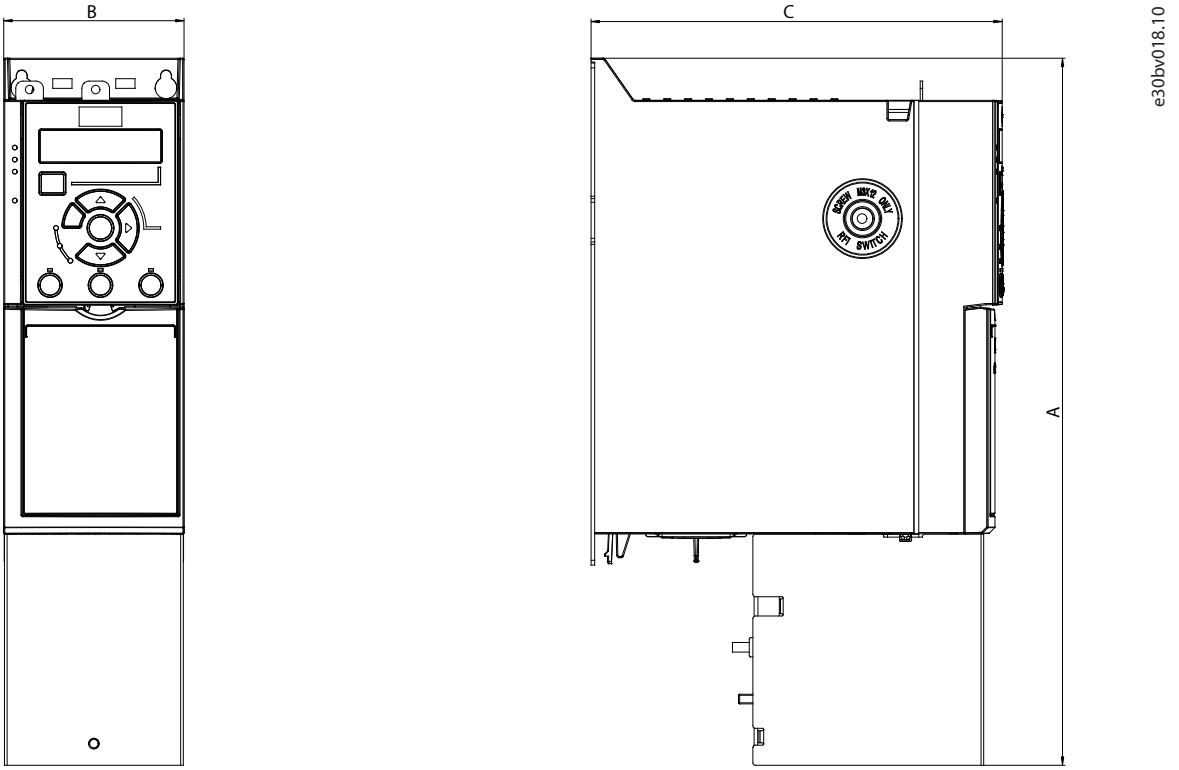


Figure 54: Standard with Bottom Cable Entry Cover (w/o Top Cover)

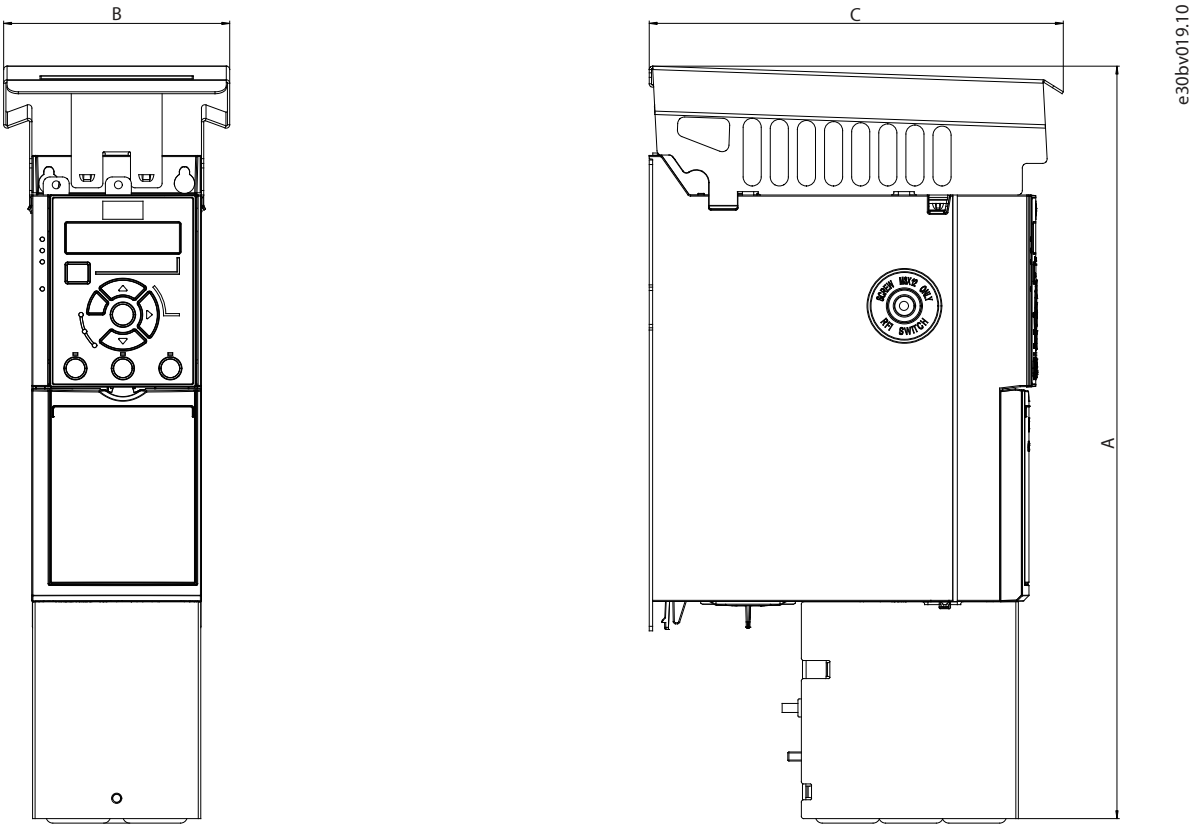


Figure 55: Standard with IP21/UL/Type 1 Kit

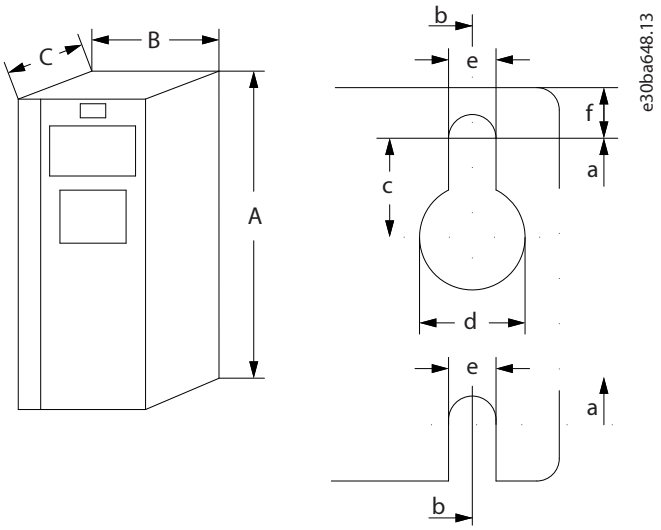


Figure 56: Top and Bottom Mounting Holes

10 Appendix

10.1 Abbreviations and Symbols

Table 68: Abbreviations and Symbols

°C	Degrees celsius
°F	Degrees fahrenheit
AC	Alternating current
AEO	Automatic energy optimization
AWG	American wire gauge
AMA	Automatic motor adaptation
CU	Control unit
DC	Direct current
DI	Digital input
EMC	Electromagnetic compatibility
ETR	Electronic thermal relay
$f_{M, N}$	Nominal motor frequency
FC	Frequency converter
FSoE	Fail Safe over EtherCAT
GSD	General station description
I_{INV}	Rated inverter output current
I_{LIM}	Current limit
$I_{M, N}$	Nominal motor current
$I_{VLT, MAX}$	Maximum output current
$I_{VLT, N}$	Rated output current supplied by the drive
IP	Ingress protection
LCP	Local control panel
MCT	Motion control tool
MM	Memory module
MMP	Memory module programmer
n_s	Synchronous motor speed
$P_{M, N}$	Nominal motor power
PELV	Protective extra low voltage
PCB	Printed circuit board
PLC	Programmable logic controller
PM motor	Permanent magnet motor
PU	Power unit
PUD	Power unit data
PUST	Power up self-test

Table 68: Abbreviations and Symbols (continued)

PWM	Pulse width modulation
RPM	Revolutions per minute
SIL	Safety integrity level
SIVP	Specific initialization values and protection
SO	Safety option
SS1-t	Safe Stop 1 time controlled
STO	Safe Torque Off
T_{LIM}	Torque limit
$U_{M, N}$	Nominal motor voltage

10.2 Conventions

- Numbered lists indicate procedures and description of figures.
- Bullet lists indicate other information.
- Italicized text indicates:
  - Cross-reference.
  - Link.
  - Parameter name.
  - Parameter group name.
  - Parameter option.
  - Footnote.
- All dimensions in drawings are in [mm] (in).
- An asterisk (*) indicates a default setting of a parameter.

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