MAKING MODERN LIVING POSSIBLE

Operating Guide
VLT® Midi Drive FC 280

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THE REAL DRIVE

Contents

1 Introduction

1.1 Purpose of the Manual

This operating guide provides information for the safe installation and commissioning of the VLT® Midi Drive FC 280 adjustable frequency drive.

The operating guide is intended for use by qualified personnel.

To use the adjustable frequency drive safely and professionally, read and follow the operating guide. Pay particular attention to the safety instructions and general warnings. Always keep this operating guide with the adjustable frequency drive.

VLT® is a registered trademark.

1.2 Additional Resources

Resources available to understand advanced adjustable frequency drive functions, programming, and maintenance:

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

Supplementary publications and manuals are available from Danfoss. See *drives.danfoss.com/knowledge-center/technical-documentation/* for listings.

1.3 Document and Software Version

This manual is regularly reviewed and updated. All suggestions for improvement are welcome. *Table 1.1* shows the document version and the corresponding software version.

Edition	Remarks	Software version
MG07A2	Enclosure sizes K4 and K5 introduced.	1.1x

Table 1.1 Document and Software Version

1.4 Product Overview

1.4.1 Intended Use

The adjustable frequency 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 adjustable frequency drive, the motor and equipment driven by the motor.
- System and motor status surveillance.

The adjustable frequency drive can also be used for motor overload protection.

Depending on configuration, the adjustable frequency drive can be used in standalone applications or form part of a larger appliance or installation.

The adjustable frequency drive is allowed for use in residential, industrial and commercial environments in accordance with local laws and standards.

NOTICE!

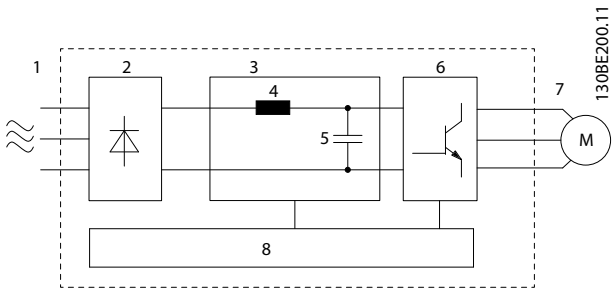
In a residential environment, this product can cause radio interference, in which case supplementary mitigation measures may be required.

Foreseeable misuse

Do not use the adjustable frequency drive in applications which are non-compliant with specified operating conditions and environments. Ensure compliance with the conditions specified in *chapter 9 Specifications*.

1.4.2 Block Diagram of the Adjustable Frequency Drive

Figure 1.1 is a block diagram of the internal components of the adjustable frequency drive.



Area	Component	Functions
1	Line power input	• AC line power supply to the adjustable frequency 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 intermediate DC circuit current. • Provides electrical 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.

Figure 1.1 Example of Block Diagram for a 3-phase Adjustable Frequency Drive

1.4.3 Enclosure Sizes and Power Ratings

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

1.4.4 Safe Torque Off (STO)

The VLT® Midi Drive FC 280 adjustable frequency drive supports Safe Torque Off (STO). See *chapter 6 Safe Torque Off (STO)* for details about the installation, commissioning, maintenance and technical data of STO.

1.5 Approvals and Certifications

Functional Safety Type Approved
TÜVRheinland CERTIFIED
www.tuv.com ID 0600000000

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

The adjustable frequency drive complies with UL 508C thermal memory retention requirements. For more information, refer to the chapter *Motor Thermal Protection* in the *Design Guide*.

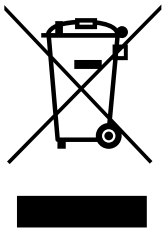
Applied standards and compliance for STO

Using STO on terminals 37 and 38 requires fulfillment of all provisions for safety including relevant laws, regulations, and guidelines.

The integrated STO function complies with the following standards:

- IEC/EN 61508: 2010 SIL2
- IEC/EN 61800-5-2: 2007 SIL2
- IEC/EN 61326-3-1: 2008
- EN ISO 13849-1: 2008 Category 3 PL d

1.6 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 this document:

⚠WARNING

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

⚠CAUTION

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

NOTICE!

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

2.2 Qualified Personnel

Correct and reliable transport, storage, installation, operation and maintenance are required for the trouble-free and safe operation of the frequency converter. Only qualified personnel are allowed to install or 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, personnel must be familiar with the instructions and safety measures described in this guide.

2.3 Safety Precautions

⚠WARNING

HIGH VOLTAGE

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

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

⚠WARNING

UNINTENDED START

When the frequency converter 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. The motor can start with an external switch, a serial communication bus command, an input reference signal from the LCP, via remote operation using MCT 10 Set-up Software or after a cleared fault condition.

To prevent unintended motor start:

- **Disconnect the adjustable frequency drive from line power.**
- **Press [Off/Reset] on the LCP before programming parameters.**
- **Completely wire and assemble the frequency converter, motor and any driven equipment before connecting the frequency converter to AC mains, DC supply or load sharing.**

⚠WARNING

DISCHARGE TIME

The adjustable frequency drive contains DC link capacitors that can remain charged even when the adjustable frequency drive is not powered. High voltage can be present even when the warning LED indicator lights are off. Failure to wait the specified time after power has been removed before performing service or repair work can result in death or serious injury.

- **Stop the motor.**
- **Disconnect AC line power and remote DC link supplies, including battery backups, UPS and DC link connections to other adjustable frequency drives.**
- **Disconnect or lock PM motor.**
- **Wait for the capacitors to discharge fully. The minimum waiting time is specified in *Table 2.1*.**
- **Before performing any service or repair work, use an appropriate voltage measuring device to make sure that the capacitors are fully discharged.**

2

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

Table 2.1 Discharge Time

⚠WARNING

LEAKAGE CURRENT HAZARD

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

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

⚠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 adjustable frequency drive can result in serious injury when the adjustable frequency drive is not closed properly.

- **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 may vary according to product configuration.

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

Figure 3.1 Product Nameplate (Example)

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

Table 3.1 Product Nameplate (Example)

NOTICE!

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

3.1.2 Storage

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

3.2 Installation Environment

NOTICE!

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 adjustable frequency drive. Ensure that requirements for air humidity, temperature and altitude are met.

Vibration and shock

The adjustable frequency 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 specifications, refer to *chapter 9.4 Ambient Conditions*.

3

3.3 Mounting

NOTICE!

Improper mounting can result in overheating and reduced performance.

Cooling

- Ensure 100 mm (4 in) of top and bottom clearance for air cooling.

Lifting

- To determine a safe lifting method, check the weight of the unit, see *chapter 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.

Mounting

To adapt the mounting holes of VLT® Midi Drive FC 280, contact the local Danfoss supplier to order a separate backplate.

To mount the adjustable frequency drive:

1. Ensure that the mounting location is strong enough to support the unit weight. The adjustable frequency drive allows side-by-side installation.
2. Place the unit as close to the motor as possible. Keep the motor cables as short as possible.
3. Mount the unit vertically to a solid flat surface or to the optional backplate to provide cooling airflow.
4. When provided, use the slotted mounting holes on the unit for wall mounting.

NOTICE!

For dimensions of mounting holes, see *chapter 9.9 Enclosure Sizes, Power Ratings and Dimensions*.

3.3.1 Side-by-side Installation

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.

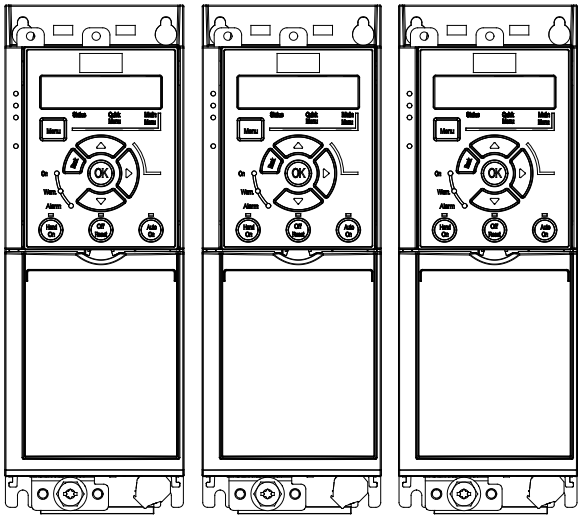


Figure 3.2 Side-by-side Installation

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.

- **Avoid mounting the units side by side if IP21 conversion kit is used.**

3.3.2 Bus Decoupling Kit

The bus decoupling kit ensures mechanical fixation and electrical shielding of cables for the following control cassette variants:

- Control cassette with PROFIBUS.
- Control cassette with PROFINET.
- Control cassette with CANopen.
- Control cassette with Ethernet.

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

3.3.3 Mounting

To mount the bus decoupling kit:

1. Place the horizontal decoupling plate on the control cassette mounted on the adjustable frequency drive and fasten the plate using two

screws as shown in *Figure 3.3*. Tightening torque is 0.7–1.0 Nm (6.2–8.9 in-lb).

2. Optional: Mount the vertical decoupling plate as follows:

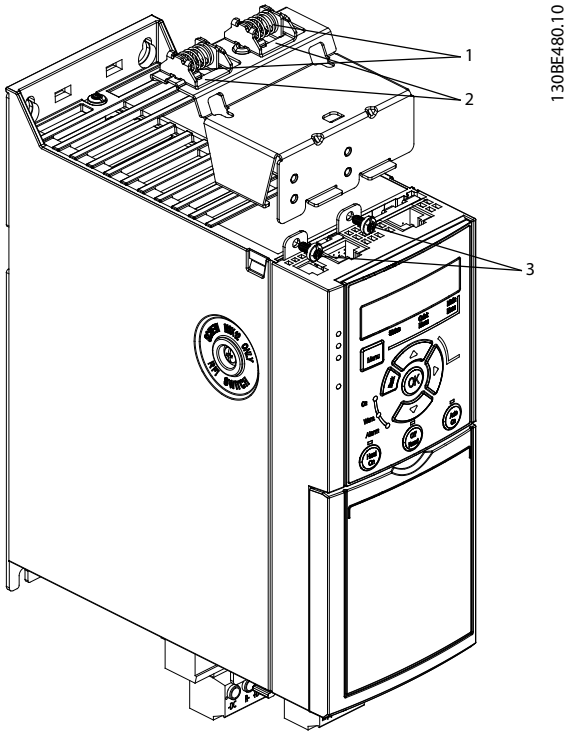
   2a Remove the two mechanical springs and two metal clamps from the horizontal plate.

   2b Mount the mechanical springs and metal clamps on the vertical plate.

   2c Fasten the plate with two screws as shown in *Figure 3.4*. Tightening torque is 0.7–1.0 Nm (6.2–8.9 in-lb).

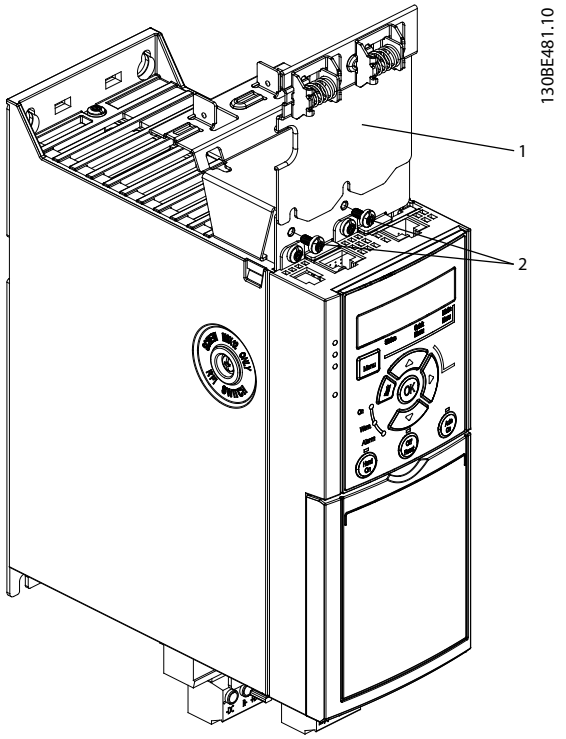
NOTICE!

If the IP21 top cover is used, do not mount the vertical decoupling plate because its height affects the proper installation of the IP21 top cover.



1	Mechanical springs
2	Metal clamps
3	Screws

Figure 3.3 Fasten the Horizontal Decoupling Plate with Screws



1	Vertical decoupling plate
2	Screws

Figure 3.4 Fasten the Vertical Decoupling Plate with Screws

Both *Figure 3.3* and *Figure 3.4* show PROFINET sockets. The actual sockets are based on the type of the control cassette mounted on the adjustable frequency drive.

3. Push the PROFIBUS/PROFINET/CANopen/Ethernet cable connectors into the sockets in the control cassette.

4. 4a Place the PROFIBUS/CANopen cables between the spring-loaded metal clamps to establish mechanical fixation and electrical contact between the shielded sections of the cables and the clamps.

   4b Place the PROFINET/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 2 Safety* for general safety instructions.

4

⚠WARNING

INDUCED VOLTAGE

Induced voltage from output motor cables of different adjustable frequency drives that run together can charge equipment capacitors, even when the equipment is turned off and locked out. Failure to run output motor cables separately, use shielded cables, or metal conduits could result in death or serious injury.

- **Run output motor cables separately.**
- **Use shielded cables or metal conduits.**
- **Lock out all the adjustable frequency drives simultaneously.**

⚠WARNING

SHOCK HAZARD

The adjustable frequency drive can cause a DC current in the PE conductor and hence result in death or serious injury.

- **When a residual current-operated protective device (RCD) is used for protection against electrical shock, only an RCD of Type B is allowed on the supply side.**

Failure to follow the recommendation means that the RCD cannot provide the intended protection.

NOTICE!

The adjustable frequency drive is supplied with Class 20 motor overload protection.

Overcurrent protection

- Extra protective equipment, such as short circuit protection or motor thermal protection between adjustable frequency drive and motor, is required for applications with multiple motors.
- Input fusing is required to provide protection against short circuit and overcurrent. If fuses are not factory-supplied, the installer must provide them. See maximum fuse ratings in *chapter 9.8 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 *chapter 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 *chapter 4.3 Grounding*, *chapter 4.4 Wiring Schematic*, *chapter 4.6 Motor Connection*, and *chapter 4.8 Control Wiring*.

4.3 Grounding

⚠WARNING

LEAKAGE CURRENT HAZARD

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

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

For electrical safety

- Ground the adjustable frequency drive in accordance with applicable standards and directives.
- Use a dedicated ground wire for input power, motor power and control wiring.
- Do not ground one adjustable frequency drive to another in a daisy-chain fashion (see *Figure 4.1*).
- Keep the ground wire connections as short as possible.
- Follow the motor manufacturer wiring requirements.
- Minimum cable cross-section: 10 mm^2 (7 AWG) (Separately terminate two ground wires, both complying with the dimension requirements).

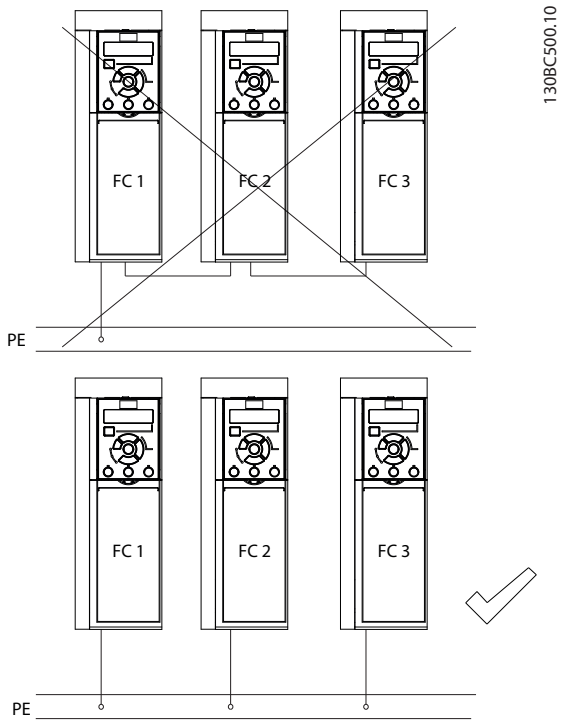


Figure 4.1 Grounding Principle

For EMC-compliant installation

- Establish electrical contact between the cable shield and the adjustable frequency drive enclosure by using metal cable connector or by using the clamps provided on the equipment (see *chapter 4.6 Motor Connection*).
- Use high-strand wire to reduce burst transient.
- Do not use pigtails.

NOTICE!

POTENTIAL EQUALIZATION

Risk of transient interference when the ground potential between the adjustable frequency drive and the control system is different. Install equalizing cables between the system components. Recommended cable cross-section: 16 mm^2 (6 AWG).

4

4.4 Wiring Schematic

This section describes how to wire the adjustable frequency drive.

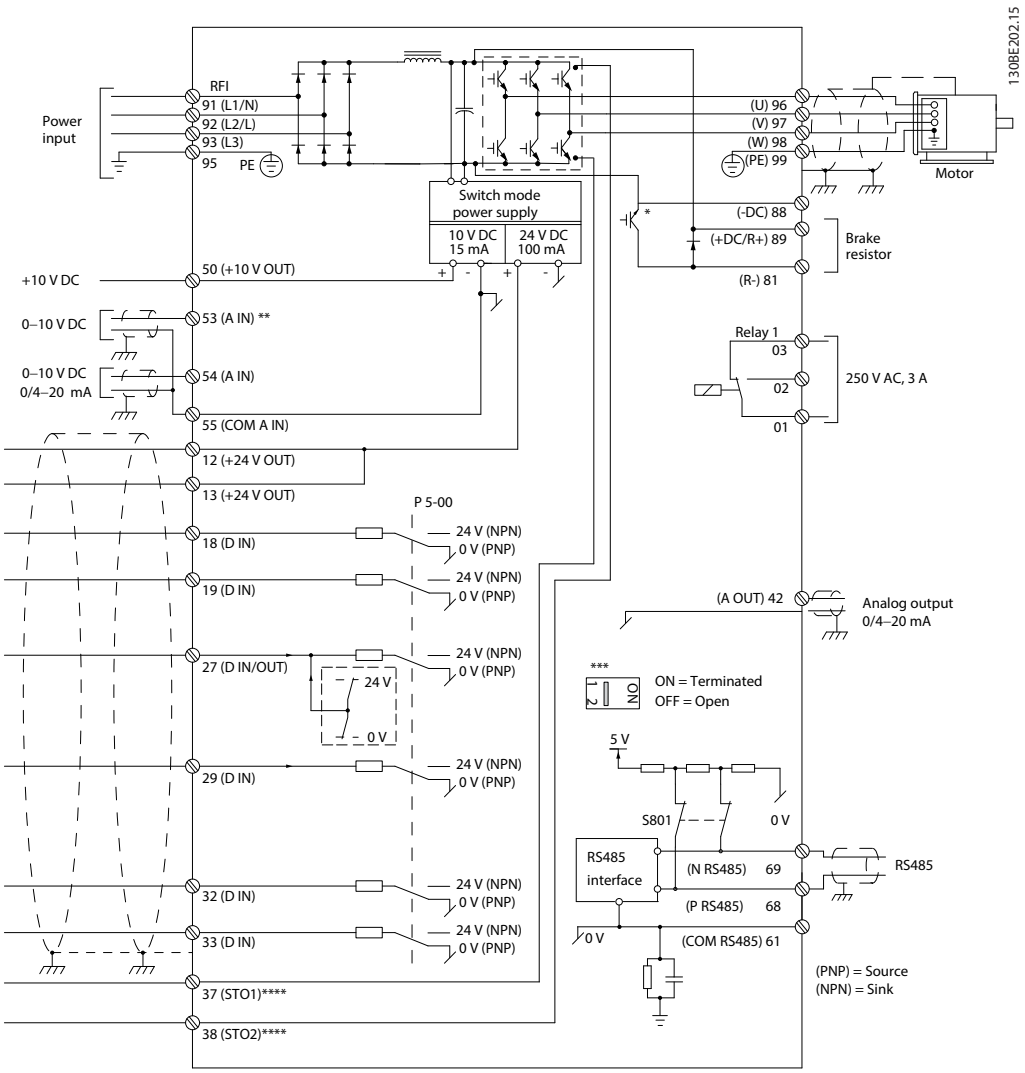


Figure 4.2 Basic Wiring Schematic Drawing

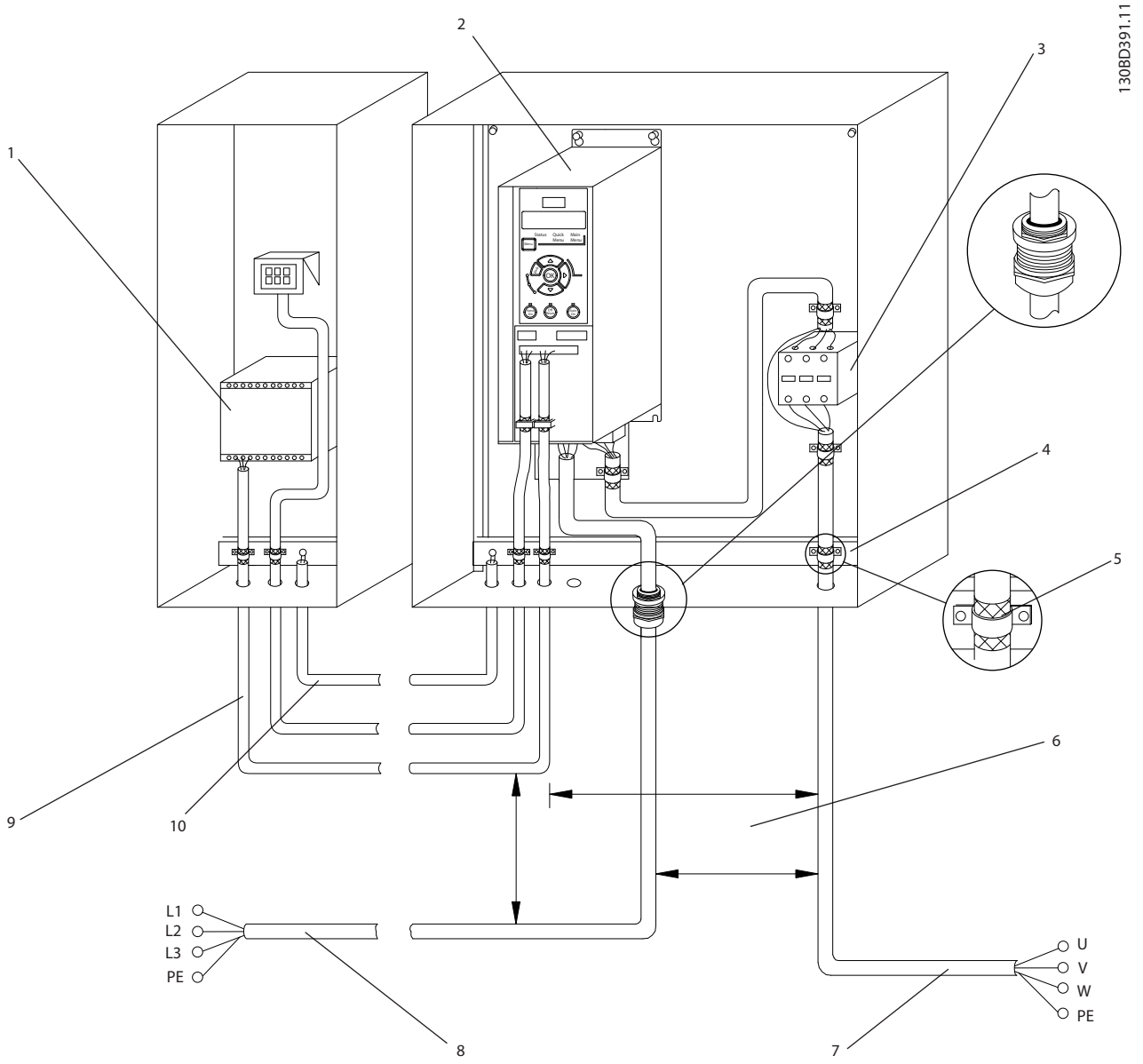
A=Analog, D=Digital

** Built-in brake chopper is only available on 3-phase units.*

*** Terminal 53 can also be used as digital input.*

**** Switch S801 (bus terminal) can be used to enable termination on the RS485 port (terminals 68 and 69).*

***** Refer to chapter 6 Safe Torque Off (STO) for the correct STO wiring.*



1	PLC	6	Minimum 200 mm (8 in) between control cables, motor, and line power
2	Adjustable frequency drive	7	Motor, 3-phase and PE
3	Output contactor (not recommended)	8	Line power, single-phase, 3-phase and reinforced PE
4	Grounding rail (PE)	9	Control wiring
5	Cable shielding (stripped)	10	Equalizing minimum 16 mm^2 (5 AWG)

Figure 4.3 Typical Electrical Connection

4.5 Access

- Remove the cover plate with a screwdriver. See *Figure 4.4*.

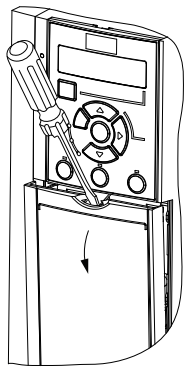


Figure 4.4 Control Wiring Access

4.6 Motor Connection

⚠WARNING

INDUCED VOLTAGE

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

- Run output motor cables separately.
- Use shielded cables or metal conduits.
- Comply with local and national electrical codes for cable sizes. For maximum cable sizes, see *chapter 9.1 Electrical Data*.
- Follow the motor manufacturer wiring requirements.
- Motor wiring knockouts or access panels are provided at the base of IP21 (NEMA1/12) units.
- Do not wire a starting or pole-changing device (for example, Dahlander motor or slip ring induction motor) between the adjustable frequency drive and the motor.

Procedure

1. Strip a section of the outer cable insulation.
2. Position the stripped cable under the cable clamp to establish mechanical fixation and electrical contact between the cable shield and ground.
3. Connect the ground cable to the nearest grounding terminal in accordance with the grounding instructions provided in *chapter 4.3 Grounding*. See *Figure 4.5*.
4. Connect the 3-phase motor wiring to terminals 96 (U), 97 (V) and 98 (W) as shown in *Figure 4.5*.
5. Tighten the terminals in accordance with the information provided in *chapter 9.7 Connection Tightening Torques*.

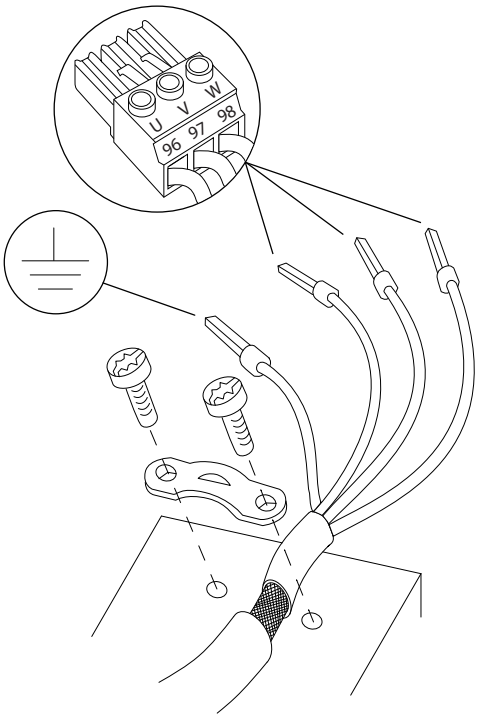


Figure 4.5 Motor Connection

The line power, motor, and grounding connection for single-phase and 3-phase adjustable frequency drives are shown in *Figure 4.6* and *Figure 4.7*, respectively. Actual configurations vary with unit types and optional equipment.

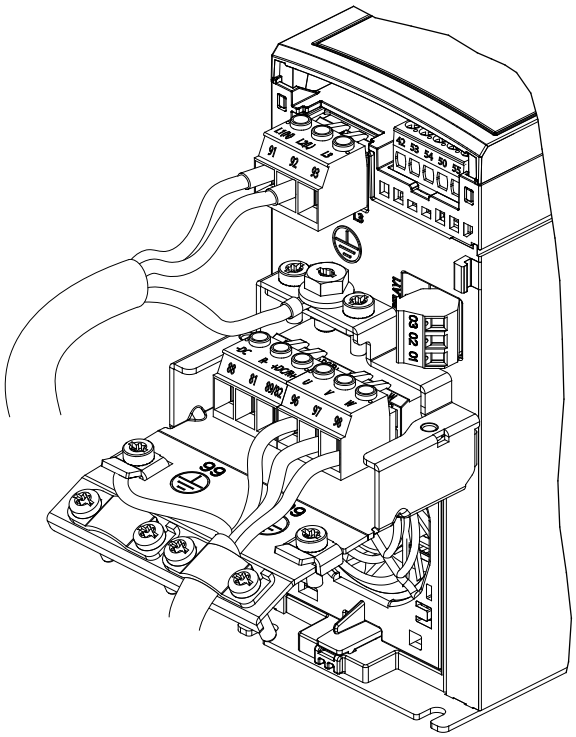


Figure 4.6 Line power, Motor and Grounding Connection for Single-phase Units

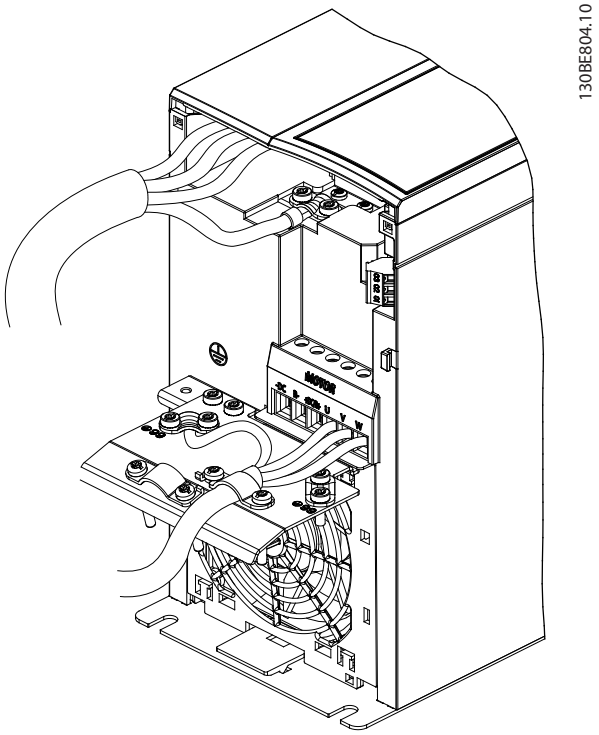


Figure 4.8 Line Power, Motor, and Grounding Connection for 3-phase Units (K4, K5)

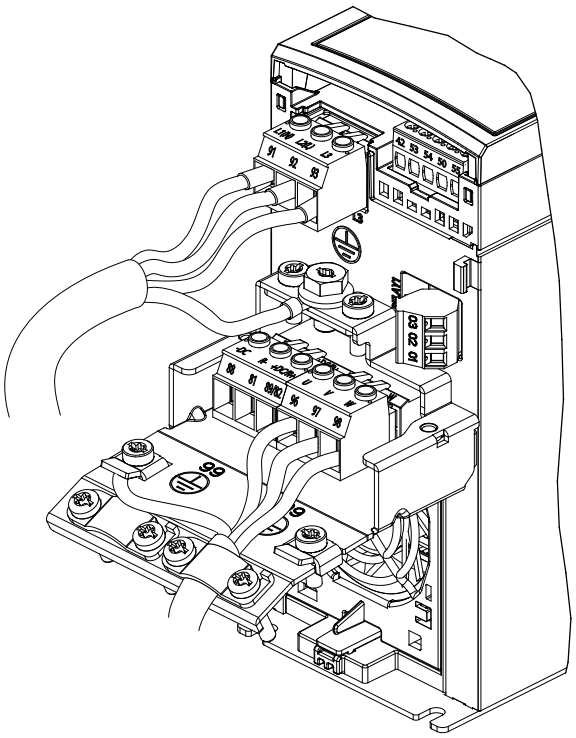


Figure 4.7 Line power, Motor and Grounding Connection for 3-phase Units

4.7 AC Line Input Connection

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

Procedure

1. Connect the AC input power cables to terminals N and L for single-phase units (see *Figure 4.6*) or to terminals L1, L2 and L3 for 3-phase units (see *Figure 4.7*).
2. Depending on the configuration of the equipment, connect the input power to the line power input terminals or the input disconnect.
3. Ground the cable in accordance with the grounding instructions in *chapter 4.3 Grounding*.
4. When supplied from an isolated line power source (IT line power or floating delta) or TT/TN-S line power 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.

4.8 Control Wiring

4.8.1 Control Terminal Types

Figure 4.9 shows the removable adjustable frequency drive connectors. Terminal functions and default settings are summarized in *Table 4.1* and *Table 4.2*.

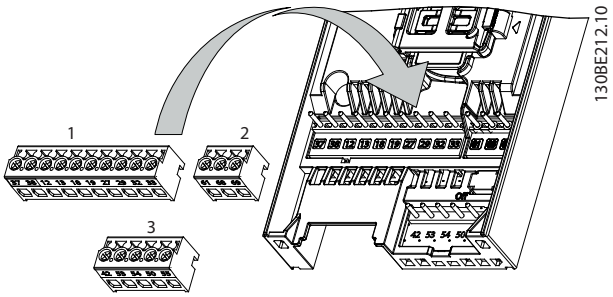


Figure 4.9 Control Terminal Locations

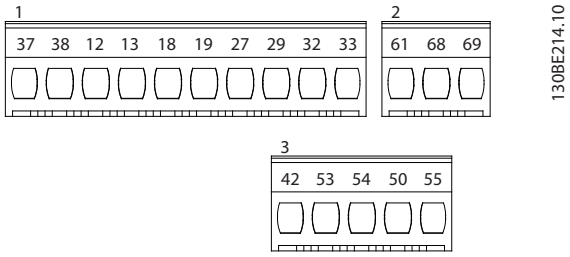


Figure 4.10 Terminal Numbers

See *chapter 9.6 Control Input/Output and Control Data* for terminal ratings details.

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.
19	*Parameter 5-11 Terminal 19 Digital Input*	*[10] Reversing*	
27	*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.
29	*Parameter 5-13 Terminal 29 Digital Input*	*[14] Jog*	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*	*[16] Preset ref bit 0*	
37, 38	–	STO	Functional safety inputs.
Analog inputs/outputs			
42	*Parameter 6-91 Terminal 42 Analog Output*	*[0] No operation*	Programmable analog output. The analog signal is 0–20 mA or 4–20 mA at a maximum of 500 Ω. Can also be configured as digital outputs.
50	–	+10 V DC	10 V DC analog supply voltage. 15 mA maximum commonly used for potentiometer or thermistor.
53	6-1* parameter group	–	Analog input. Only voltage mode is supported. It can also be used as digital input.
54	6-2* parameter group	–	Analog input. Selectable between voltage or current mode.

Terminal	Parameter	Default setting	Description
55	–	–	Common for digital and analog inputs.

Table 4.1 Terminal Descriptions - Digital Inputs/Outpus, Analog Input/Outputs

Terminal	Parameter	Default setting	Description
Serial communication			
61	–	–	Integrated RC filter for cable shield. ONLY for connecting the shield when experiencing EMC problems.
68 (+)	8-3* parameter group	–	RS-485 interface. A control card switch is provided for termination resistance.
69 (-)	8-3* parameter group	–	
Relays			
01, 02, 03	5-40	*[9] Alarm*	Form C relay output. These relays are in various locations depending upon the adjustable frequency drive configuration and size. Usable for AC or DC voltage and resistive or inductive loads.

Table 4.2 Terminal Descriptions - Serial Communication

4.8.2 Wiring to Control Terminals

Control terminal connectors can be unplugged from the adjustable frequency drive for ease of installation, as shown in *Figure 4.9*.

For details about STO wiring, refer to *chapter 6 Safe Torque Off (STO)*.

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.

See *chapter 9.5 Cable Specifications* for control terminal cable sizes and *chapter 7 Application Examples* for typical control cable connections.

4.8.3 Enabling Motor Operation (Terminal 27)

A jumper wire is required between terminal 12 (or 13) and terminal 27 for the adjustable frequency 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 adjustable frequency drive cannot operate without a signal on terminal 27, unless terminal 27 is reprogrammed.

4.8.4 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 adjustable frequency drive is unable to keep the motor at standstill, for example, due to the load being too heavy.

4

- 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 adjustable frequency drive carries out a stop command.

If the adjustable frequency drive is in alarm mode or in an overvoltage situation, the mechanical brake immediately closes.

The adjustable frequency 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.

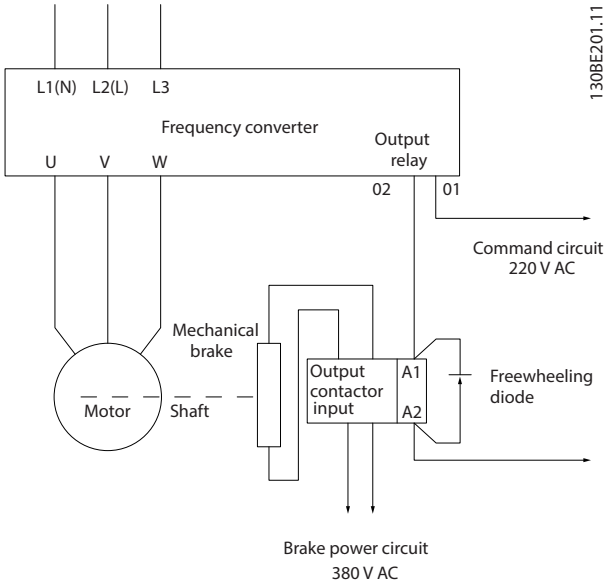


Figure 4.11 Connecting the Mechanical Brake to the Adjustable Frequency Drive

4.8.5 USB Data Communication

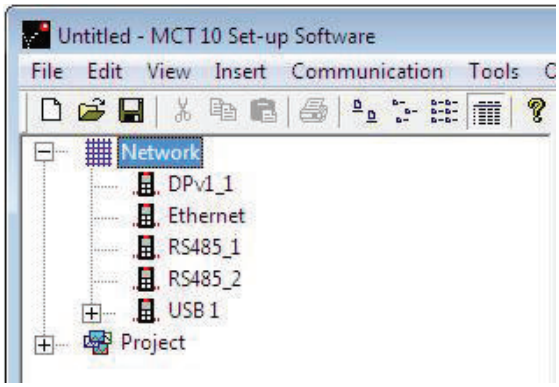


Figure 4.12 Network Bus List

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

NOTICE!

A USB bus has no address-setting capacity and no bus name to configure. If connecting more than one adjustable frequency drive through USB, the bus name is auto-incremented in the MCT 10 Set-up Software Network bus list.
Connecting more than one adjustable frequency drive through a USB cable often causes computers installed with Windows XP to throw an exception and crash. Therefore, it is advised only to connect one adjustable frequency drive via USB to the PC.

4.8.6 RS485 Serial Communication

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

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

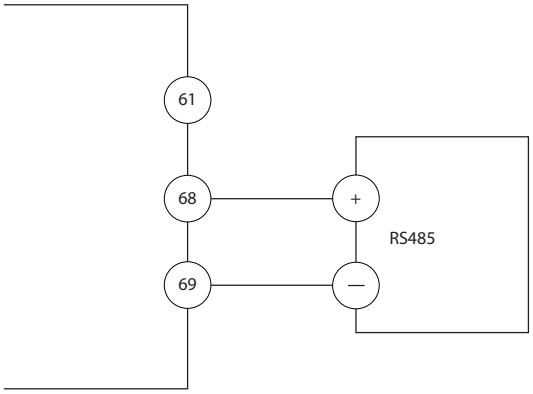


Figure 4.13 Serial Communication Wiring Diagram

For basic serial communication set-up, select the following:

1. Protocol type in *parameter 8-30 Protocol*.
2. Adjustable frequency drive address in *parameter 8-31 Address*.
3. Baud rate in *parameter 8-32 Baud Rate*.

- Two communication protocols are internal to the adjustable frequency drive. Follow the motor manufacturer wiring requirements.
  - Danfoss FC
  - Modbus RTU
- 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 Installation Checklist

Before completing installation of the unit, inspect the entire installation as detailed in *Table 4.3*. Check and mark the items when completed.

Inspect for	Description	☑
Auxiliary equipment	• Look for auxiliary equipment, switches, disconnects, or input fuses/circuit breakers, which may reside on the input power side of the adjustable frequency 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 adjustable frequency drive. • Remove any power factor correction capacitors on the motor(s). • Adjust any power factor correction capacitors on the line power side and ensure that they are dampened.	
Cable routing	• Ensure that the motor wiring and control wiring are separated, shielded, or in three 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.	
Cooling clearance	• Ensure that the top and bottom clearance is adequate to ensure proper airflow for cooling, see *chapter 3.3 Mounting*.	
Ambient conditions	• Check that requirements for ambient conditions are met.	
Fusing and circuit breakers	• 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 they are tight and free of oxidation. • Do not ground to conduit or mount the back panel to a metal surface.	
Input and output power wiring	• Check for loose connections. • Check that the motor and line cables are in separate conduits or have 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.	

Table 4.3 Installation Check List

⚠CAUTION

POTENTIAL HAZARD IN THE EVENT OF INTERNAL FAILURE

Risk of personal injury if the adjustable frequency drive is not properly closed.

- **Before applying power, ensure that all safety covers are in place and securely fastened.**

5 Commissioning

5.1 Safety Instructions

See *chapter 2 Safety* for general safety instructions.

⚠WARNING

HIGH VOLTAGE

Adjustable frequency drives contain high voltage when connected to AC line power. Failure to perform installation, start-up and maintenance by qualified personnel could result in death or serious injury.

- **Installation, start-up and maintenance must be performed by qualified personnel only.**

Before applying power:

1. Close the cover properly.
2. Check that all cable connectors are firmly tightened.
3. Ensure that input power to the unit is off and locked out. Do not rely on the adjustable frequency 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 adjustable frequency drive and the motor.
8. Inspect the adjustable frequency drive for loose connections on the terminals.
9. Confirm that the supply voltage matches the voltage of the adjustable frequency drive and the motor.

5.2 Applying Power

Apply power to the adjustable frequency drive using the following steps:

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 adjustable frequency drive now. For units with a disconnect switch, turn it to the ON position to apply power to the adjustable frequency drive.

5.3 Local Control Panel Operation

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

NOTICE!

The adjustable frequency drive can also be programmed from the MCT 10 Set-up Software on PC via RS485 communication port or USB port. This software can be ordered using code number 130B1000 or downloaded from the Danfoss website: *www.danfoss.com/BusinessAreas/DrivesSolutions/softwaredownload*.

5.3.1 Numeric Local Control Panel (LCP)

The numerical local control panel (NLCP) is divided into four functional sections.

A. Numeric display.

B. Menu key.

C. Navigation keys and LEDs.

D. Operation keys and LEDs.

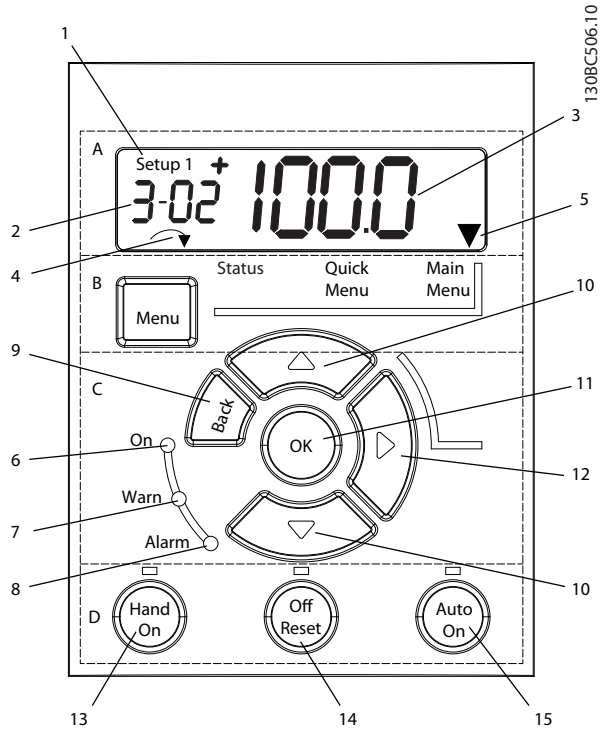


Figure 5.1 View of the NLCP

A. Numeric display

The LCD display is backlit with one numeric line. All data is shown in the NLCP.

1	The set-up number shows the active set-up and the edit set-up. If the same set-up acts as both the active and edit set-up, only that set-up number is shown (factory setting). When the active and edit set-up differ, both numbers are shown in the display (for example, set-up 12). The number flashing indicates the edit set-up.
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.

Table 5.1 Legend to *Figure 5.1*, Section A

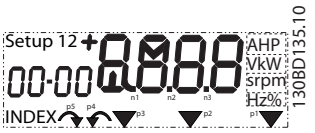


Figure 5.2 Display Information

B. Menu key

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

C. Indicator lights (LEDs) and navigation keys

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

Table 5.2 Legend to *Figure 5.1*, Indicator Lights (LEDs)

	Key	Function
9	[Back]	For moving to the previous step or layer in the navigation structure.
10	Arrows [▲] [▼]	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.

Table 5.3 Legend to *Figure 5.1*, Navigation Keys

D. Operation keys and LEDs

	Key	Function
13	Hand On	Starts the adjustable frequency 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 adjustable frequency drive, or it resets the adjustable frequency drive manually after a fault has been cleared.
15	Auto On	Puts the system in remote operational mode. • Responds to an external start command by control terminals or serial communication.

Table 5.4 Legend to *Figure 5.1*, Section D

⚠WARNING

ELECTRICAL HAZARD

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

- **Do not touch any live parts.**

5.3.2 The Right Key Function on NLCP

Press [►] to edit any of the four digits on the display individually. When pressing [►] once, the cursor moves to the first digit and the digit starts flashing as shown in *Figure 5.3*. Press the [▲] [▼] to change the value. Pressing [►] does not change the value of the digits or move the decimal point.

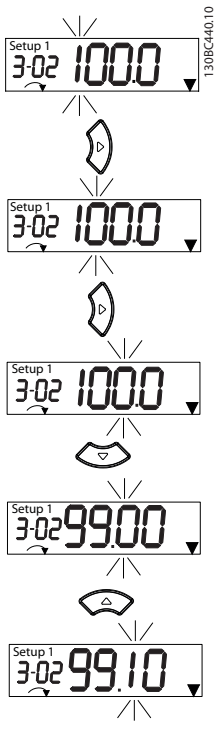


Figure 5.3 Right Key Function

[►] can also be used for moving between parameter groups. When in Main Menu, press [►] to move to the first 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*).

NOTICE!

During start-up, the LCP shows the message *INITIALIZING*. When this message is no longer shown, the adjustable frequency drive is ready for operation. Adding or removing options can extend the duration of start-up.

5.3.3 Quick Menu on NLCP

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 three times if in QM2 and QM3) to enter *Status*, or press [Menu] once to enter *Main Menu*.

5

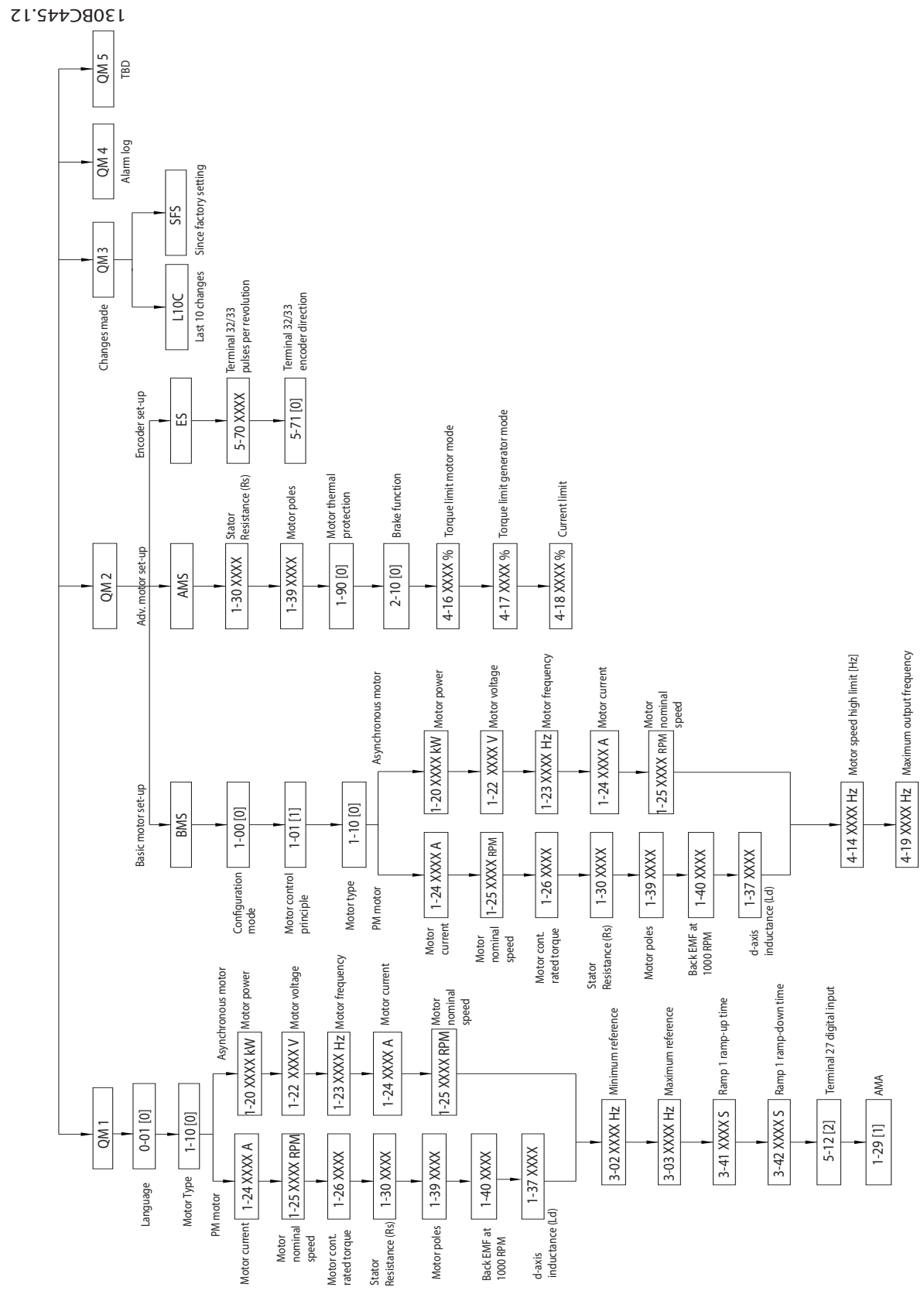


Figure 5.4 Quick Menu Structure

5.3.4 Main Menu on NLCP

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 three times for array parameters) to enter *Main Menu*, or press [Menu] once to enter *Status*.

See *Figure 5.5*, *Figure 5.6* and *Figure 5.7* for the principles of changing the value of continuous, enumerated and array parameters, respectively. The actions in the figures are described in *Table 5.5*, *Table 5.6* and *Table 5.7*.

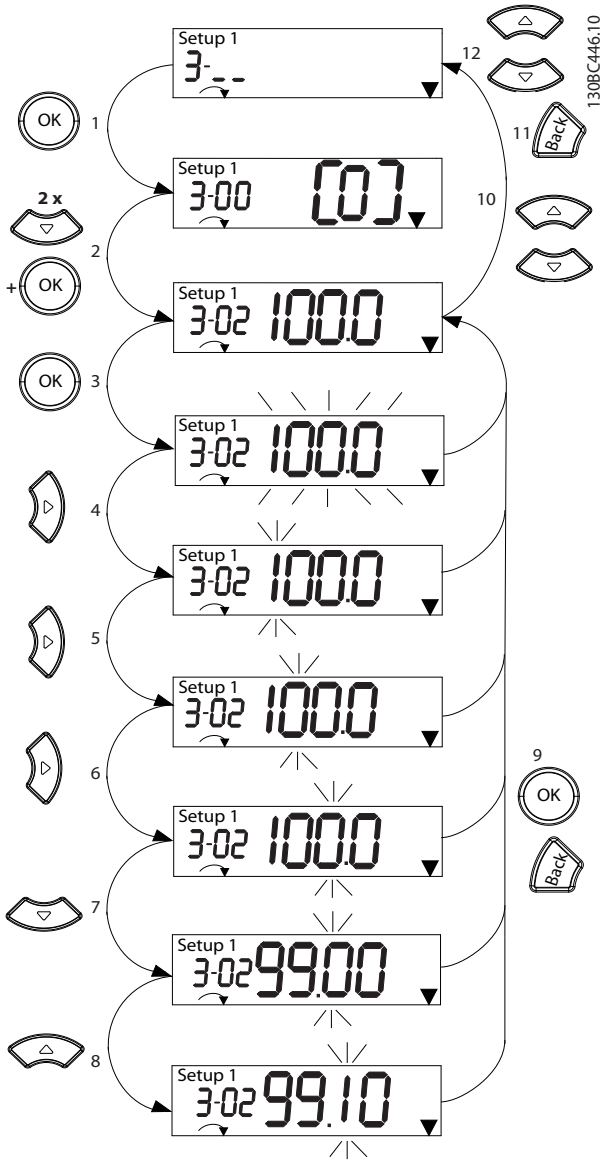


Figure 5.5 Main Menu Interactions - Continuous Parameters

1	[OK]: The first parameter in the group is shown.
2	Press [▼] repeatedly to move down to the parameter.
3	Press [OK] to start editing.
4	[►]: First digit flashing (can be edited).
5	[►]: Second digit flashing (can be edited).
6	[►]: Third digit flashing (can be edited).
7	[▼]: Decrease the parameter value, the decimal point changes automatically.
8	[▲]: Increase the parameter value.
9	[Back]: Cancel changes, return to 2. [OK]: Accept changes, return to 2.
10	[▲][▼]: Select parameter within the group.
11	[Back]: Remove the value and show the parameter group.
12	[▲][▼]: Select group.

Table 5.5 Changing Values in Continuous 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 first part of the bracket.

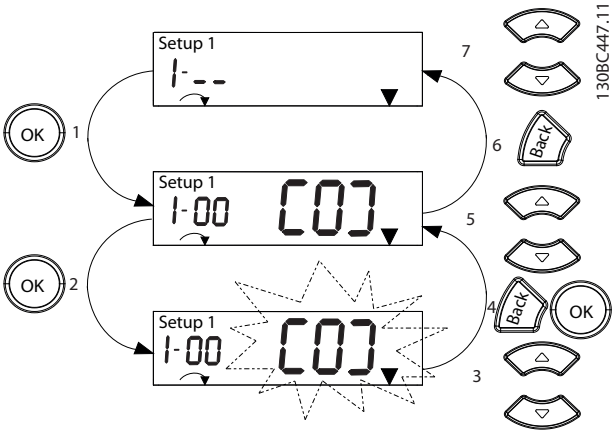


Figure 5.6 Main Menu Interactions - Enumerated Parameters

1	[OK]: The first 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]: Remove the value and show the parameter group.
7	[▲][▼]: Select a group.

Table 5.6 Changing Values in Enumerated Parameters

Array parameters function as follows:

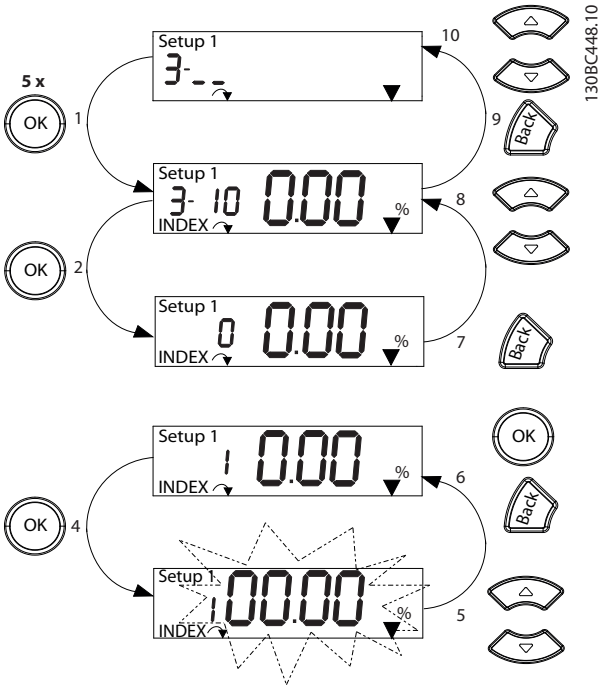


Figure 5.7 Main Menu Interactions - Array Parameters

1	[OK]: Show parameter numbers and the value in the first index.
2	[OK]: Index can be selected.
3	[▲][▼]: Select index.
4	[OK]: Value can be edited.
5	[▲][▼]: Change parameter value (flashing).
6	[Back]: Cancel changes. [OK]: Accept changes.
7	[Back]: Cancel editing index, select a new parameter.
8	[▲][▼]: Select parameter within the group.
9	[Back]: Remove parameter index value and show the parameter group.
10	[▲][▼]: Select group.

Table 5.7 Changing Values in Array Parameters

5.3.5 GLCP Layout

The GLCP is divided into four functional groups (see *Figure 5.8*).

A. Display area

B. Display menu keys

C. Navigation keys and LEDs

D. Operation keys and reset

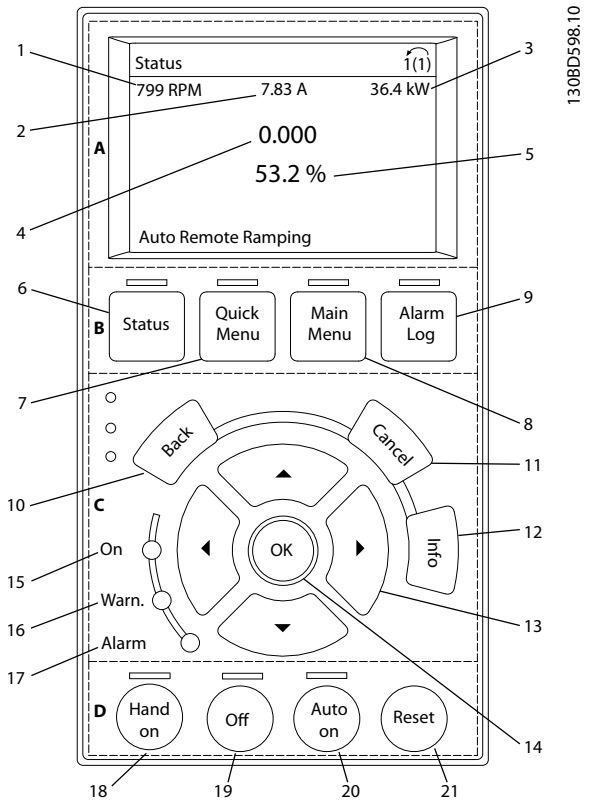


Figure 5.8 Graphic Local Control Panel (GLCP)

A. Display area

The display area is activated when the adjustable frequency drive receives power from the AC line 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*.

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*

Table 5.8 Legend to *Figure 5.8*, Display Area

B. Display menu keys

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

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

Table 5.9 Legend to *Figure 5.8*, Display Menu Keys

C. Navigation keys and 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 three adjustable frequency drive status indicator lights in this area.

	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 four navigation keys.
14	OK	Press to access parameter groups or to enable a selection.

Table 5.10 Legend to *Figure 5.8*, Navigation Keys

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

Table 5.11 Legend to *Figure 5.8*, Indicator Lights (LEDs)

D. Operation keys and reset
Operation keys are at the bottom of the LCP.

	Key	Function
18	Hand On	Starts the adjustable frequency 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 adjustable frequency 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 adjustable frequency drive manually after a fault has been cleared.

Table 5.12 Legend to *Figure 5.8*, Operation Keys and Reset

NOTICE!

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

5.3.6 Parameter Settings

Establishing the correct programming for applications often requires setting functions in several related parameters. Details for parameters are provided in *chapter 10.2 Parameter Menu Structure*.
Programming data is stored internally in the adjustable frequency drive.

- For backup, upload data into the LCP memory.
- To download data to another adjustable frequency 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.

5.3.7 Changing Parameter Settings with GLCP

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.

1. Press [Quick Menu] or [Main Menu] on the LCP.
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.

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 set-up.
- Parameters which have been reset to default values are not listed.
- The message *Empty* indicates that no parameters have been changed.

5.3.8 Uploading/Downloading Data to/from the GLCP

1. Press [Off] 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.

5.3.9 Restoring Default Settings with GLCP

NOTICE!

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 adjustable frequency drive. Initialization is carried out through *parameter 14-22 Operation Mode* (recommended) or manually. Initialization does not reset the settings for *parameter 1-06 Clockwise Direction*.

- Initialization using *parameter 14-22 Operation Mode* does not reset adjustable frequency drive settings, such as operating hours, serial communication selections, fault log, alarm log and other monitoring functions.
- Manual initialization erases all motor, programming, localization and monitoring data and restores factory default settings.

Recommended initialization procedure via *parameter 14-22 Operation Mode*

1. Press [Main Menu] twice to access parameters.
2. Scroll to *parameter 14-22 Operation Mode* and press [OK].
3. Scroll to *[2] Initialization* and press [OK].
4. Remove power to the unit and wait for the display to turn off.
5. Apply power to the unit.

Default parameter settings are restored during start-up. This may take slightly longer than normal.

6. Alarm 80 is displayed.
7. Press [Reset] to return to operation mode.

Manual initialization procedure

1. Remove power to the unit and wait for the display to turn off.
2. Press and hold [Status], [Main Menu] and [OK] at the same time while applying power to the unit (approximately 5 s or until a click is heard and the fan starts).

Factory default parameter settings are restored during start-up. This may take slightly longer than normal.

Manual initialization does not reset the following adjustable frequency drive information:

- *Parameter 15-00 Operating hours*
- *Parameter 15-03 Power-ups*
- *Parameter 15-04 Over Temps*
- *Parameter 15-05 Over Volts*

5.4 Basic Programming

5.4.1 Asynchronous Motor Set-up

Enter the following motor data. Find the information on the motor nameplate.

1. *Parameter 1-20 Motor Power [kW]*.
2. *Parameter 1-22 Motor Voltage*.
3. *Parameter 1-23 Motor Frequency*.
4. *Parameter 1-24 Motor Current*.
5. *Parameter 1-25 Motor Nominal Speed*.

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). Run a complete AMA using *parameter 1-29 Automatic Motor Adaptation (AMA) [1] Enable Complete AMA* or enter the parameters manually.

1. *Parameter 1-30 Stator Resistance (Rs)*.
2. *Parameter 1-31 Rotor Resistance (Rr)*.
3. *Parameter 1-33 Stator Leakage Reactance (X1)*.
4. *Parameter 1-35 Main Reactance (Xh)*.

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.

5.4.2 PM Motor Set-up in VVC$^+$

Initial programming steps

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

NOTICE!

Encoder feedback is not supported for PM motors.

Programming motor data

After selecting one of the PM motor options in *parameter 1-10 Motor Construction*, the PM motor-related parameters in parameter groups *1-2* Motor Data*, *1-3* Adv. Motor Data* and *1-4* Adv. Motor Data II* are active.
Find the information on the motor nameplate and in the motor data sheet.

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-line data is available, divide the line-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-line value with 2 to achieve the line-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 PM motor at 1000 RPM mechanical speed (RMS value). Back EMF is the voltage generated by a PM motor when no adjustable frequency drive is connected and the shaft is turned externally. Back EMF is normally specified for nominal motor speed or for 1000 RPM measured between two 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*.

Test motor operation

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

Parking

This function is the recommended choice for applications where the motor rotates at slow 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. *Table 5.13* shows recommendations in different applications.

Application	Settings
Low inertia applications I_{Load}/I_{Motor} <5	• Increase the value for *parameter 1-17 Voltage Filter Time Const.* by factor 5–10. • 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).

Table 5.13 Recommendations for Different Applications

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

Starting torque can be adjusted in *parameter 1-66 Min. Current at Low Speed*. 100% provides nominal torque as starting torque.

5.4.3 Automatic Motor Adaptation (AMA)

To optimize compatibility between the adjustable frequency drive and the motor in VVC+ mode, run AMA.

- The adjustable frequency drive builds a mathematical model of the motor for regulating output motor current, thus enhancing motor performance.
- Some motors may be 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 8.4 List of Warnings and Alarms*.
- For best results, run this procedure on a cold motor.

To run AMA using the LCP

1. By default parameter setting, connect terminals 12 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.

Depending on the power size, the AMA takes 3 to 10 minutes to complete.

NOTICE!

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

5.5 Checking Motor Rotation

Before running the adjustable frequency drive, check the motor rotation.

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 adjustable frequency drive and the motor is correct.
5. Verify that the motor running direction matches the setting in *parameter 1-06 Clockwise Direction*.
   - 5a When *parameter 1-06 Clockwise Direction* is set to *[0] Normal* (default clockwise):
     a. Verify that the motor turns clockwise.
     b. Verify that the LCP direction arrow is clockwise.
   - 5b When *parameter 1-06 Clockwise Direction* is set to *[1] Inverse* (counter-clockwise):
     a. Verify that the motor turns counter-clockwise.
     b. Verify that the LCP direction arrow is counter-clockwise.

5.6 Checking Encoder Rotation

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.

5.7 Local Control Test

1. Press [Hand On] to provide a local start command to the adjustable frequency drive.
2. Accelerate the adjustable frequency 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.

If acceleration or deceleration problems occur, see *chapter 8.5 Troubleshooting*. See *chapter 8.2 Warning and Alarm Types* for resetting the adjustable frequency drive after a trip.

5.8 System Start-up

The procedure in this section requires user-wiring and application programming to be completed. The following procedure is recommended after application set-up 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 8.2 Warning and Alarm Types* for resetting the adjustable frequency drive after a trip.

5.9 STO Commissioning

Refer to *chapter 6 Safe Torque Off (STO)* for the correct installation and commissioning of STO.

6 Safe Torque Off (STO)

The Safe Torque Off (STO) function is a component in a safety control system. STO prevents the unit from generating the energy that is required to rotate the motor, thus ensuring safety in emergency situations.

The STO function is designed and approved suitable for the requirements of:

- IEC/EN 61508: 2010 SIL2
- IEC/EN 61800-5-2: 2007 SIL2
- IEC/EN 62061: 2012 SILCL of SIL2
- EN ISO 13849-1: 2008 Category 3 PL d

To achieve the required level of operational safety, select and apply the components in the safety control system appropriately. Before using STO, carry out a thorough risk analysis on the installation to determine whether the STO function and safety levels are appropriate and sufficient.

The STO function in the adjustable frequency drive is controlled via control terminals 37 and 38. When STO is activated, the power supply on the high side and low side of the IGBT gate driving circuits is cut off. *Figure 6.1* shows the STO architecture. *Table 6.1* shows STO statuses based on whether terminals 37 and 38 are energized.

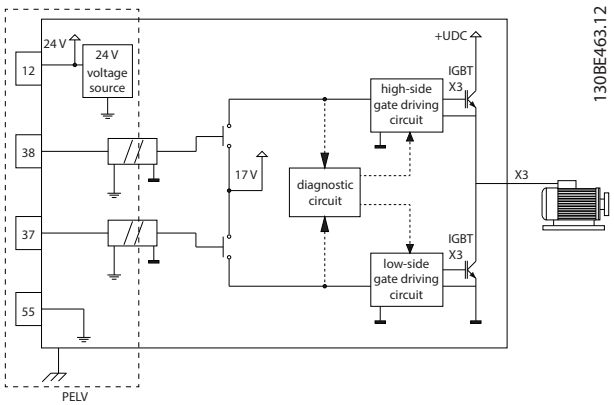


Figure 6.1 STO Architecture

Terminal 37	Terminal 38	Torque	Warning or alarm
Energized[1)]	Energized	Yes[2)]	No warnings or alarms.
De-energized[3)]	De-energized	No	Warning/alarm 68: Safe Torque Off.
De-energized	Energized	No	Alarm 188: STO Function Fault.
Energized	De-energized	No	Alarm 188: STO Function Fault.

Table 6.1 STO Status

1) Voltage range is 24 V ±5 V, with terminal 55 as the reference terminal.

2) Torque is present only when the adjustable frequency drive is operating.

3) Open circuit, or the voltage within the range of 0 V ±1.5 V, with terminal 55 as the reference terminal.

Test pulse filtering

For safety devices that generate test pulses on the STO control lines: If the pulse signals stay at low level (≤1.8 V) for no longer than 5 ms, they are ignored, as shown in *Figure 6.2*.

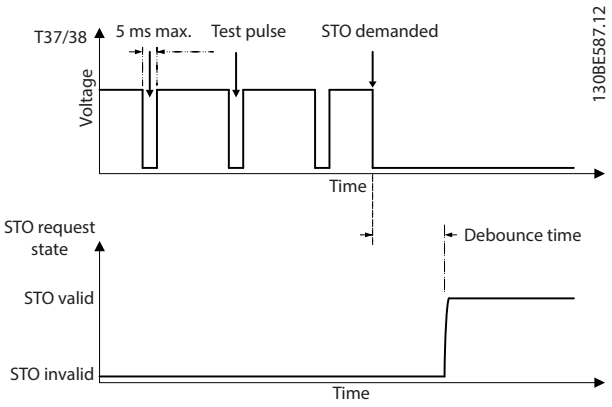


Figure 6.2 Test Pulse Filtering

Asynchronous input tolerance

The input signals at the two terminals are not always synchronous. If the discrepancy between the two signals is longer than 12 ms, the STO fault alarm (*alarm 188, STO Function Fault*) occurs.

Valid signals
To activate STO, the two signals must both be at low level for at least 80 ms. To terminate STO, the two signals must both be at high level for at least 20 ms. Refer to *chapter 9.6 Control Input/Output and Control Data* for the voltage levels and input current of STO terminals.

6.1 Safety Precautions for STO

Qualified personnel
Only qualified personnel are allowed to install or 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 personnel must be familiar with the instructions and safety measures described in this manual.

NOTICE!

After installation of STO, perform a commissioning test as specified in *chapter 6.3.3 STO Commissioning Test*. A passed commissioning test is mandatory after first installation and after each change to the safety installation.

⚠WARNING

RISK OF ELECTRICAL SHOCK

The STO function does NOT isolate AC line voltage to the adjustable frequency drive or auxiliary circuits and therefore does not provide electrical safety. Failure to isolate the AC line voltage supply from the unit and wait the time specified could result in death or serious injury.

- **Perform work on electrical parts of the adjustable frequency drive or the motor only after isolating the AC line voltage supply and waiting the time specified in *chapter 2.3.1 Discharge Time*.**

NOTICE!

When designing the machine application, consider the timing and distance for a coast to stop (STO). For more information regarding stop categories, refer to EN 60204-1.

6.2 Safe Torque Off Installation

For motor connection, AC line input connection, and control wiring, follow the instructions for safe installation in *chapter 4 Electrical Installation*.

Enable the integrated STO as follows:

1. Remove the jumper between control terminals 12 (24 V), 37 and 38. Cutting or breaking the jumper is not sufficient to avoid short-circuiting. See the jumper in *Figure 6.3*.

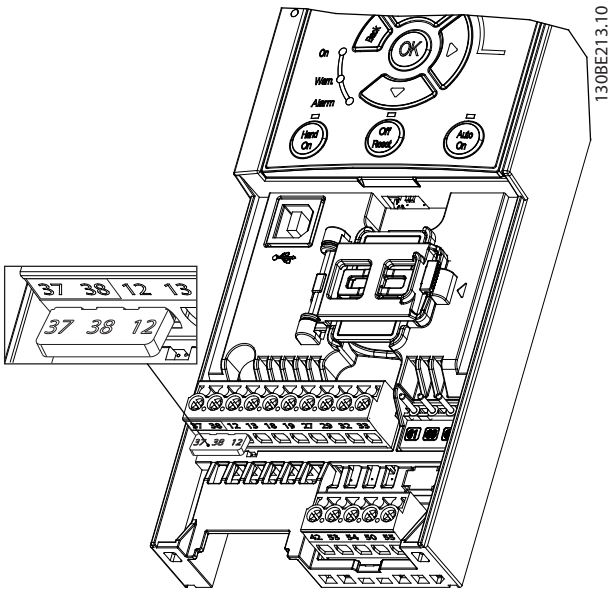
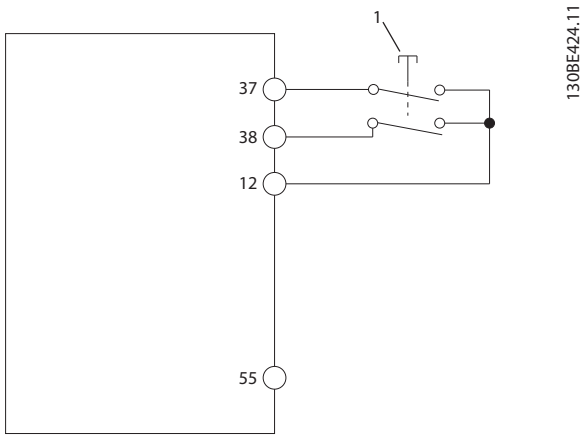


Figure 6.3 Jumper between Terminal 12 (24 V), 37 and 38

2. Connect a dual-channel safety device (for example, safety PLC, light curtain, safety relay or emergency stop button) to terminals 37 and 38 to form a safety application. The device must comply with the required safety level based on the hazard assessment. *Figure 6.4* shows the wiring schematic of STO applications where the adjustable frequency drive and the safety device are in the same cabinet. *Figure 6.5* shows the wiring schematic of STO applications where external supply is used.

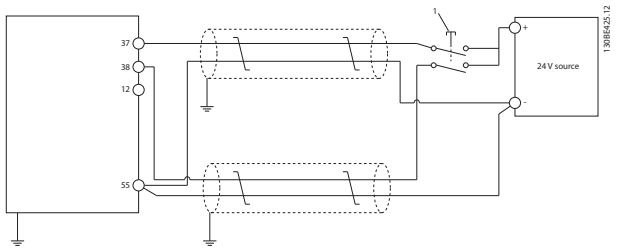
NOTICE!

The STO signal must be PELV supplied.



1	Safety device

Figure 6.4 STO Wiring in 1 Cabinet, Adjustable Frequency Drive Provides the Supply Voltage



1	Safety device

Figure 6.5 STO Wiring, External Supply

3. Complete the wiring according to the instructions in *chapter 4 Electrical Installation*, and:
   - Eliminate short circuit risks.
   - Ensure that the STO cables are shielded if they are longer than 20 m (65.6 ft) or outside the cabinet.
   - Connect the safety device directly to terminals 37 and 38.

6.3 STO Commissioning

6.3.1 Activation of Safe Torque Off

To activate the STO function, remove the voltage at terminals 37 and 38 of the adjustable frequency drive.

When STO is activated, the adjustable frequency drive issues *alarm 68, Safe Torque Off* or *warning 68, Safe Torque Off*, trips the unit, and coasts the motor to stop. Use the STO function to stop the adjustable frequency drive in emergency stop situations. In normal operating mode when STO is not required, use the standard stop function instead.

NOTICE!

If STO is activated when the adjustable frequency drive issues *warning 8, DC undervoltage* or *alarm 8, DC undervoltage*, the adjustable frequency drive skips *alarm 68, Safe Torque Off*, but the STO operation is not affected.

6.3.2 Deactivation of Safe Torque Off

Follow the instructions in *Table 6.2* to deactivate the STO function and resume normal operation based on the restart mode of the STO function.

⚠WARNING

RISK OF INJURY OR DEATH

Reapplying 24 V DC supply to either terminal 37 or 38 terminates the SIL2 STO state, potentially starting the motor. Unexpected motor start may cause personal injuries or death.

- **Ensure that all safety measures are taken before reapplying 24 V DC supply to terminals 37 and 38.**

Restart mode	Steps to deactivate STO and resume normal operation	Restart mode configuration
Manual restart	1. Reapply 24 V DC supply to terminals 37 and 38. 2. Initiate a reset signal (via serial communication bus, digital I/O or [Reset]/[Off Reset] key on the LCP).	Default setting. *Parameter 5-19 Terminal 37/38 Safe Torque Off=[1] Safe Torque Off Alarm*
Automatic restart	Reapply 24 V DC supply to terminals 37 and 38.	*Parameter 5-19 Terminal 37/38 Safe Torque Off= [3] Safe Torque Off Warning.*

Table 6.2 STO Deactivation

6.3.3 STO Commissioning Test

After installation and before first operation, perform a commissioning test of the installation using STO. Perform the test again after each modification of the installation or application involving the STO.

NOTICE!

A successful commissioning test of the STO function is required after the initial installation and after each subsequent change to the installation.

6

To perform a commissioning test:

- Follow the instructions in *chapter 6.3.4 Test for STO Applications in Manual Restart Mode* if STO is set to manual restart mode.
- Follow the instructions in *chapter 6.3.5 Test for STO Applications in Automatic Restart Mode* if STO is set to automatic restart mode.

6.3.4 Test for STO Applications in Manual Restart Mode

For applications where *parameter 5-19 Terminal 37/38 Safe Torque Off* is set to the default value *[1] Safe Torque Off Alarm*, conduct the commissioning test as follows.

1. Set *parameter 5-40 Function Relay* to *[190] Safe Function active*.
2. Remove the 24 V DC voltage supply to terminals 37 and 38 using the safety device while the adjustable frequency drive drives the motor (that is, the line power supply is not interrupted).
3. Verify that:
   - 3a The motor coasts. It may take a long time for the motor to stop.
   - 3b If the LCP is mounted, *alarm 68, Safe Torque Off* shows on the LCP. If the LCP is not mounted, *alarm 68, Safe Torque Off* is logged in *parameter 15-30 Alarm Log: Error Code*.
4. Reapply 24 V DC to terminals 37 and 38.
5. Ensure that the motor remains in the coasted state, and the customer relay (if connected) remains activated.
6. Send reset signal (via serial communication bus, digital I/O or [Reset]/[Off Reset] key on the LCP).
7. Ensure that the motor becomes operational and runs within the original speed range.

The commissioning test is successfully completed when all the above-mentioned steps are passed.

6.3.5 Test for STO Applications in Automatic Restart Mode

For applications where *parameter 5-19 Terminal 37/38 Safe Torque Off* is set to *[3] Safe Torque Off Warning*, conduct the commissioning test as follows:

1. Remove the 24 V DC voltage supply to terminals 37 and 38 by the safety device while the adjustable frequency drive drives the motor (that is, the line power supply is not interrupted).
2. Verify that:
   - 2a The motor coasts. It may take a long time for the motor to stop.
   - 2b If the LCP is mounted *Warning 68, Safe Torque Off W68*, shows on the LCP. If the LCP is not mounted, *Warning 68, Safe Torque Off W68* is logged in bit 30 of *parameter 16-92 Warning Word*.
3. Reapply 24 V DC to terminals 37 and 38.
4. Ensure that the motor becomes operational and runs within the original speed range.

The commissioning test is successfully completed when all the above-mentioned steps are passed.

NOTICE!

See the warning on the restart behavior in *chapter 6.1 Safety Precautions for STO*.

6.4 Maintenance and Service for STO

- The user is responsible for security measures.
- The adjustable frequency drive parameters can be protected with a password.

The functional test consists of two parts:

- Basic functional test.
- Diagnostic functional test.

When all the steps are completed successfully, the functional test is successful.

Basic functional test

If the STO function has not been used for one year, conduct a basic functional test to detect any failure or malfunction of STO.

1. Ensure that *parameter 5-19 Terminal 37/38 Safe Torque Off* is set to **[1] Safe Torque Off Alarm*.
2. Remove the 24 V DC voltage supply for terminals 37 and 38.
3. Check if the LCP shows *alarm 68, Safe Torque Off*.
4. Verify that the adjustable frequency drive trips the unit.
5. Verify that the motor is coasting and stops completely.
6. Initiate a start signal (via serial communication bus, digital I/O or the LCP), and verify that the motor does not start.
7. Reconnect the 24 V DC voltage supply to terminals 37 and 38.
8. Verify that the motor is not started automatically and restarts only by giving a reset signal (via serial communication bus, digital I/O or [Reset]/ [Off Reset] key on the LCP).

Diagnostic functional test

1. Verify that *warning 68, Safe Torque Off* and *alarm 68, Safe Torque Off* do not occur when 24 V supply is connected to terminals 37 and 38.
2. Remove the 24 V supply for terminal 37, and verify that the LCP shows *alarm 188, STO Function Fault* if the LCP is mounted. If the LCP is not mounted, verify that *alarm 188, STO Function Fault* is logged in *parameter 15-30 Alarm Log: Error Code*.
3. Reapply 24 V supply to terminal 37, and verify that resetting the alarm is successful.
4. Remove the 24 V supply for terminal 38 and verify that the LCP shows *alarm 188, STO Function Fault* if the LCP is mounted. If the LCP is not mounted, verify that *alarm 188, STO Function Fault* is logged in *parameter 15-30 Alarm Log: Error Code*.
5. Reapply 24 V supply to terminal 38 and verify that resetting the alarm is successful.

6.5 STO Technical Data

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

- FC 280 takes 10% of the total failure budget for an SIL2 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 A 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.

Safety standards	Safety of Machinery	ISO 13849-1, IEC 62061
	Functional Safety	IEC 61508
Safety function	Safe Torque Off	IEC 61800-5-2
Safety performance	**ISO 13849-1**	
	Category	Cat. 3
	Diagnostic Coverage (DC)	60% (Low)
	Mean Time to Dangerous Failure (MTTFd)	2400 years (High)
	Performance Level	PL d
	IEC 61508/IEC 61800-5-2/IEC 62061	
	Safety Integrity Level	SIL2
	Probability of Dangerous Failure per Hour (PFH) (High Demand Mode)	7.54E-9 (1/h)
	Probability of Dangerous Failure on Demand (PFD_{avg} for PTI = 20 years) (Low Demand Mode)	6.05E-4
	Safe Failure Fraction (SFF)	> 84%
	Hardware Fault Tolerance (HFT)	1 (Type A, 1oo2D)
	Proof Test Interval[2)]	20 Years
	Common Cause Failure (CCF)	β = 5%; β_D = 5%
	Diagnostic Test Interval (DTI)	160 ms
	Systematic Capability	SC 2
Reaction time[1)]	Input to output response time	Enclosure sizes K1–K3: Maximum 50 ms Enclosure sizes K4 and K5: Maximum 30 ms

Table 6.3 Technical Data for STO

1) Reaction time is the amount of time from an input signal condition that triggers the STO until the torque is off on the motor.

2) For the way to perform proof test, please refer to chapter 6.4 Maintenance and Service for STO.

7 Application Examples

7.1 Introduction

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

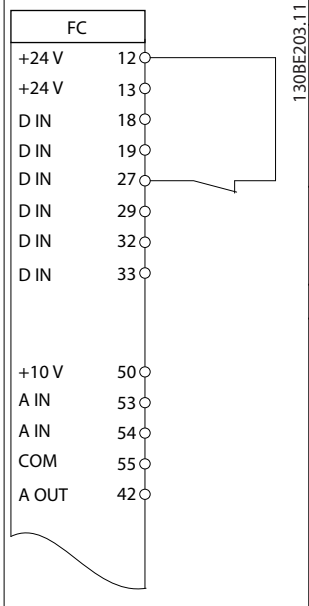
- Parameter settings are the regional default values unless otherwise indicated (selected in *parameter 0-03 Regional Settings*).
- Parameters associated with the terminals and their settings are shown next to the drawings.
- Required switch settings for analog terminals 53 or 54 are also shown.

NOTICE!

When the STO feature is not used, a jumper wire is required between terminals 12, 37 and 38 for the adjustable frequency drive to operate with factory default programming values.

7.2 Application Examples

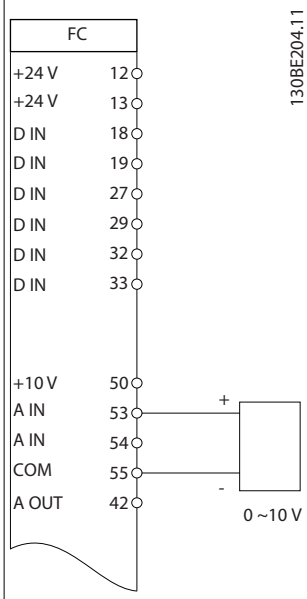
7.2.1 AMA



	Parameters	
	Function	**Setting**
	Parameter 1-29 Automatic Motor Adaptation (AMA)	*[1] Enable complete AMA*
	Parameter 5-12 Terminal 27 Digital Input	*[2] Coast inverse*
*=Default value		
Notes/comments: Set parameter group *1-2* Motor Data* according to motor specifications. ***NOTICE!*** **If terminal 12 and 27 are not connected, set *parameter 5-12 Terminal 27 Digital Input* to *[0] No operation*.**		

Table 7.1 AMA with T27 Connected

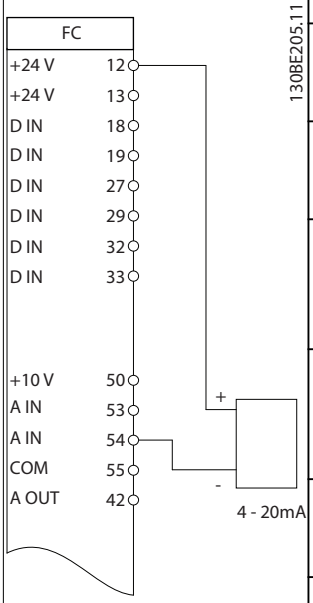
7.2.2 Speed



	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:		

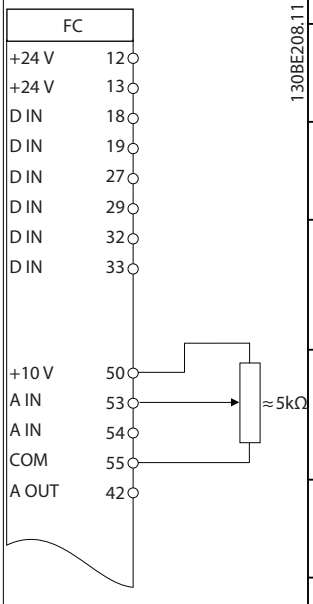
Table 7.2 Analog Speed Reference (Voltage)

7



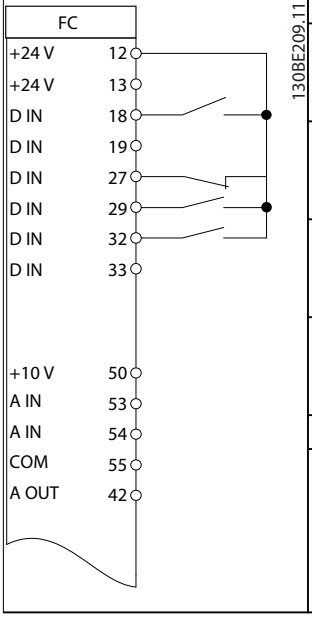
Parameters	
Function	**Setting**
Parameter 6-22 Terminal 54 Low Current	4 mA*
Parameter 6-23 Terminal 54 High Current	20 mA*
Parameter 6-24 Terminal 54 Low Ref./Feedb. Value	0
Parameter 6-25 Terminal 54 High Ref./Feedb. Value	50
Parameter 6-29 Terminal 54 mode	*[0] Current*
*=Default value	
Notes/comments:	

Table 7.3 Analog Speed Reference (Current)



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 7.4 Speed Reference (Using a Manual Potentiometer)



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] Slow
*=Default value	
Notes/comments:	

Table 7.5 Speed Up/Slow

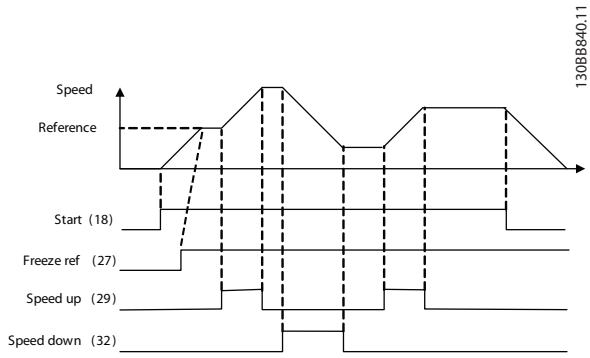
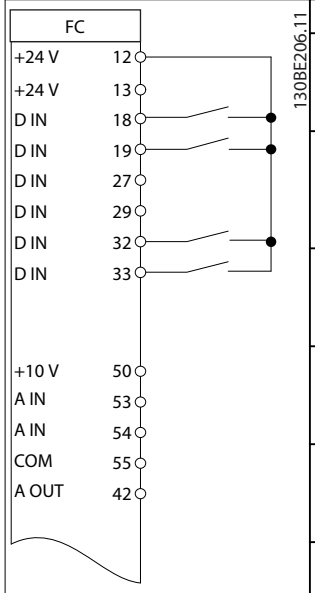


Figure 7.1 Speed Up/Slow

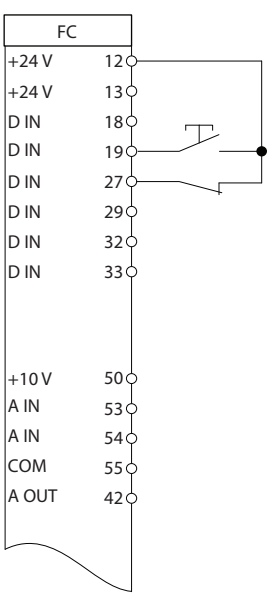
7.2.3 Start/Stop



Parameters	
Function	**Setting**
Parameter 5-10 Terminal 18 Digital Input	*[8] Start*
Parameter 5-11 Terminal 19 Digital Input	**[10] Reversing*
Parameter 5-12 Terminal 27 Digital Input	*[0] No operation*
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:	

Table 7.6 Start/Stop with Reversing and Four Preset Speeds

7.2.4 External Alarm Reset



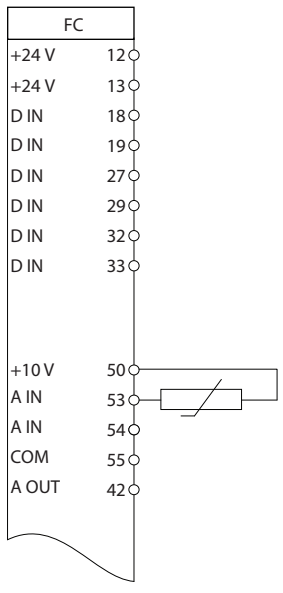
Parameters	
Function	**Setting**
Parameter 5-11 Terminal 19 Digital Input	*[1] Reset*
*=Default value	
Notes/comments:	

Table 7.7 External Alarm Reset

7.2.5 Motor Thermistor

NOTICE!

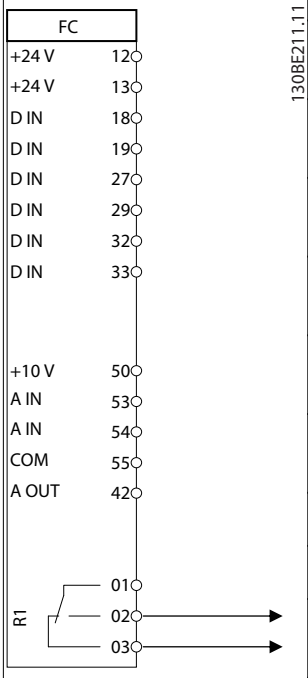
To meet PELV insulation requirements, use reinforced or double insulation on the thermistors.



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*.	

Table 7.8 Motor Thermistor

7.2.6 SLC



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 S peed PID Feedback Source	*[1] 24 V encoder*
Parameter 5-70 T erm 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 F unction 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 adjustable frequency drive continues, and the warning disappears. But relay 1 persists until [Off/Reset] is pressed.	

Table 7.9 Using SLC to Set a Relay

8 Maintenance, Diagnostics and Troubleshooting

8.1 Maintenance and Service

Under normal operating conditions and load profiles, the adjustable frequency drive is maintenance-free throughout its designed lifetime. To prevent breakdown, danger and damage, examine the frequency converter at regular intervals depending on the operating conditions. Replace worn or damaged parts with original spare parts or standard parts. For service and support, contact the local Danfoss supplier.

⚠WARNING

UNINTENDED START

When the frequency converter 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. The motor can start with an external switch, a serial communication bus command, an input reference signal from the LCP, via remote operation using MCT 10 Set-up Software or after a cleared fault condition.

To prevent unintended motor start:

- **Disconnect the adjustable frequency drive from line power.**
- **Press [Off/Reset] on the LCP before programming parameters.**
- **Completely wire and assemble the frequency converter, motor and any driven equipment before connecting the frequency converter to AC mains, DC supply or load sharing.**

8.2 Warning and Alarm Types

Warning/ alarm type	Description
Warning	A warning indicates an abnormal operating condition that leads to an alarm. A warning stops when the abnormal condition is removed.
Alarm	An alarm indicates a fault that requires immediate attention. The fault always triggers a trip or trip lock. Reset the adjustable frequency drive after an alarm. Reset the adjustable frequency drive in any of four ways: • Press [Reset]/[Off/Reset]. • Digital reset input command. • Serial communication reset input command. • Auto reset.

Trip

When tripping, the adjustable frequency drive suspends operation to prevent damage to the adjustable frequency drive and other equipment. When a trip occurs, the motor coasts to a stop. The adjustable frequency drive logic continues to operate and monitor the adjustable frequency drive status. After the fault condition is remedied, the adjustable frequency drive is ready for a reset.

Trip lock

When trip locking, the adjustable frequency drive suspends operation to prevent damage to the adjustable frequency drive and other equipment. When a trip lock occurs, the motor coasts to a stop. The adjustable frequency drive logic continues to operate and monitor the adjustable frequency drive status. The adjustable frequency drive starts a trip lock only when serious faults occur that can damage the adjustable frequency drive or other equipment. After the faults are fixed, cycle the input power before resetting the adjustable frequency drive.

8.3 Warning and Alarm Display

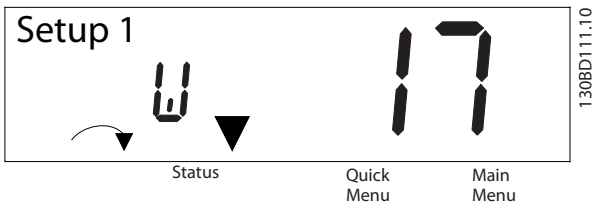


Figure 8.1 Warning Display

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

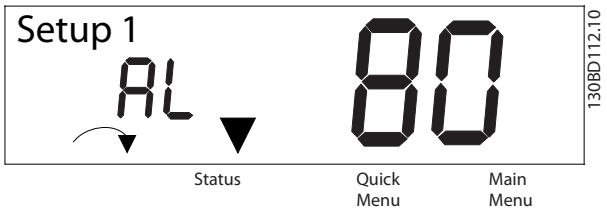


Figure 8.2 Alarm/Trip Lock Alarm

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

8

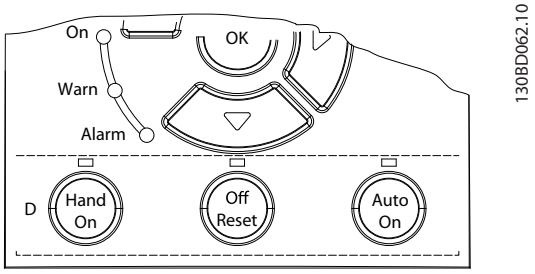


Figure 8.3 Status Indicator Lights

8.4 List of Warnings and Alarms

8.4.1 Warning and Alarm Code List

An (X) marked in *Table 8.1* indicates that the warning or alarm has occurred.

No.	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 6-20 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 adjustable frequency 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 limit.
8	DC undervoltage[1)]	X	X	–	DC link voltage drops below the voltage warning low limit.
9	Inverter overloaded	X	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 overtem-perature	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 adjustable frequency 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.
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	–	PROFIBUS communication issues have occurred.
35	Option fault	–	X	–	Serial communication bus detects internal faults.
36	Mains failure	X	X	–	This warning/alarm is only active if the supply voltage to the adjustable frequency drive is less than the value set in *parameter 14-11 Mains Voltage at Mains Fault*, and *parameter 14-10 Mains Failure* is NOT set to *[0] No Function*.
38	Internal fault	–	X	X	Contact the local Danfoss supplier.

No.	Description	Warning	Alarm	Trip lock	Cause
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.
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 Danfoss.
59	Current limit	X	X	–	Adjustable frequency drive overload.
61	Encoder loss	X	X	–	–
63	Mechanical brake low	–	X	–	Actual motor current has not exceeded release brake current within start delay time window.
65	Control card temp	X	X	X	The cut-out 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 Stop	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 serial communication bus, 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 adjustable frequency drive to normal operation.
69	Power card temp	X	X	X	The cut-out 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 braking	X	–	–	Occurs in IT line power when the adjustable frequency 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	–	–
120	Position control fault	–	X	–	–
188	STO internal fault	–	X	–	24 V DC supply is connected to only one of the 2 STO terminals (37 and 38), or a failure in STO channels is detected. Ensure that both terminals are connected to 24 V DC supply, and that the discrepancy between the signals at the two terminals is less than 12 ms. If the fault still occurs, contact the local Danfoss supplier.
nw run	Not while running	–	–	–	Parameter can only be changed when the motor is stopped.

No.	Description	Warning	Alarm	Trip lock	Cause
Err.	An incorrect password was entered	–	–	–	Occurs when using an incorrect password for changing a password-protected parameter.

Table 8.1 Warnings and Alarms Code List

1) Line power distortions may cause these faults. Installing a Danfoss line filter may rectify this problem.

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

8.5 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: • The reference signal is local, remote or bus reference? • Preset reference is active? • Terminal connection is correct? • The scaling of terminals is correct? • The reference signal is 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.
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*.

Symptom	Possible cause	Test	Solution
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 group 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.
Line power current imbalance greater than 3%	Problem with line power (see *alarm 4, Mains phase loss* description)	Rotate input power leads into the adjustable frequency 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 line power supply.
	Problem with the adjustable frequency drive unit	Rotate input power leads into the adjustable frequency 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 leads one 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 adjustable frequency drive unit	Rotate output motor leads one 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.
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 Dampening*.	

Table 8.2 Troubleshooting

9 Specifications

9.1 Electrical Data

Adjustable frequency driver typical shaft output [kW] (hp)	PK37 0.37 (0.5)	PK55 0.55 (0.75)	PK75 0.75 (1.0)	P1K1 1.1 (1.5)	P1K5 1.5 (2.0)	P2K2 2.2 (3.0)	P3K0 3.0 (4.0)
Enclosure protection rating IP20	K1	K1	K1	K1	K1	K1	K2
Output current							
Shaft output [kW] (hp)	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)
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 (line power, 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 (lbs)	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 (7.94)
Efficiency [%][2)]	96.2	97.0	97.2	97.4	97.4	97.6	97.5

Table 9.1 Line Power Supply 3x380–480 V AC

Adjustable frequency driver typical shaft output [kW] (hp)	P4K0 4 (5)	P5K5 5.5 (7.5)	P7K5 7.5 (10)	P11K 11 (15)	P15K 15 (20)	P18K 18.5 (25)	P22K 22 (30)
Enclosure protection rating IP20	K2	K2	K3	K4	K4	K5	K5
Output current							
Shaft output [kW] (hp)	4 (5)	5.5 (7.5)	7.5 (10)	11 (15)	15 (20)	18.5 (25)	22 (30)
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 size (line power, motor, brake) [mm² (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] (lbs)	3.6 (7.94)	3.6 (7.94)	4.1 (9.04)	9.4 (20.7)	9.5 (20.94)	12.3 (27.12)	12.5 (27.6)
Efficiency [%][2)]	97.6	97.7	98.0	97.8	97.8	98.1	97.9

Table 9.2 Line Power Supply 3x380–480 V AC

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 adjustable frequency drive, and motors with high efficiency reduce power loss.
Applies to dimensioning of adjustable frequency drive cooling. If the switching frequency is higher than the default setting, the power losses may rise. LCP and typical control card power consumptions are included. Further options and customer load may add up to 30 W to the losses (though typically only 4 W extra for a fully loaded control card or serial communication bus).
For power loss data according to EN 50598-2, refer to www.danfoss.com/vltenergyefficiency.

2) Measured using 50 m (164 ft) (shielded motor cables at rated load and rated frequency.) For energy efficiency class, see chapter 9.4 Ambient Conditions. For part load losses, see www.danfoss.com/vltenergyefficiency.

9.2 Line Power Supply (3-phase)

Line power supply (L1, L2, L3)	
Supply terminals	L1, L2, L3
Supply voltage	380–480 V: -15% (-25%)[1)] to +10%

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

Supply frequency	50/60 Hz ±5%
Maximum imbalance temporary between line 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, L2, L3 (power-ups) ≤7.5 kW (10 hp)	Maximum two times/minute
Switching on input supply L1, L2, L3 (power-ups) 11–22 kW (15–30 hp)	Maximum one time/minute

The unit is suitable for use on a circuit capable of delivering less than 5000 RMS symmetrical Amperes, 480 V maximum.

9.3 Motor Output and Motor Data

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

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+ mode (independent of f_{sw})	Maximum 50 ms

1) Percentage relates to the nominal torque.

9.4 Ambient Conditions

Ambient conditions	
Enclosure protection rating, adjustable frequency drive	IP20/chassis
Enclosure protection rating, conversion kit	IP21/Type 1
Vibration test, all enclosure sizes	1.0 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)]
- at full constant output current with some power sizes	Maximum 50 °C (122 °F)
- at full constant output current	Maximum 45 °C (113 °F)
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 (9243 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, IEC 61800-3
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 61326-3-1
Energy efficiency class[3)]	IE2

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

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

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

3) 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

Cable lengths and cross-sections[1)]	
Maximum motor cable length, shielded	50 m (165 ft)
Maximum motor cable length, unshielded	75 m (245 ft)
Maximum cross-section of control terminals, flexible/rigid wire	2.5 mm^2/13 AWG
Minimum cross-section of control terminals	0.55 mm^2/20 AWG
Maximum STO input cable length, unshielded	20 m (65 ft)

1) For power cables, see Table 9.1 and Table 9.2.

9.6 Control Input/Output and Control Data

Digital inputs	
Terminal number	18, 19, 27[1)], 29, 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 ranges	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.

STO inputs[1)]	
Terminal number	37, 38
Voltage level	0–30 V DC
Voltage level, low	<1.8 V DC
Voltage level, high	>20 V DC
Maximum voltage on input	30 V DC
Minimum input current (each pin)	6 mA

1) Refer to chapter 6 Safe Torque Off (STO) for more details about STO inputs.

Analog inputs	
Number of analog inputs	2
Terminal number	53[1)], 54
Modes	Voltage or current
Mode select	Software
Voltage level	0–10 V
Input resistance, R_i	Approximately 10 kΩ
Maximum voltage	-15 V 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

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

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

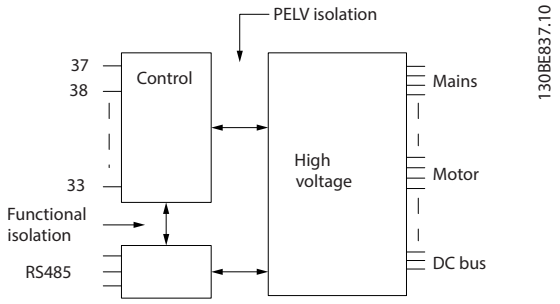


Figure 9.1 Galvanic Isolation

NOTICE!

HIGH ALTITUDE

For installation at altitudes above 2000 m (6600 ft), contact Danfoss hotline regarding PELV.

Pulse inputs	
Programmable pulse inputs	2
Terminal number pulse	29, 33
Maximum frequency at terminal 29, 33	32 kHz (push-pull driven)
Maximum frequency at terminal 29, 33	5 kHz (open collector)
Minimum frequency at terminal 29, 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 (0.1–1 kHz)	Maximum error: 0.1% of full scale
Pulse input accuracy (1–32 kHz)	Maximum error: 0.05% of full scale

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.

Analog outputs	
Number of programmable analog outputs	1
Terminal number	42
Current range at analog output	0/4–20 mA
Maximum resistor load to common at analog output	500 Ω
Accuracy on analog output	Maximum error: 0.8% of full scale
Resolution on analog output	10 bit

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

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.

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.

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).

Control card, USB serial communication	
USB standard	1.1 (Full speed)
USB plug	USB type B plug

Connection to 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 ground. Use only an isolated laptop as PC connection to the USB connector on the adjustable frequency drive.

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.

Control card performance	
Scan interval	1 ms

Control characteristics	
Resolution of output frequency at 0–500 Hz	±0.003 Hz
System response time (terminals 18, 19, 27, 29, 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.

Enclosure type	Power [kW (hp)]	Torque [Nm (in-lb)]					
		Line power	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)	0.5 (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)	0.5 (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)	0.5 (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)	0.5 (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)	0.5 (4.4)

Table 9.3 Tightening Torques

9.8 Fuses and Circuit Breakers

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 adjustable frequency drive (first fault).

Branch circuit protection
Protect all branch circuits in an installation (including switch gear 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.

Table 9.4 lists the recommended fuses and circuit breakers that have been tested.

⚠CAUTION

PERSONAL INJURY AND EQUIPMENT DAMAGE RISK
Malfunction or failing to follow the recommendations may result in personal risk as well as damage to the adjustable frequency drive and other equipment.

- **Select fuses according to recommendations. Possible damage can be limited to be inside the adjustable frequency drive.**

NOTICE!

EQUIPMENT DAMAGE
Using fuses and/or circuit breakers is mandatory to ensure compliance with IEC 60364 for CE. Failure to follow the protection recommendations can result in damage to the adjustable frequency drive.

Danfoss recommends using the fuses and circuit breakers in *Table 9.4* to ensure compliance with UL or IEC 61800-5-1. For non-UL applications, design circuit breakers for protection in a circuit capable of delivering a maximum of 50,000 A_{rms} (symmetrical), 400 V. The adjustable frequency drive short-circuit current rating (SCCR) is suitable for use on a circuit capable of delivering no more than 10,0000 A_{rms}, 480 V maximum when protected by T-Class fuses.

Enclosure size	Power [kW (hp)]	Non-UL fuse	Non-UL circuit breaker	UL fuse
K1	0.37 (0.5)	gG-10	PKZM0-16	JJS-3
	0.55–0.75 (0.74–1.0)			JJS-6
	1.1–1.5 (1.48–2.0)	gG-20		JJS-10
	2.2 (3.0)			JJS-15
K2	3.0–5.5 (4.0–7.5)	gG-25	PKZM0-20	JJS-25
K3	7.5 (10)	gG-25	PKZM0-25	JJS-25
K4	11–15 (15–20)	gG-50	–	JJS-50
K5	18.5–22 (25–30)	gG-80	–	JJS-80

Table 9.4 Fuse and Circuit Breaker, 380–480 V

9

9.9 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 (5.0)	5.5 (7.5)	7.5 (10)	11 (15)	15 (20)	18.5 (25)	22 (30)
Dimensions [mm (in)]	**FC 280 IP20**														
	Height A	210 (8.3)						272.5 (10.7)			272.5 (10.7)	317.5 (12.5)		410 (16.1)	
	Width B	75 (3.0)						90 (3.5)			115 (4.5)	133 (5.2)		150 (5.9)	
	Depth C	168 (6.6)						168 (6.6)			168 (6.6)	245 (9.6)		245 (9.6)	
	FC 280 with IP21 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 NEMA Type 1 kit														
	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	168 (6.6)						168 (6.6)			168 (6.6)	245 (9.6)		245 (9.6)	
Weight [kg (lb)]		2.5 (5.5)						3.6 (7.9)			4.6 (10.1)	8.2 (18.1)		11.5 (25.4)	
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)	

Table 9.5 Enclosure Sizes, Power Ratings and Dimensions

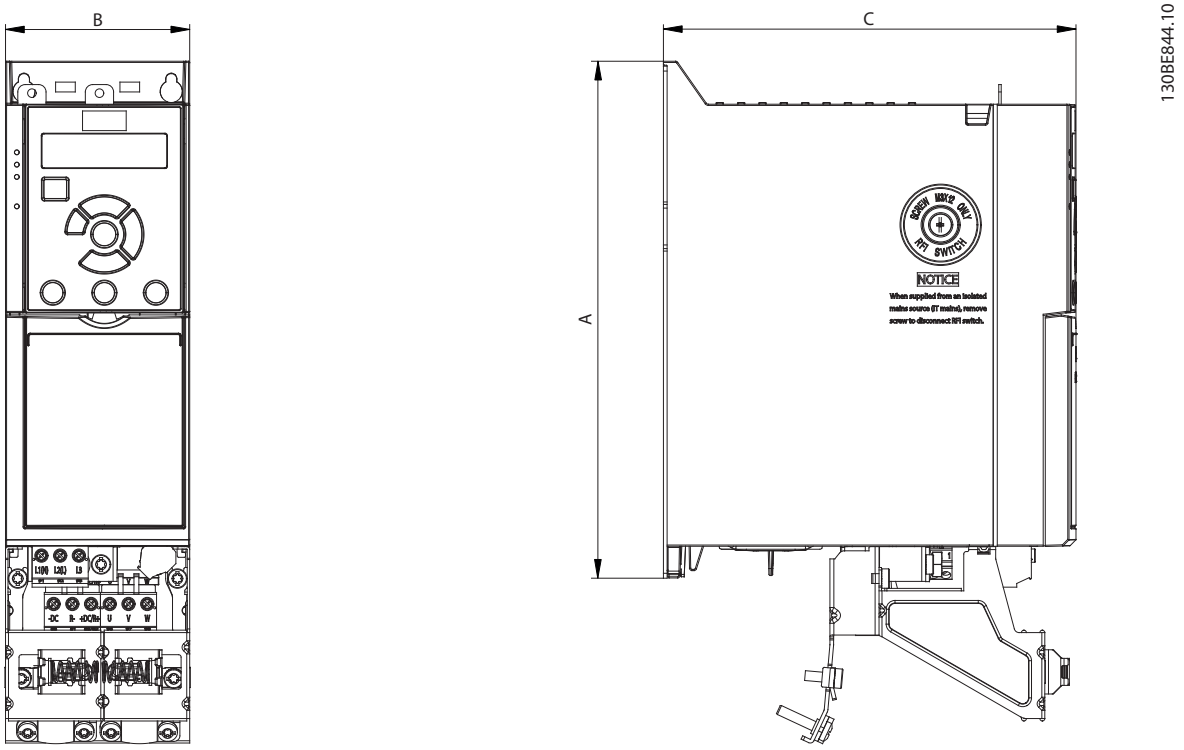


Figure 9.2 Standard with Decoupling Plate

9

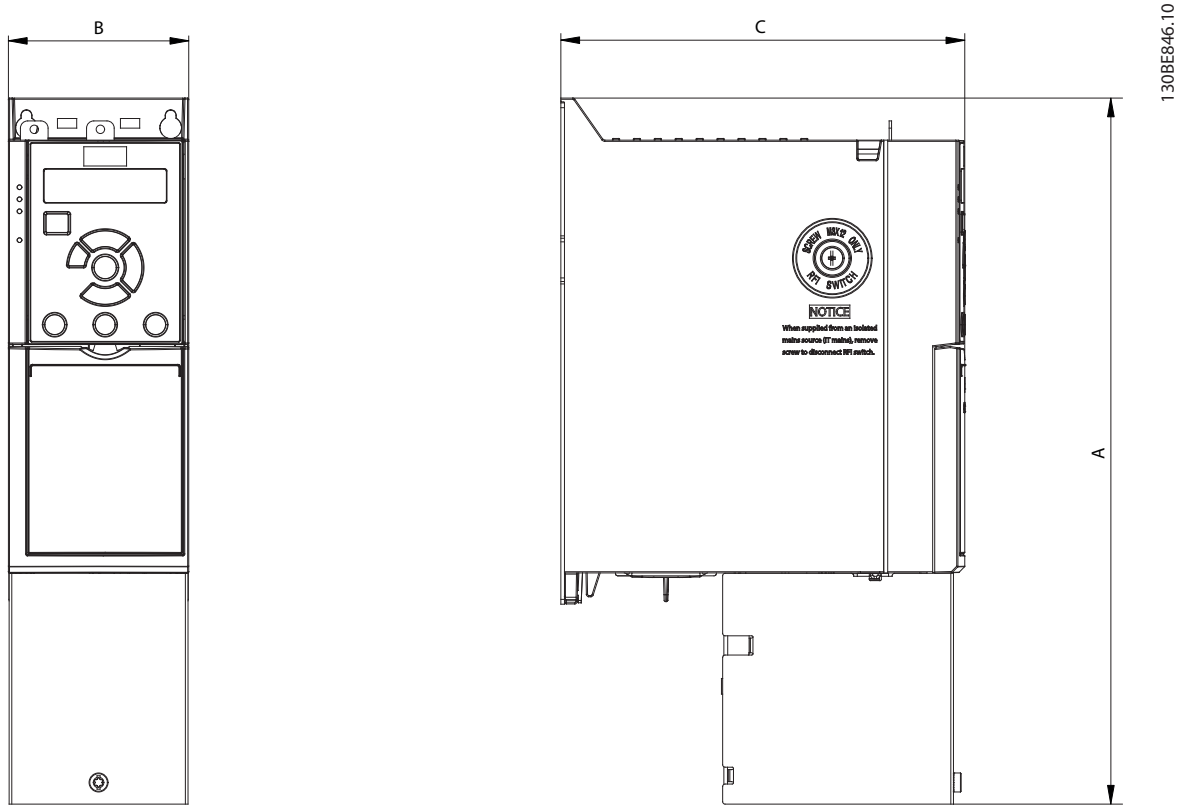


Figure 9.3 Standard with IP21

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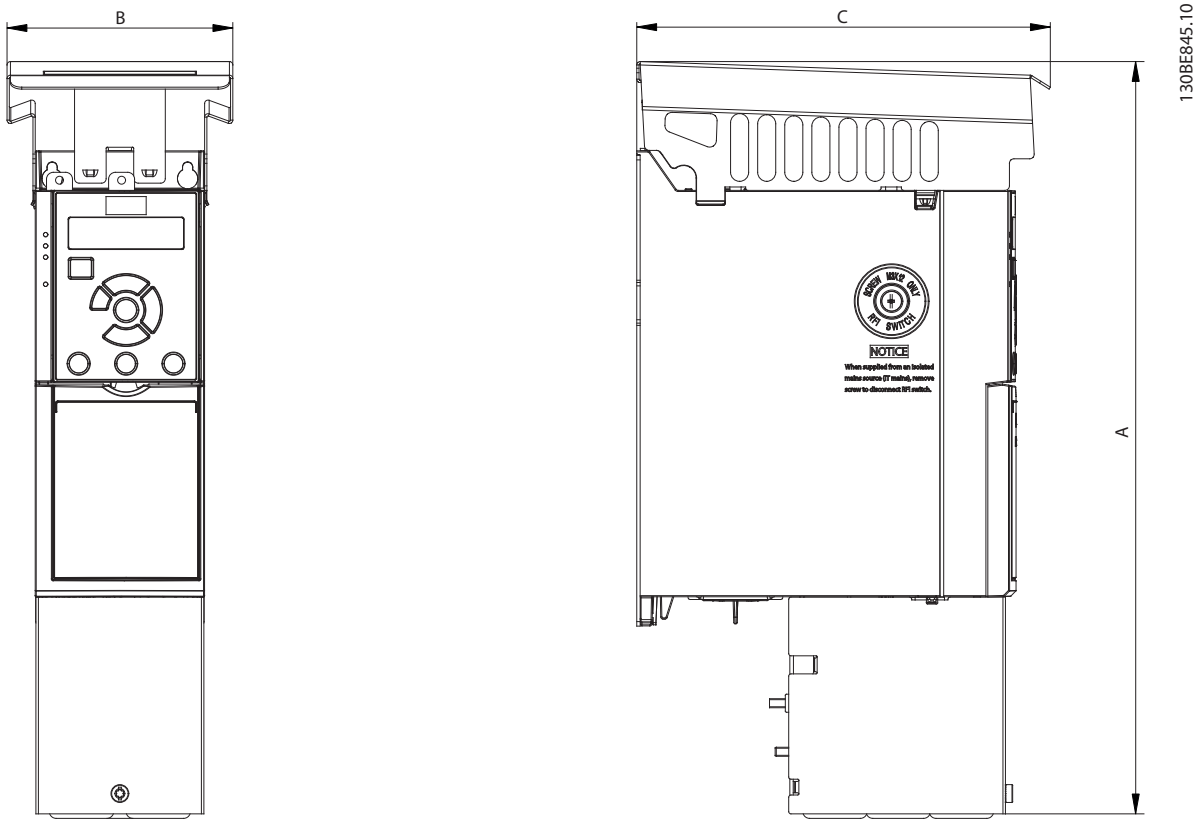

Figure 9.4 Standard with NEMA/Type 1

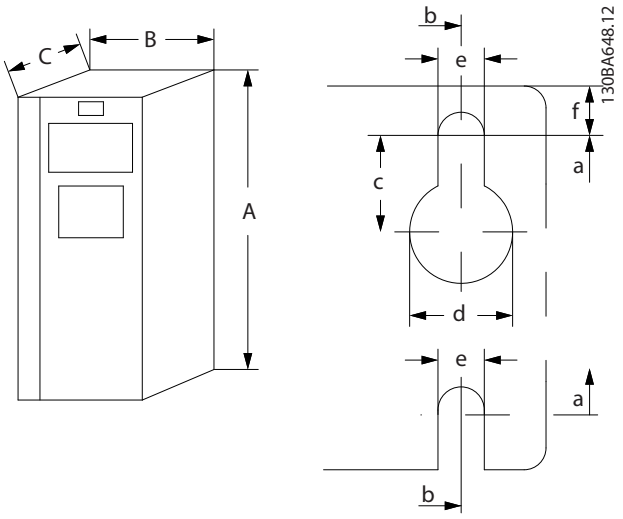

Figure 9.5 Top and Bottom Mounting Holes

10 Appendix

10.1 Symbols, Abbreviations and Conventions

°C	Degrees celsius
AC	Alternating current
AEO	Automatic energy optimization
AWG	American wire gauge
AMA	Automatic motor adaptation
DC	Direct current
EMC	Electromagnetic compatibility
ETR	Electronic thermal relay
$f_{M,N}$	Nominal motor frequency
FC	Adjustable frequency drive
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 adjustable frequency drive
IP	Ingress protection
LCP	Local control panel
MCT	Motion control tool
n_s	Synchronous motor speed
$P_{M,N}$	Nominal motor power
PELV	Protective extra low voltage
PCB	Printed circuit board
PM Motor	Permanent magnet motor
PWM	Pulse width modulation
RPM	Revolutions per minute
STO	Safe Torque Off
T_{LIM}	Torque limit
$U_{M,N}$	Nominal motor voltage

Table 10.1 Symbols and Abbreviations

Conventions

- For figures, all dimensions are in [mm (in)].
- An asterisk (*) indicates the default setting of a parameter.
- Numbered lists indicate procedures.
- Bullet lists indicate other information.
- Italicized text indicates:
  - Cross-reference.
  - Link.
  - Parameter name.

10.2 Parameter Menu Structure

0-	**Operation/Display**
0-0*	**Basic Settings**
0-01	Language
0-03	Regional Settings
0-04	Operating State at Power-up
0-06	GridType
0-07	Auto DC Braking
0-1*	**Set-up Operations**
0-10	Active Set-up
0-11	Programming Set-up
0-12	Link Set-ups
0-14	Readout: Edit Set-ups / Channel
0-16	Application Selection
0-2*	**LCP Display**
0-20	Display Line 1.1 Small
0-21	Display Line 1.2 Small
0-22	Display Line 1.3 Small
0-23	Display Line 2 Large
0-24	Display Line 3 Large
0-3*	**LCP Custom Readout**
0-30	Custom Readout Unit
0-31	Custom Readout Min Value
0-32	Custom Readout Max Value
0-37	Display Text 1
0-38	Display Text 2
0-39	Display Text 3
0-4*	**LCP Keypad**
0-40	[Hand on] Key on LCP
0-42	[Auto on] Key on LCP
0-44	[Off/Reset] Key on LCP
0-5*	**Copy/Save**
0-50	LCP Copy
0-51	Set-up Copy
0-6*	**Password**
0-60	Main Menu Password
1-	**Load and Motor**
1-0*	**General Settings**
1-00	Configuration Mode
1-01	Motor Control Principle
1-03	Torque Characteristics
1-06	Clockwise Direction
1-08	Motor Control Bandwidth
1-1*	**Motor Selection**
1-10	Motor Construction
1-14	Damping Gain
1-15	Low Speed Filter Time Const.
1-16	High Speed Filter Time Const.
1-17	Voltage Filter Time Const.
1-2*	**Motor Data**
1-20	Motor Power
1-22	Motor Voltage
1-23	Motor Frequency
1-24	Motor Current
1-25	Motor Nominal Speed
1-26	Motor Cont. Rated Torque
1-29	Automatic Motor Adaption (AMA)
1-3*	**Adv. Motor Data I**
1-30	Stator Resistance (Rs)
1-31	Rotor Resistance (Rr)
1-33	Stator Leakage Reactance (X1)
1-35	Main Reactance (Xh)
1-37	d-axis Inductance (Ld)
1-38	q-axis Inductance (Lq)
1-39	Motor Poles
1-4*	**Adv. Motor Data II**
1-40	Back EMF at 1000 RPM
1-42	Motor Cable Length
1-43	Motor Cable Length Feet
1-44	d-axis Inductance Sat. (LdSat)
1-45	q-axis Inductance Sat. (LqSat)
1-46	Position Detection Gain
1-48	Current at Min Inductance for d-axis
1-49	Current at Min Inductance for q-axis
1-5*	**Load Indep. Setting**
1-50	Motor Magnetization at Zero Speed
1-52	Min Speed Normal Magnetizing [Hz]
1-55	U/f Characteristic - U
1-56	U/f Characteristic - F
1-6*	**Load Depen. Setting**
1-60	Low Speed Load Compensation
1-61	High Speed Load Compensation
1-62	Slip Compensation
1-63	Slip Compensation Time Constant
1-64	Resonance Dampening
1-65	Resonance Dampening Time Constant
1-66	Min. Current at Low Speed
1-7*	**Start Adjustments**
1-70	PM Start Mode
1-71	Start Delay
1-72	Start Function
1-73	Flying Start
1-75	Start Speed [Hz]
1-76	Start Current
1-78	Compressor Start Max Speed [Hz]
1-79	Compressor Start Max Time to Trip
1-8*	**Stop Adjustments**
1-80	Function at Stop
1-82	Min Speed for Function at Stop [Hz]
1-83	Precise Stop Function
1-84	Precise Stop Counter Value
1-85	Precise Stop Speed Compensation Delay
1-88	AC Brake Gain
1-9*	**Motor Temperature**
1-90	Motor Thermal Protection
1-93	Thermistor Source
2-	**Brakes**
2-0*	**DC Brake**
2-00	DC Hold/Motor Preheat Current
2-01	DC Brake Current
2-02	DC Braking Time
2-04	DC Brake Cut-in Speed
2-06	Parking Current
2-07	Parking Time
2-1*	**Brake Energy Funct.**
2-10	Brake Function
2-11	Brake Resistor (ohm)
2-12	Brake Power Limit (kW)
2-14	Brake voltage reduce
2-16	AC Brake, Max current
2-17	Overvoltage Control
2-19	Overvoltage Gain
2-2*	**Mechanical Brake**
2-20	Release Brake Current
2-22	Activate Brake Speed [Hz]
2-23	Activate Brake Delay
3-	**Reference / Ramps**
3-0*	**Reference Limits**
3-00	Reference Range
3-01	Reference/Feedback Unit
3-02	Minimum Reference
3-03	Maximum Reference
3-04	Reference Function
3-1*	**References**
3-10	Preset Reference
3-11	Jog Speed [Hz]
3-12	Catch up/slow-down value
3-14	Preset Relative Reference
3-15	Reference 1 Source
3-16	Reference 2 Source
3-17	Reference 3 Source
3-18	Relative Scaling Reference Resource
3-4*	**Ramp 1**
3-40	Ramp 1 Type
3-41	Ramp 1 Ramp-up Time
3-42	Ramp 1 Ramp-down Time
3-5*	**Ramp 2**
3-50	Ramp 2 Type
3-51	Ramp 2 Ramp-up Time
3-52	Ramp 2 Ramp-down Time
3-6*	**Ramp 3**
3-60	Ramp 3 Type
3-61	Ramp 3 Ramp-up Time
3-62	Ramp 3 Ramp-down Time
3-7*	**Ramp 4**
3-70	Ramp 4 Type
3-71	Ramp 4 Ramp-up Time
3-72	Ramp 4 Ramp-down Time
3-8*	**Other Ramps**
3-80	Jog Ramp Time
3-81	Quick Stop Ramp Time
3-9*	**Digital Pot. Meter**
3-90	Step Size
3-92	Power Restore
3-93	Maximum Limit
3-94	Minimum Limit
3-95	Ramp Delay
3-96	Maximum Limit Switch Reference
4-	**Limits / Warnings**
4-1*	**Motor Limits**
4-10	Motor Speed Direction
4-12	Motor Speed Low Limit [Hz]
4-14	Motor Speed High Limit [Hz]
4-16	Torque Limit Motor Mode
4-17	Torque Limit Generator Mode
4-18	Current Limit
4-19	Max Output Frequency
4-2*	**Limit Factors**
4-20	Torque Limit Factor Source
4-21	Speed Limit Factor Source
4-22	Break Away Boost
4-3*	**Motor Fb Monitor**
4-30	Motor Feedback Loss Function
4-31	Motor Feedback Speed Error
4-32	Motor Feedback Loss Timeout
4-4*	**Adj. Warnings 2**
4-40	Warning Freq. Low
4-41	Warning Freq. High
4-42	Adjustable Temperature Warning
4-5*	**Adj. Warnings**
4-50	Warning Current Low
4-51	Warning Current High
4-54	Warning Reference Low
4-55	Warning Reference High
4-56	Warning Feedback Low
4-57	Warning Feedback High
4-58	Missing Motor Phase Function
4-6*	**Speed Bypass**
4-61	Bypass Speed From [Hz]
4-63	Bypass Speed To [Hz]
5-	**Digital In/Out**
5-0*	**Digital I/O mode**
5-00	Digital Input Mode
5-01	Terminal 27 Mode
5-1*	**Digital Inputs**
5-10	Terminal 18 Digital Input
5-11	Terminal 19 Digital Input
5-12	Terminal 27 Digital Input
5-13	Terminal 29 Digital Input
5-14	Terminal 32 Digital Input
5-15	Terminal 33 Digital Input
5-19	Terminal 37/38 Safe Torque Off
5-3*	**Digital Outputs**
5-30	Terminal 27 Digital Output
5-34	On Delay, Digital Output
5-35	Off Delay, Digital Output
5-4*	**Relays**
5-40	Function Relay
5-41	On Delay, Relay
5-42	Off Delay, Relay
5-5*	**Pulse Input**
5-50	Term. 29 Low Frequency
5-51	Term. 29 High Frequency
5-52	Term. 29 Low Ref./Feedb. Value
5-53	Term. 29 High Ref./Feedb. Value
5-55	Term. 33 Low Frequency
5-56	Term. 33 High Frequency
5-57	Term. 33 Low Ref./Feedb. Value
5-58	Term. 33 High Ref./Feedb. Value
5-6*	**Pulse Output**
5-60	Terminal 27 Pulse Output Variable
5-62	Pulse Output Max Freq 27
5-7*	**24 V Encoder Input**
5-70	Term 32/33 Pulses Per Revolution
5-71	Term 32/33 Encoder Direction
5-9*	**Bus Controlled**
5-90	Digital & Relay Bus Control
5-93	Pulse Out 27 Bus Control
5-94	Pulse Out 27 Timeout Preset
6-	**Analog In/Out**
6-0*	**Analog I/O Mode**
6-00	Live Zero Timeout Time
6-01	Live Zero Timeout Function
6-1*	**Analog Input 53**
6-10	Terminal 53 Low Voltage
6-11	Terminal 53 High Voltage
6-14	Terminal 53 Low Ref./Feedb. Value
6-15	Terminal 53 High Ref./Feedb. Value
6-16	Terminal 53 Filter Time Constant
6-18	Terminal 53 Digital Input
6-19	Terminal 53 mode
6-2*	**Analog Input 54**
6-20	Terminal 54 Low Voltage
6-21	Terminal 54 High Voltage
6-22	Terminal 54 Low Current
6-23	Terminal 54 High Current
6-24	Terminal 54 Low Ref./Feedb. Value
6-25	Terminal 54 High Ref./Feedb. Value
6-26	Terminal 54 Filter Time Constant
6-29	Terminal 54 mode
6-9*	**Analog/Digital Output 42**
6-90	Terminal 42 Mode
6-91	Terminal 42 Analog Output
6-92	Terminal 42 Digital Output
6-93	Terminal 42 Output Min Scale
6-94	Terminal 42 Output Max Scale
6-96	Terminal 42 Output Bus Control
6-98	Drive Type
7-	**Controllers**
7-0*	**Speed PID Ctrl.**
7-00	Speed PID Feedback Source
7-02	Speed PID Proportional Gain
7-03	Speed PID Integral Time
7-04	Speed PID Differentiation Time
7-05	Speed PID Diff. Gain Limit
7-06	Speed PID Low-pass Filter Time
7-07	Speed PID Feedback Gear Ratio
7-08	Speed PID Feed Forward Factor
7-1*	**Torque PID Ctrl.**
7-12	Torque PID Proportional Gain
7-13	Torque PID Integration Time
7-2*	**Process Ctrl. Feedb**
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