ENGINEERING TOMORROW

Service Guide
VLT® Midi Drive FC 280

vlt-drives.danfoss.com

Contents

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1 Introduction

1.1 Purpose of the Guide

This guide is intended to be used by a Danfoss authorized, qualified technician to service the VLT® frequency converters.

This guide provides the following information:

- Data for the different enclosure sizes.
- Description of user interfaces and internal processing.
- Troubleshooting and test instructions.
- Assembly and disassembly instructions.

This guide provides instructions for the frequency converter models and voltage ranges described in *chapter 1.9 Ratings Tables*.

VLT® is a registered trademark.

1.2 Additional Resources

Additional resources are available to understand advanced frequency converter functions and programming.

- *VLT® Midi Drive FC 280 Operating Guide* provides information required to install and commission the frequency converter.
- *VLT® Midi Drive FC 280 Design Guide* provides detailed information about the design and applications of the frequency converter.
- *VLT® Midi Drive FC 280 Programming Guide* provides information on how to program and includes complete parameter descriptions.

Contact the local Danfoss supplier or go to *drives.danfoss.com/knowledge-center/technical-documentation/* to download the documentations.

1.3 Document and Software Version

This guide is regularly reviewed and updated. All suggestions for improvement are welcome. *Table 1.1* shows the document version and the corresponding software version.
In the frequency converter, read the software version in *parameter 15-43 Software Version*.

Edition	Remarks	Software version
MG07D2	More information for single-phase and 3-phase 200-240 V frequency converters introduced.	1.2

Table 1.1 Document and Software Version

1.4 Abbreviations

°C	Degrees Celsius
°F	Fahrenheit
AC	Alternating current
AEO	Automatic energy optimization
ACP	Application control processor
AWG	American wire gauge
AMA	Automatic motor adaptation
DC	Direct current
EEPROM	Electrically erasable programmable read-only memory
EMC	Electromagnetic compatibility
EMI	Electromagnetic interference
ESD	Electrostatic discharge
ETR	Electronic thermal relay
$f_{M,N}$	Nominal motor frequency
FC	Frequency converter
IGBT	Insulated-gate bipolar transistor
IP	Ingress protection
I_{LIM}	Current limit
I_{INV}	Rated inverter output current
$I_{M,N}$	Nominal motor current
$I_{VLT,MAX}$	Maximum output current
$I_{VLT,N}$	Rated output current supplied by the frequency converter
L_d	Motor d-axis inductance
L_q	Motor q-axis inductance
LCP	Local control panel
LED	Light-emitting diode
MCP	Motor control processor
N.A.	Not applicable
NEMA	National Electrical Manufacturers Association
$P_{M,N}$	Nominal motor power

PCB	Printed circuit board
PE	Protective earth
PELV	Protective extra low voltage
PWM	Pulse-width modulation
R_s	Stator resistance
Regen	Regenerative terminals
RPM	Revolutions per minute
RFI	Radio frequency interference
SCR	Silicon controlled rectifier
SMPS	Switch mode power supply
T_{LIM}	Torque limit
$U_{M,N}$	Nominal motor voltage
X_h	Motor main reactance

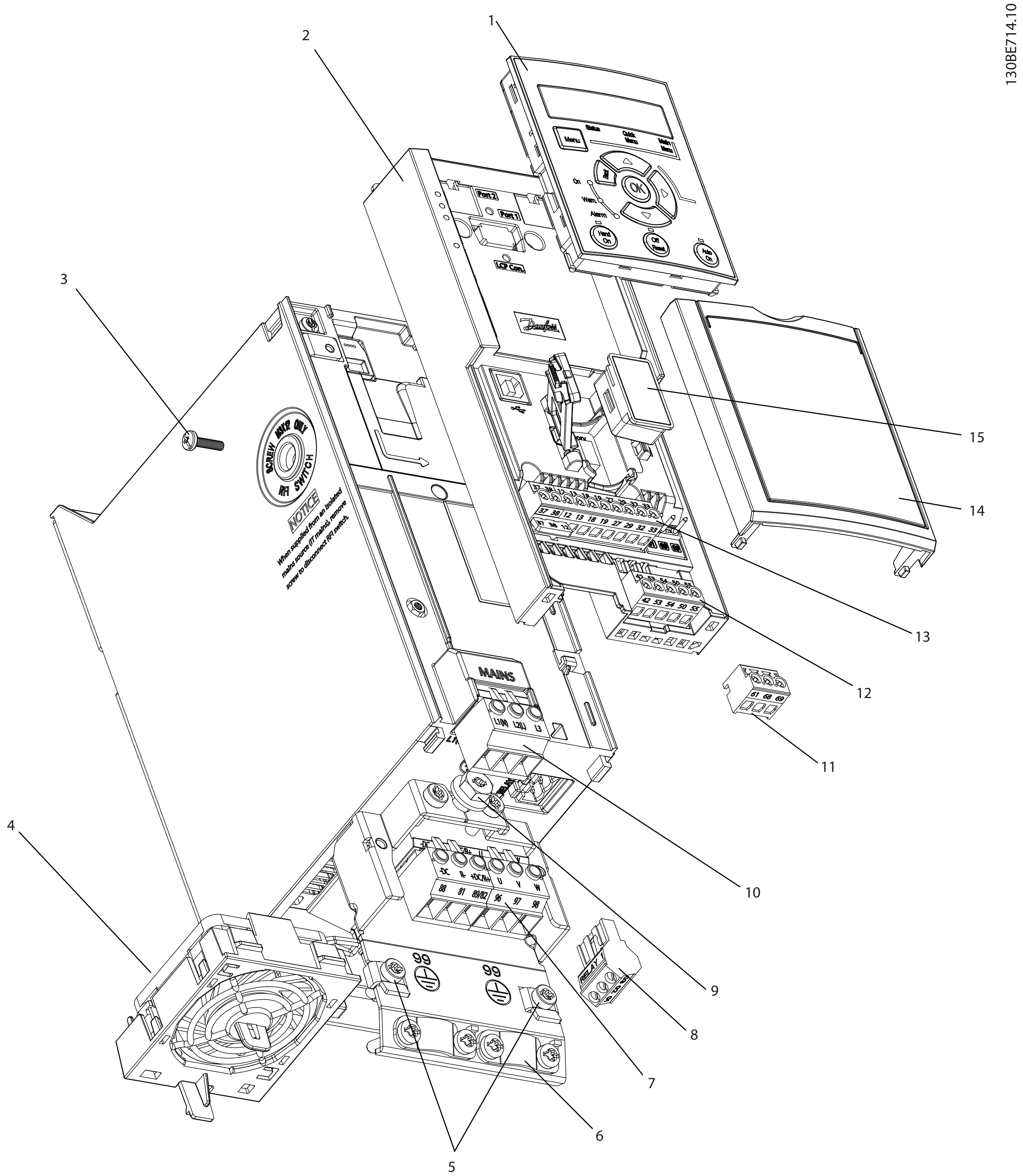
Table 1.2 Abbreviations

1.5 Conventions

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

1.6 Product Overview

1.6.1 Exploded Views



1	NLCP (accessory)	9	PE ground
2	Control cassette	10	Mains terminals
3	RFI switch (screw M3x12 only)	11	Pluggable RS485 terminal
4	Removable fan assembly	12	5-pole pluggable I/O terminal
5	Grounding clamp (accessory)	13	10-pole pluggable I/O terminal
6	Shielded cable grounding clamp and strain relief (accessory)	14	Terminal cover
7	Motor terminals (U, V, W), and brake and load sharing terminals	15	VLT® Memory Module MCM 102
8	3-pole relay		

Illustration 1.1 Exploded View, K1–K5 (0.37–22 kW/0.5–30 hp), IP20

1.6.2 Enclosure Sizes, Power Ratings, and Dimensions

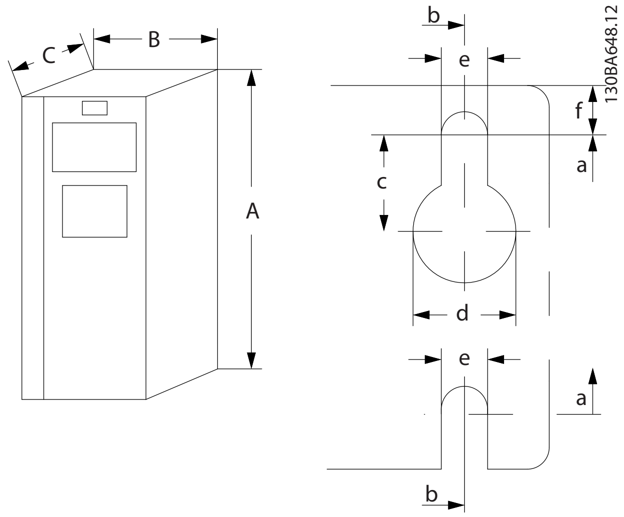


Illustration 1.2 Dimensions and Mounting Holes (See *Table 1.3*)

	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)	3.0 (4.0)	4.0 (5.0)	5.5 (7.5)	7.5 (10)	11 (15)	15 (20)	18.5 (25)	22 (30)
Dimensions [mm (in)]	Height A	210 (8.27)						272.5 (10.73)			272.5 (10.73)	317.5 (12.5)		410 (16.14)	
	Width B	75 (2.95)						90 (3.54)			115 (4.53)	133 (5.24)		150 (5.9)	
	Depth C	168 (6.61)						168 (6.61)			168 (6.61)	245 (9.65)		245 (9.65)	
Mounting holes [mm (in)]	a	198 (7.8)						260 (10.24)			260 (10.24)	297.5 (11.71)		390 (15.35)	
	b	60 (2.36)						70 (2.76)			90 (3.54)	105 (4.13)		120 (4.72)	
	c	5 (0.2)						6.4 (0.25)			6.5 (0.26)	8 (0.31)		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 1.3 Enclosure Sizes, Power Ratings, and Dimensions

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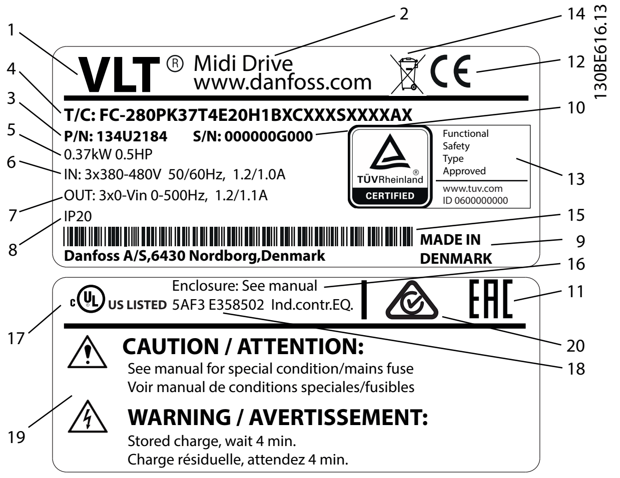
1.7 Identification and Variants

Make sure that the equipment matches the requirements and ordering information by checking power size, voltage, and overload data on the nameplate of the frequency converter.



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
20	RCM logo

Illustration 1.3 Product Nameplate (Example)

1.8 Options and Accessories

Options and accessories	Ordering number
Accessory bag FC 280 plugs	132B0350
Fan 50x20 IP21 PWM	132B0351
Fan 60x20 IP21 PWM	132B0352
Fan 70x20 IP21 PWM	132B0353
Fan 92x38 IP21 PWM	132B0371
Fan 120x38 IP21 PWM	132B0372
Terminal cover enclosure size K1	132B0354
Terminal cover enclosure size K2	132B0355
Terminal cover enclosure size K3	132B0356
Terminal cover enclosure size K4	132B0357
Terminal cover enclosure size K5	132B0358
VLT® Memory Module MCM 102	132B0359
VLT® Control Panel LCP 21 (Numeric)	132B0254
VLT® Control Panel LCP 102 (Graphical)	130B1107
Graphical LCP adapter	132B0281
VLT® Control Panel LCP Blind Cover	132B0262
Bus cable decoupling kit, FC 280	132B0369
Decoupling kit, power I/O, K1	132B0373
Decoupling kit, power I/O, K2/K3	132B0374
Decoupling kit, power I/O, K4/K5	132B0375
VLT® Cassette control - Standard	132B0345
VLT® Cassette control - CANopen	132B0346
VLT® Cassette control - PROFIBUS	132B0347
VLT® Cassette control - PROFINET	132B0348
VLT® Cassette control - EtherNet/IP	132B0349
IP21/Type 1 conversion kit, K1	132B0335
IP21/Type 1 conversion kit, K2	132B0336
IP21/Type 1 conversion kit, K3	132B0337
IP21/Type 1 conversion kit, K4	132B0338
IP21/Type 1 conversion kit, K5	132B0339
Adapter plate, VLT® 2800 size A	132B0363
Adapter plate, VLT® 2800 size B	132B0364
Adapter plate, VLT® 2800 size C	132B0365
Adapter plate, VLT® 2800 size D	132B0366
VLT® 24 V DC supply MCB 106	132B0368
LCP Remote Mounting Kit, w/3 m (10 ft) cable	132B0102
LCP Mounting Kit, w/no LCP	130B1117

Table 1.4 Ordering Numbers for Options and Accessories

1.9 Ratings Tables

1.9.1 Short Circuit and Overcurrent Trips

The frequency converter is protected against short circuits with current measurement in the DC link. A short circuit between 2 output phases causes an overcurrent in the frequency converter. The frequency converter turns off the IGBTs individually when the short-circuit current exceeds the allowed value (*alarm 16, Trip Lock*).

1.9.2 DC Voltage Levels

	3x380–440 V AC	3x441–480 V AC	3x200–240 V	1x200–240 V
Inrush circuit disabled [V]	314	422	202	225
Undervoltage [V]	314	422	202	225
Undervoltage re-enables [V]	314+30	422+30	202+15	225+15
Overvoltage [V]	800	800	410	410
Overvoltage re-enables [V]	800-30	800-30	410-15	410-15
IT Grid turn on [V]	800+30	800+30	410+15	410+15

Table 1.5 DC Voltage Levels

1.10 Tools Required for Service

Item	Description
ESD protection kit	Wrist strap and mat
Metric socket set	10–42 mm
Torque wrench	Torque range 1.3–7.0 Nm (11.5–62.0 in-lb)
Torx driver set	T10 and T20
Needle nose pliers	–
Ratchet	–
Screwdrivers	Standard and Phillips

Table 1.6 Tools Required for Service of Frequency Converter

Item	Description
Digital voltmeter or digital ohmmeter	• Rated for true RMS. • Supports diode mode. • Rated for 1000 V DC or 600 V units.
Analog voltmeter	–
Oscilloscope	–
Clamp-on ammeter	Clamp-on ammeter rated for true RMS. Also known as a clamp-on ampere meter.

Table 1.7 Instruments Recommended for Testing of Frequency Converter

1.11 Service Report

Report the serial number of the frequency converter when requesting support, or preparing the service report. The serial number is listed on the nameplate. See *chapter 1.7 Identification and Variants* for more details.

2 Safety

2.1 Introduction

This section describes requirements to personnel and safe practices to observe when performing service and maintenance procedures.

2.2 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.

2.3 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, the personnel must be familiar with the instructions and safety measures described in this guide.

2.4 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 fieldbus command, an input reference signal from the LCP or LOP, via remote operation using MCT 10 Set-up Software, or after a cleared fault condition.

To prevent unintended motor start:

- **Press [Off/Reset] on the LCP before programming parameters.**
- **Disconnect the frequency converter from the mains.**
- **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 frequency converter contains DC-link capacitors, which can remain charged even when the frequency converter 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 mains and remote DC-link supplies, including battery back-ups, UPS, and DC-link connections to other frequency converters.**
- **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.**

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 frequency converter 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 frequency converter can result in serious injury when the frequency converter is not properly closed.

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

WARNING

EXTERNAL FORCES

If external forces act on the motor, equip the motor with extra measures for fall protection. An example could be a case of vertical axis (suspended loads) where an unwanted movement, for example caused by gravity, could cause a hazard. Failure to equip the motor with measures for fall protection could lead to death or serious injury.

- **Install mechanical brakes and/or other protective devices.**

2.5 Electrostatic Discharge (ESD)

CAUTION

ELECTROSTATIC DISCHARGE

When performing service, use proper electrostatic discharge (ESD) procedures to prevent damage to sensitive components. Many electronic components within the frequency converter are sensitive to static electricity. The voltage of static electricity can reduce lifetime, affect performance, or completely destroy sensitive electronic components.

- **Do not touch components on the circuit boards.**
- **Hold circuit boards by the edges or corners only.**

3

3 Frequency Converter Control

3.1 Introduction

The frequency converter 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 frequency converter 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 ordering number 130B1000 or downloaded from the Danfoss website: *www.danfoss.com/BusinessAreas/DrivesSolutions/softwaredownload*.

3.1.1 Numeric Local Control Panel (LCP)

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

A. Numeric display.

B. Menu key.

C. Navigation keys and indicator lights (LEDs).

D. Operation keys and indicator lights (LEDs).

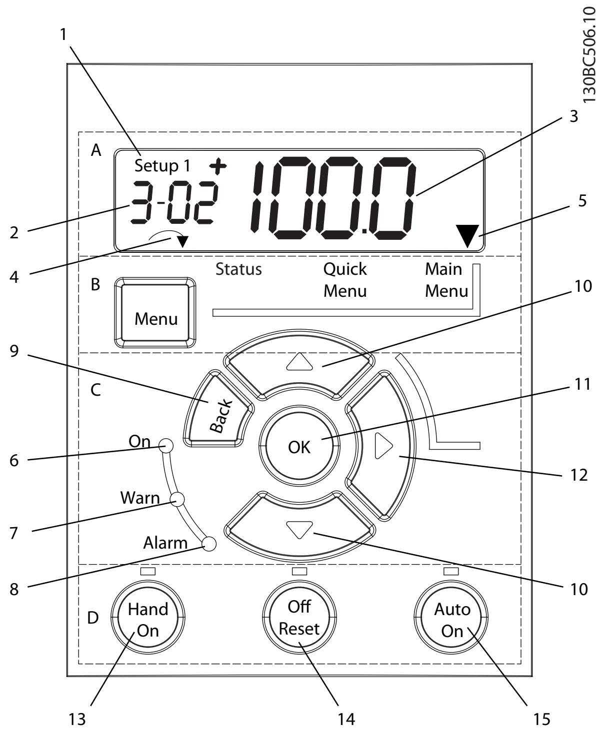


Illustration 3.1 View of the NLCP

A. Numeric display
The LCD display is backlit with 1 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 active and edit set-up, only that set-up number is shown (factory setting). When 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 3.1 Legend to *Illustration 3.1*, Section A

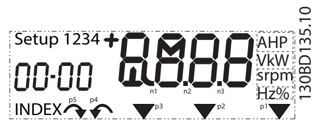


Illustration 3.2 Display Information

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

Table 3.2 Legend to *Illustration 3.1*, Indicator Lights (LEDs)

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

Table 3.3 Legend to *Illustration 3.1*, Navigation Keys

D. Operation keys and indicator lights (LEDs)

	Key	Function
13	Hand On	Starts the frequency converter 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 frequency converter or resets the frequency converter 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 3.4 Legend to *Illustration 3.1*, Section D

⚠WARNING

ELECTRICAL HAZARD

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

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

3.1.2 GLCP Layout

The GLCP is divided into 4 functional groups (see *Illustration 3.3*).

A. Display area

B. Display menu keys

C. Navigation keys and indicator lights (LEDs)

D. Operation keys and reset

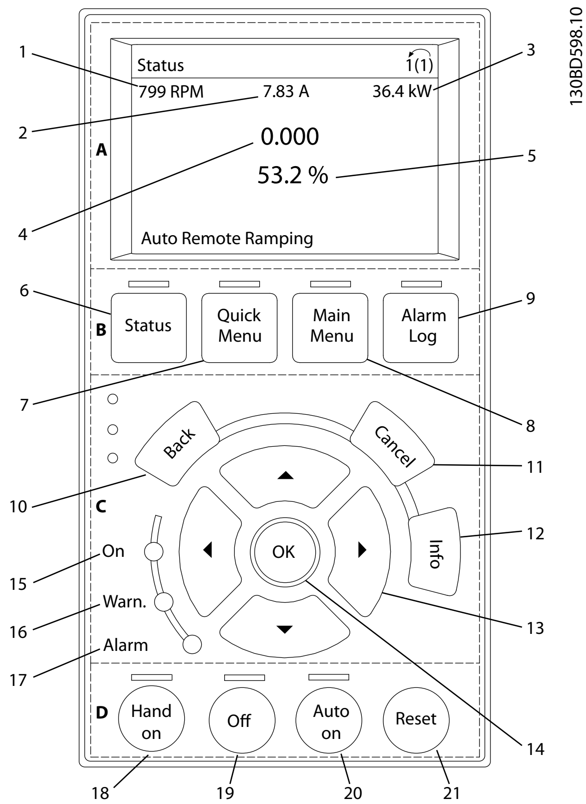


Illustration 3.3 Graphic Local Control Panel (GLCP)

A. Display area

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

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

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 3.5 Legend to *Illustration 3.3*, 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.

3

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

Table 3.6 Legend to *Illustration 3.3*, Display Menu Keys

C. Navigation keys and indicator lights (LEDs)
Navigation keys are used for programming functions and moving the display cursor. The navigation keys also provide speed control in local operation. There are also 3 frequency converter 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 4 navigation keys.
14	OK	Press to access parameter groups or to enable a selection.

Table 3.7 Legend to *Illustration 3.3*, Navigation Keys

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

Table 3.8 Legend to *Illustration 3.3*, Indicator Lights (LEDs)

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

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

Table 3.9 Legend to *Illustration 3.3*, Operation Keys and Reset

NOTICE

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

3.2 Frequency Converter Inputs and Outputs

The frequency converter operates by receiving control input signals. The frequency converter can also output status data or control auxiliary devices.

Control input is sent to the frequency converter in 3 ways:

- Via the optional LCP connected by cable to the frequency converter, operating in hand-on mode. These inputs include:
  - Start.
  - Stop.
  - Reset.
  - Speed reference.
- Via serial communication from a fieldbus that is connected to the frequency converter through the RS485 serial port. The serial communication protocol is used to:
  - Supply commands and references to the frequency converter.
  - Program the frequency converter.
  - Read status data from the frequency converter.
- Via signal wiring connected to the frequency converter control terminals.

NOTICE

Improperly connected control wiring can result in the frequency converter failing to start or to respond to a remote input.

3.2.1 Input Signals

The frequency converter can receive 2 types of remote input signals: Digital or analog. Digital inputs are wired to terminals 18, 19, 27, 29, 32, and 33. Terminals 37 and 38 are used as input for Safe Torque Off functionality. Analog inputs are wired to terminals 53 (or 54) and 55 (common).

The terminals can be configured as follows:

- Terminals 32, 33: 24 V encoder feedback.
- Terminals 29, 33: Pulse inputs.
- Terminal 27: Digital or pulse output.

Analog signals
Analog signals can be either voltage (0 V to +10 V DC) or current (0–20 mA or 4–20 mA). Terminal 54 supports both voltage and current mode. Terminal 53 supports only voltage mode. The frequency converter can be programmed to increase or decrease output in relation to the amount of current or voltage. For example, a sensor or external controller may supply a variable current or voltage. The frequency converter output, in turn, regulates the speed of the motor connected to the frequency converter in response to the analog signal.

Digital signals
Digital signals are a simple binary 0 or 1 acting as a switch. A 0–24 V DC signal controls the digital signals. Digital inputs to the frequency converter are switched commands such as start, stop, reverse, coast, and reset. Do not confuse these digital inputs with serial communication formats where digital bytes are grouped into communication words and protocols.

To enable STO functionality, remove the jumper between terminals 12, 37, and 38. Refer to *Chapter Safe Torque Off (STO)* in *VLT® Midi Drive FC 280 Operating Guide*.

The RS485 serial communication connector is wired to terminals (+) 68 and (-) 69. Terminal 61 is a common terminal. It is used for terminating shields only when the control cable is run between frequency converters, and not between frequency converters and other devices.

3.2.2 Output Signals

The frequency converter also produces output signals that are carried either through the RS485 fieldbus or terminal 27 and terminal 42. Output terminal 42 can be programmed for either a variable analog signal in mA or a digital signal (0 or 1) in 24 V DC. Output analog signals generally indicate the frequency, current, torque, and so on, to an external controller or system. Digital outputs can be control signals used to open or close a damper, or send a start or stop command to auxiliary equipment.

More terminals are Form C relay outputs on terminals 01, 02, and 03.

Terminal 12 and terminal 13, which are connected inside the frequency converter, provide 24 V DC low-voltage power, often used to supply power to the digital input terminals (18–33). In VLT® Midi Drive FC 280, there is overload protection on 24 V supply. Power terminals 18–33 from either terminal 12/13, or from a customer supplied external 24 V DC power source. Improperly connected control wiring is a common service issue for a motor not operating or the frequency converter not responding to a remote input.

For terminal 27, refer to *chapter 8.6 Control Input/Output and Control Data* for the specifications of digital output 27.

Terminal 42 can be configured as digital output.

Terminal number[1]	42
Voltage level at digital output	17 V
Maximum output current at digital output	20 mA
Maximum load at digital output	1 kΩ

Table 3.10 Digital Output

1) Terminal 42 can also be programmed as analog output.

Terminal	Parameter	Default setting	Description
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 5-01 Terminal 27 Mode*; *Parameter 5-12 Terminal 27 Digital Input*; *Parameter 5-30 Terminal 27 Digital Output*.	DI *[2] Coast inverse* DO *[0] No operation*	Selectable for either digital input, digital output, or pulse output. The default setting is digital input.
29	*Parameter 5-13 Terminal 29 Digital Input*	DI *[14] Jog*	
32	*Parameter 5-14 Terminal 32 Digital Input*	*[0] No operation*	Digital input, 24 V encoder. Terminal 33 can be used for pulse input.
33	*Parameter 5-15 Terminal 33 Digital Input*	*[0] No operation*	

3

Terminal	Parameter	Default setting	Description
37, 38	–	STO	Functional safety inputs.
55	–	–	Common.

Table 3.11 Terminal Descriptions - Digital Inputs/Outputs, Pulse Input/Outputs, and Encoder

Terminal	Parameter	Default setting	Description
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	*Parameter group 6-1* Analog Input 53*	–	Analog input. Only voltage mode is supported.
54	*Parameter group 6-2* Analog Input 54*	–	Analog input. Selectable between voltage or current mode.
55	–	–	Common.

Table 3.12 Terminal Descriptions - Analog Input/Outputs

Terminal	Parameter	Default setting	Description
61	–	–	Integrated RC-filter for cable shield. ONLY for connecting the shield when experiencing EMC problems.

Terminal	Parameter	Default setting	Description
68 (+)	*Parameter group 8-3* FC Port Settings*	–	RS485 interface. A control card switch is provided for termination resistance.
69 (-)	*Parameter group 8-3* FC Port Settings*	–	

Table 3.13 Terminal Descriptions - Serial Communication

Terminal	Parameter	Default setting	Description
01, 02, 03	*Parameter 5-40 Function Relay* [0]	*[1] Control Ready*	Form C relay output. These relays are in various locations depending on the frequency converter configuration and size. Usable for AC or DC voltage and resistive or inductive loads.

Table 3.14 Terminal Descriptions - Relays

3.3 Service Functions

Access 24 different items included in:

- Counters that tabulate, for example hour runs.
- Fault logs that store frequency converter status values present at the 10 most recent events that stopped the frequency converter.
- Frequency converter nameplate data.

Parameter 14-28 Production Settings and *parameter 14-29 Service Code* are the relevant service parameters.

Press [Main Menu] to show the parameter settings.

Press the navigation keys [▲], [▼], [►] to scroll through parameters.

See the *VLT® Midi Drive FC 280 Programming Guide* for detailed information on accessing and showing parameters, and for descriptions and procedures for service information available in *parameter group 6-** Analog In/Out*.

3.4 Control Terminals

For proper function of the frequency converter functioning, the input control terminals must be:

- Wired properly.
- Powered.
- Programmed correctly for the intended function.

Ensure that the input terminal is wired correctly:

1. Confirm that the control and power sources are wired to the terminal.
2. Check the signal in either of 2 ways:
    - 2a Press [Display Mode], then select *Digital Input*. The LCP shows the digital inputs which are correctly wired.
    - 2b Use a voltmeter to check for voltage at the control terminal.

Confirm that each control terminal is programmed for the correct function. Each terminal has specific functions and a numbered parameter associated with it. The setting selected in the parameter enables the function of the terminal.

See the *VLT® Midi Drive FC 280 Operating Guide* and *VLT® Midi Drive FC 280 Programming Guide* for details on changing parameters and the functions available for each control terminal.

3.5 Grounding Shielded Cables

Connect the shielded control cables to the metal cabinet of the frequency converter with cable camps at both ends. *Illustration 3.5* shows ground cabling for optimal results.

Correct grounding
To ensure the best possible electrical connection, fit control cables and cables for serial communication with cable clamps at both ends.

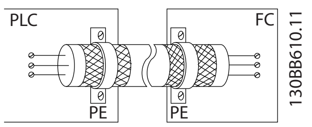
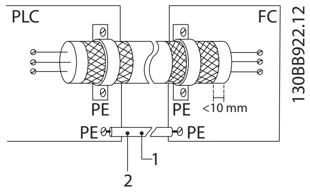


Illustration 3.4 Correct Grounding

Incorrect grounding
Do not use twisted cable ends (pigtails) since they increase shield impedance at high frequencies.

Ground potential protection
When the ground potential between the frequency converter and the PLC or other interface device is different, electrical noise may occur that can disturb the entire system. Resolve the electrical noise by fitting an equalizing cable next to the control cable. Minimum cable cross-section is 10 mm^2 (8 AWG).



1	Minimum 10 mm^2 (8 AWG)
2	Equalizing cable

Illustration 3.5 Ground Potential Protection

50/60 Hz ground loops
When using long control cables, 50/60 Hz ground loops may occur that can disturb the entire system. Resolve the ground loops by connecting 1 end of the shield with a 100 nF capacitor and keeping the lead short.

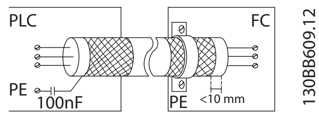


Illustration 3.6 50/60 Hz Ground Loops

Serial communication control cables
Low-frequency noise currents between frequency converters can be eliminated by connecting 1 end of the shielded cable to frequency converter terminal 61. This terminal connects to ground through an internal RC link. To reduce the differential mode interference between conductors, use twisted-pair cables.

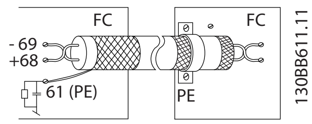


Illustration 3.7 Serial Communication Control Cables

4 Troubleshooting

4.1 Troubleshooting Tips

Before troubleshooting a frequency converter

- Read the warnings in *chapter 2 Safety*.
- Note all warnings concerning voltages present in the frequency converter. Verify the presence of AC input voltage and DC-link voltage before working on the unit. Some points in the frequency converter are referenced to the negative DC-link. They are at DC-link potential even though it sometimes appears on diagrams to be a neutral reference.
- Wait for discharge of the DC link. For discharge time, see *Table 2.1* or the label on the frequency converter.
- Do not apply power to a unit that is suspected of being faulty. Many faulty components within the frequency converter can damage other components when power is applied. Always perform the procedure for testing the unit after repair as described in *chapter 6.4 Initial Start-up or After-repair Tests*.
- Do not attempt to defeat any fault protection circuitry within the frequency converter, as this results in unnecessary component damage and can cause personal injury.
- Use factory approved replacement parts. The frequency converter is designed to operate within certain specifications. Incorrect parts can affect tolerances and result in further damage to the unit.
- Read the *VLT® Midi Drive FC 280 Operating Guide*. When in doubt, consult the factory or an authorized repair center for assistance.

4.2 Exterior Fault Troubleshooting

There may be slight differences in servicing a frequency converter that has been operational for extended time, compared to a new installation. In either case, use proper troubleshooting procedures.

⚠CAUTION

RISK OF INJURY OR PROPERTY DAMAGE

Never assume that a motor is wired properly after a service of the frequency converter. Check for:

- **Loose connections.**
- **Improper programming.**
- **Added equipment.**

Failure to perform these checks can result in personal injury, property damage, or less than optimal performance.

Take a systematic approach, beginning with a visual inspection of the system. See *Table 4.1* for items to examine.

4.3 Fault Symptom Troubleshooting

The troubleshooting procedures are divided into sections based on the symptom being experienced.

- See the visual inspection check list in *Table 4.1*. Often, incorrect installation or wiring of the frequency converter causes the problem. The check list provides guidance through the items to inspect during servicing of the frequency converter.
- The most common fault symptoms are described in *chapter 4.5 Fault Symptoms*:
    - Problems with motor operation.
    - A warning or alarm shown by the frequency converter.

  The frequency converter processor monitors inputs and outputs and internal frequency converter functions. An alarm or warning does not necessarily indicate a problem within the frequency converter itself.

For each incident, further description explains how to troubleshoot that particular symptom. When necessary, further referrals are made to other parts of the guide for more procedures.

When troubleshooting is complete, perform the list of tests provided in *chapter 6.4 Initial Start-up or After-repair Tests*.

4.4 Visual Inspection

Visually inspect the conditions that are described in *Table 4.1* as part of an initial troubleshooting procedure.

Inspect for	Description
Auxiliary equipment	• Look for any auxiliary equipment, switches, disconnects, or input fuses/circuit breakers that reside on input power side of frequency converter or output side to motor. • Examine operation and condition of these items as possible causes for operational faults. • Check function and installation of pressure sensors or encoders used for feedback to the frequency converter.
Cable routing	• Avoid routing motor wiring, AC line wiring, and signal wiring in parallel. If parallel routing is unavoidable, try to maintain a separation of 150–200 mm (6–8 in) between the cables or separate them with a grounded conductive partition. • Avoid routing cables through free air.
Control wiring	• Check for broken or damaged wires and connections. • Check the voltage source of the signals. Though not always necessary, depending on the installation conditions, the use of shielded cable or a twisted pair is recommended. • Ensure that the shield is terminated correctly.
Frequency converter cooling	• Check operational status of all cooling fans. • Check for blockage or constrained air passages. Verify that the bottom gland plate is installed.
Frequency converter display	The display shows: • Warnings • Alarms • Frequency converter status • Fault history and other important information.
Frequency converter interior	• Frequency converter interior must be free of: - Dirt. - Metal chips. - Moisture. - Corrosion. • Check for burnt or damaged power components or carbon deposits that were the result of a catastrophic component failure. • Check for cracks or breaks in the housings of power semiconductors, or pieces of broken component housings loose inside the unit.
EMC considerations	• Check for proper installation regarding electromagnetic capability. • Refer to the *VLT® Midi Drive FC 280 Operating Guide* and this chapter for further details.
Environmental conditions	• Under specific conditions, these units can be operated within a maximum ambient of 50 °C (122 °F) with derating. • Humidity levels must be less than 95% non-condensing. • Check for harmful airborne contaminates such as sulphur-based compounds.
Grounding	• The frequency converter requires a dedicated ground wire from its chassis to the building ground. • It is also suggested that the motor is grounded to the frequency converter enclosure. • The use of conduit or mounting of the frequency converter to a metal surface is not considered a suitable ground. • Check for good ground connections that are tight and free of oxidation.

Inspect for	Description
Input power wiring	• Check for loose connections. • Check for proper fusing. • Check for blown fuses.
Motor	• Check nameplate ratings of motor. • Ensure that motor ratings match frequency converter ratings. • Ensure that the motor parameters (*1-20* to *1-25*) are set according to motor ratings.
Output to motor wiring	• Check for loose connections. • Check for switching components in output circuit. • Check for faulty contacts in switch gear.
Programming	• Ensure that frequency converter parameter settings are correct according to motor, application, and I/O configuration.
Proper clearance	These frequency converters require top and bottom clearance adequate to ensure proper air flow for cooling in accordance with the frequency converter size.
Vibration	• Though subjective, look for an unusual amount of vibration that the frequency converter may be subjected to. • Mount the frequency converter solidly or use shock mounts.

Table 4.1 Visual Inspection

4.5 Fault Symptoms

4.5.1 No Display

The LCP display provides 2 display indications. One with the backlit alphanumeric display. The other is 3 LED indicator lights near the bottom of the LCP.

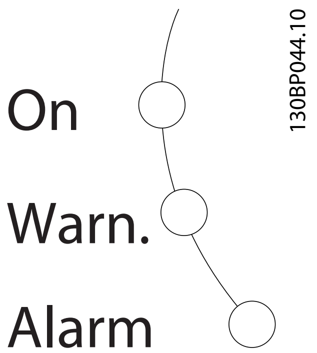


Illustration 4.1 LED Indicator Lights

If the green power-on LED is illuminated, but the backlit display is dark, it indicates that the LCP is defective and must be replaced. Be certain, however, that the display is dark.

A single character or just a dot in the upper corner of the LCP indicates that communications may have failed with the control card. This situation typically appears when a fieldbus communication option has been installed in the frequency converter and is either not connected properly or is malfunctioning.

If neither indication is available, then the source of the problem is elsewhere. Proceed to the next troubleshooting steps.

4.5.2 Intermittent Display

Cutting out or flashing of the entire display and power LED indicates that the supply (SMPS) is shutting down due to overload. Improper control wiring or a fault within the frequency converter itself can cause the overload.

The first step is to rule out a problem in the control wiring. To do so, disconnect all control wiring by unscrewing or unplugging the control terminal blocks from the control card.

If the display stays lit, the problem is in the control wiring (external to the frequency converter). Check all control wiring for short circuits or incorrect connections.

If the display continues to cut out, follow the procedure for *chapter 4.5.1 No Display* as though the display was not lit at all.

4.5.3 Motor Does Not Run

If this symptom is detected, verify that the unit is properly powered up (display is lit) and that there are no warning or alarm messages shown. The most common cause of this problem is either incorrect control logic or an incorrectly programmed frequency converter. Such occurrences result in 1 or more of the following status messages being shown.

LCP stop
[Off/Reset] has been pressed. Line 2 of the display also flashes when this situation occurs.

Troubleshooting

- Press [Auto On] or [Hand On].
- Refer to *chapter 6.3.11 Input Terminal Signal Tests*.

Unit ready
Terminal 27 is low (no signal).

Troubleshooting

- Ensure that terminal 27 is logic 1.
- Refer to *chapter 6.3.11 Input Terminal Signal Tests*.

Run OK, 0 Hz
This message indicates that a run command has been given to the frequency converter, but the reference (speed command) is 0 or missing.

Troubleshooting

- Check control wiring to ensure that the proper reference signal is present at the input terminals.
- Also check that the unit is properly programmed to accept the signal provided.
- Refer to *chapter 6.3.11 Input Terminal Signal Tests*.

Off 1 (2 or 3)
This message indicates that bit #1 (or #2, or #3) in the control word is logic 0. This situation only occurs when the frequency converter is being controlled via the fieldbus.

Troubleshooting

- Ensure that the correct control word is transmitted to the frequency converter over the communication bus.

Stop
One of the digital input terminals 18, 19, 27, 29, 32, or 33 is programmed for stop inverse, and the corresponding terminal is low (logic 0).

Troubleshooting

- Ensure that the digital input terminals are programmed correctly.
- Ensure that the digital input programmed for stop inverse is high (logic 1).

4.5.4 Incorrect Motor Operation

Occasionally, a fault can occur where the motor continues to run, but not in the correct manner. The symptoms and causes may vary considerably. Many of the possible problems are listed in the following by symptom along with recommended procedures for determining their causes.

Wrong speed/unit does not respond to command
Possible incorrect reference (speed command).

Troubleshooting

- Ensure that the unit is programmed correctly according to the reference signal being used, and that all reference limits are set correctly.
- Perform *chapter 6.3.11 Input Terminal Signal Tests* to check for faulty reference signals.

Motor speed unstable

- Possible incorrect parameter settings.
- Faulty current feedback circuit.
- Loss of motor (output) phase.

Troubleshooting

- Check settings of all motor parameters, including all motor compensation settings (slip compensation, load compensation, and so on).
- For closed-loop operation, check PID settings.
- Perform *chapter 6.3.11 Input Terminal Signal Tests* to check for faulty reference signals.
- Perform *chapter 6.3.10 Output Imbalance of Motor Supply Voltage Test* to check for loss of motor phase.

Motor runs rough
Possible overmagnetization (incorrect motor settings), or an IGBT misfiring.

NOTICE

The motor may also stall when loaded or the frequency converter may trip occasionally on *alarm 13, Overcurrent*.

Troubleshooting

- Check setting of all motor parameters, see *chapter 6.3.10 Output Imbalance of Motor Supply Voltage Test*.
- If output voltage is unbalanced, see *chapter 6.3.10 Output Imbalance of Motor Supply Voltage Test*.

Motor draws high current, but cannot start
Possible open winding in motor or open connection to motor.

- Perform *chapter 6.3.10 Output Imbalance of Motor Supply Voltage Test* to ensure that frequency converter is providing correct output.
- Check motor for open windings. Check all motor wiring connections.
- Run an AMA to check the motor for open windings and unbalanced resistance. Inspect all motor wiring connections.

4.6 Warnings and Alarms

When the frequency converter fault circuitry detects a fault condition or a pending fault, a warning or alarm is issued. A flashing display on the LCP indicates an alarm or warning condition and the associated number code on line 2. Sometimes a warning precedes an alarm.

4.6.1 Alarms

An alarm causes the frequency converter to trip (suspend operation). The frequency converter has 3 trip conditions which are shown in line 1:

Trip (auto restart)
The frequency converter is programmed to restart automatically after the fault is removed. The number of automatic reset attempts can be continuous or limited to a programmed number of attempts. If the selected number of automatic reset attempts is exceeded, the trip condition changes to trip (reset).

Trip (reset)
Requires resetting of the frequency converter before operation after a fault is cleared. To reset the frequency converter manually, press [Reset] or use a digital input, or a fieldbus command. For NLCP, stop and reset are the same key, [Off/Reset]. If [Off/Reset] is used to reset the frequency converter, press [Start] to initiate a run command in either hand-on mode or auto-on mode.

Trip lock (disc>mains)
Disconnect the mains AC input power to the frequency converter long enough for the display to go blank. Remove the fault condition and reapply power. Following power-up, the fault indication changes to trip (reset) and allows for manual, digital, or fieldbus reset.

4.6.2 Warnings

During a warning, the frequency converter remains operational, although the warning flashes for as long as the condition exists. The frequency converter could, however, reduce the warning condition. For example, if the warning shown was *warning 12, Torque Limit*, the frequency converter would reduce speed to compensate for the overcurrent condition. Sometimes, if the condition is not corrected or worsens, an alarm condition is activated and the frequency converter stops output to the motor terminals. Line 1 identifies the warning in plain language, and line 2 identifies the warning number.

4.6.3 Warning and Alarm Code List

An (X) marked in *Table 4.2* indicates that the warning or alarm has occurred.

No.	Description	Warning	Alarm	Trip lock	Cause
2	Live zero error	X	X	–	The 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 frequency converter.
4	Mains phase loss1)	X	X	X	Missing phase on the supply side, or the voltage imbalance is too high. Check the supply voltage.
7	DC overvoltage1)	X	X	–	DC-link voltage exceeds limit.
8	DC undervoltage1)	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 overtemperature	X	X	–	Thermistor or thermistor connection is disconnected, or the motor is too hot.
12	Torque limit	X	X	–	Torque exceeds value set in either *parameter 4-16 Torque Limit Motor Mode* or *parameter 4-17 Torque Limit Generator Mode*.

No.	Description	Warning	Alarm	Trip lock	Cause
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 frequency converter.
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	–	Fieldbus detects internal faults.
36	Mains failure	X	X	–	This warning/alarm is only active if the supply voltage to the frequency converter 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.
40	Overload T27	X	–	–	Check the load connected to terminal 27 or remove short-circuit connection.
46	Gate drive voltage fault	–	X	X	–
47	24 V supply low	X	X	X	24 V DC may be overloaded.
49	Speed limit	–	X	–	The motor speed is below the specified limit in *parameter 1-87 Compressor Min. Speed for Trip [Hz]*.
50	AMA calibration failed	–	X	–	A calibration error has occurred.
51	AMA check U_{nom} and I_{nom}	–	X	–	Wrong setting for motor voltage and/or motor current.
52	AMA low I_{nom}	–	X	–	Motor current is too low. Check the settings.
53	AMA big motor	–	X	–	The power size of the motor is too large for the AMA to operate.
54	AMA small motor	–	X	–	The power size of the motor is too small for the AMA to operate.
55	AMA parameter range	–	X	–	The parameter values of the motor are outside of the acceptable range. AMA does not run.
56	AMA interrupt	–	X	–	The AMA is interrupted.
57	AMA timeout	–	X	–	–
58	AMA internal	–	X	–	Contact Danfoss.
59	Current limit	X	X	–	Frequency converter overload.
60	External interlock	–	X	–	External interlock has been activated.
61	Encoder loss	X	X	–	–
63	Mechanical brake low	–	X	–	The actual motor current has not exceeded the release brake current within the start delay time window.
65	Control card temp	X	X	X	The cutout temperature of the control card has exceeded the upper limit.
67	Option change	–	X	–	A new option is detected or a mounted option is removed.

No.	Description	Warning	Alarm	Trip lock	Cause
68	Safe Torque Off[2)]	X	X	–	STO is activated. If STO is in manual restart mode (default), to resume normal operation, apply 24 V DC to terminals 37 and 38, and initiate a reset signal (via fieldbus, digital I/O, or [Reset]/[Off Reset] key). If STO is in automatic restart mode, applying 24 V DC to terminals 37 and 38 automatically resumes the frequency converter to normal operation.
69	Power card temp	X	X	X	The cutout temperature of the power card has exceeded the upper limit.
80	Drive initialized to default value	–	X	–	All parameter settings are initialized to default settings.
87	Auto DC braking	X	–	–	Occurs in IT mains when the frequency converter coasts, and the DC voltage is higher than 830 V for 400 V units and 425 V for 200 V units. The motor consumes energy on the DC link. This function can be enabled/disabled in *parameter 0-07 Auto DC Braking*.
88	Option detection	–	X	X	The option is removed successfully.
95	Broken belt	X	X	–	–
99	Locked rotor	–	X	–	Rotor is blocked.
120	Position control fault	–	X	–	–
126	Motor rotating	–	X	–	PM motor is rotating when execute AMA.
127	Back EMF too high	X	–	–	The back EMF of PM motor is too high before starting.
188	STO internal fault[2)]	–	X	–	24 V DC supply is connected to only 1 of the 2 STO terminals (37 and 38), or a failure in STO channels is detected. Ensure that both terminals are powered by 24 V DC supply, and that the discrepancy between the signals at the 2 terminals is less than 12 ms. If the fault still occurs, contact the local Danfoss supplier.
nw run	Not while running	–	–	–	Parameters can only be changed when the motor is stopped.
Err.	A wrong password was entered	–	–	–	Occurs when using a wrong password for changing a password-protected parameter.

Table 4.2 Warnings and Alarms Code List

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

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

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

Bit	Hex	Dec	Alarm word (*parameter 16-90 Alarm Word*)	Alarm word 2 (*parameter 16-91 Alarm Word 2*)	Alarm word 3 (*parameter 16-97 Alarm Word 3*)	Warning word (*parameter 16-92 Warning Word*)	Warning word 2 (*parameter 16-93 Warning Word 2*)	Extended status word (*parameter 16-94 Ext. Status Word*)	Extended status word 2 (*parameter 16-95 Ext. Status Word 2*)
0	00000001	1	Brake check	Reserved	STO function fault	Reserved	Reserved	Ramping	Off
1	00000002	2	Pwr. card temp	Gate drive voltage fault	MM alarm	Pwr. card temp	Reserved	AMA tuning	Hand/Auto
2	00000004	4	Earth fault	Reserved	Reserved	Reserved	Reserved	Start CW/CCW	Profibus OFF1 active
3	00000008	8	Ctrl. card temp	Reserved	Reserved	Ctrl. card temp	Reserved	Slowdown	Profibus OFF2 active

Bit	Hex	Dec	Alarm word (*parameter 16-90 Alarm Word*)	Alarm word 2 (*parameter 16-91 Alarm Word 2*)	Alarm word 3 (*parameter 16-97 Alarm Word 3*)	Warning word (*parameter 16-92 Warning Word*)	Warning word 2 (*parameter 16-93 Warning Word 2*)	Extended status word (*parameter 16-94 Ext. Status Word*)	Extended status word 2 (*parameter 16-95 Ext. Status Word 2*)
4	00000010	16	Ctrl. word TO	Reserved	Reserved	Ctrl. word TO	Reserved	Catchup	Profibus OFF3 active
5	00000020	32	Overcurrent	Reserved	Reserved	Overcurrent	Reserved	Feedback high	Reserved
6	00000040	64	Torque limit	Reserved	Reserved	Torque limit	Reserved	Feedback low	Reserved
7	00000080	128	Motor Th. over	Reserved	Reserved	Motor Th. over	Reserved	Output current high	Control ready
8	00000100	256	Motor ETR over	Broken belt	Reserved	Motor ETR over	Broken belt	Output current low	Frequency converter ready
9	00000200	512	Inverter overld.	Reserved	Reserved	Inverter overld.	Reserved	Output freq. high	Quick stop
10	00000400	1024	DC undervolt.	Start failed	Reserved	DC undervolt.	Reserved	Output freq. low	DC brake
11	00000800	2048	DC overvolt.	Speed limit	Reserved	DC overvolt.	Reserved	Brake check OK	Stop
12	00001000	4096	Short circuit	External interlock	Reserved	Reserved	Reserved	Braking max	Reserved
13	00002000	8192	Reserved	Reserved	Reserved	Reserved	Reserved	Braking	Freeze output request
14	00004000	16384	Mains ph. loss	Reserved	Reserved	Mains ph. loss	Reserved	Reserved	Freeze output
15	00008000	32768	AMA not OK	Reserved	Reserved	No motor	Auto DC braking	OVC active	Jog request
16	00010000	65536	Live zero error	Reserved	Reserved	Live zero error	Reserved	AC brake	Jog
17	00020000	131072	Internal fault	Reserved	Reserved	Reserved	Reserved	Reserved	Start request
18	00040000	262144	Brake overload	Reserved	Reserved	Brake resistor power limit	Reserved	Reserved	Start
19	00080000	524288	U phase loss	Reserved	Reserved	Reserved	Reserved	Reference high	Reserved
20	00100000	1048576	V phase loss	Option detection	Reserved	Reserved	Overload T27	Reference low	Start delay
21	00200000	2097152	W phase loss	Option fault	Reserved	Reserved	Reserved	Reserved	Sleep
22	00400000	4194304	Fieldbus fault	Locked rotor	Reserved	Fieldbus fault	Memory module	Reserved	Sleep boost
23	00800000	8388608	24 V supply low	Position ctrl. fault	Reserved	24 V supply low	Reserved	Reserved	Running
24	01000000	16777216	Mains failure	Reserved	Reserved	Mains failure	Reserved	Reserved	Bypass
25	02000000	33554432	Reserved	Current limit	Reserved	Current limit	Reserved	Reserved	Reserved
26	04000000	67108864	Brake resistor	Reserved	Reserved	Reserved	Reserved	Reserved	External interlock

Bit	Hex	Dec	Alarm word (*parameter 16-90 Alarm Word*)	Alarm word 2 (*parameter 16-91 Alarm Word 2*)	Alarm word 3 (*parameter 16-97 Alarm Word 3*)	Warning word (*parameter 16-92 Warning Word*)	Warning word 2 (*parameter 16-93 Warning Word 2*)	Extended status word (*parameter 16-94 Ext. Status Word*)	Extended status word 2 (*parameter 16-95 Ext. Status Word 2*)
27	08000000	134217728	Brake IGBT	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved
28	10000000	268435456	Option change	Reserved	Reserved	Encoder loss	Reserved	Reserved	FlyStart active
29	20000000	536870912	Frequency converter initialized	Encoder loss	Reserved	Reserved	Back EMF too high	Reserved	Heat sink clean warning
30	40000000	1073741824	Safe Torque Off	Reserved	Reserved	Safe Torque Off	Reserved	Reserved	Reserved
31	80000000	2147483648	Mech. brake low	Reserved	Reserved	Reserved	Reserved	Database busy	Reserved

Table 4.3 Description of Alarm Word, Warning Word, and Extended Status Word

WARNING/ALARM 2, Live zero error
This warning or alarm only appears if programmed in *parameter 6-01 Live Zero Timeout Function*. The signal on 1 of the analog inputs is less than 50% of the minimum value programmed for that input. Broken wiring or faulty device sending the signal can cause this condition.

Troubleshooting

- Check connections on all the analog input terminals. Control card terminals 53 and 54 for signals, terminal 55 common.
- Check that the frequency converter programming and switch settings match the analog signal type.
- Perform the input terminal signal test.

WARNING/ALARM 4, Mains phase loss
A phase is missing on the supply side, or the mains voltage imbalance is too high. This message also appears for a fault in the input rectifier. Options are programmed in *parameter 14-12 Function at Mains Imbalance*.

Troubleshooting

- Check the supply voltage and supply currents to the frequency converter.

WARNING/ALARM 7, DC overvoltage
If the DC-link voltage exceeds the limit, the frequency converter trips after a time.

Troubleshooting

- Extend the ramp time.
- Change the ramp type.

WARNING/ALARM 8, DC under voltage
If the DC-link voltage (DC-link) drops below the undervoltage limit, the frequency converter trips after a fixed time delay. The time delay varies with unit size.

Troubleshooting

- Check that the supply voltage matches the frequency converter voltage.
- Perform the input voltage test.
- Perform the soft charge circuit test.

WARNING/ALARM 9, Inverter overload
The frequency converter is about to cut out because of an overload (too high current for too long). The counter for electronic, thermal inverter protection issues a warning at 90% and trips at 100%, while giving an alarm. The frequency converter cannot be reset until the counter is below 0%.
The fault is that the frequency converter has run with more than 100% overload for too long.

Troubleshooting

- Compare the output current shown on the LCP with the frequency converter rated current.
- Compare the output current shown on the LCP with measured motor current.
- Show the thermal frequency converter load on the LCP and monitor the value. When running above the frequency converter continuous current rating, the counter increases. When running below the frequency converter continuous current rating, the counter decreases.

WARNING/ALARM 10, Motor overload temperature
According to the electronic thermal protection (ETR), the motor is too hot. Select whether the frequency converter issues a warning or an alarm when the counter reaches 100% in *parameter 1-90 Motor Thermal Protection*. The fault occurs when the motor runs with more than 100% overload for too long.

Troubleshooting

- Check for motor overheating.
- Check if the motor is mechanically overloaded.
- Check that the motor current set in *parameter 1-24 Motor Current* is correct.
- Ensure that motor data in *parameters 1-20 to 1-25* are set correctly.
- Running AMA in *parameter 1-29 Automatic Motor Adaptation (AMA)* tunes the frequency converter to the motor more accurately and reduces thermal loading.

WARNING/ALARM 11, Motor thermistor overtemp
Check whether the thermistor is disconnected. Select whether the frequency converter issues a warning or an alarm in *parameter 1-90 Motor Thermal Protection*.

Troubleshooting

- Check for motor overheating.
- Check if the motor is mechanically overloaded.
- When using terminal 53 or 54, check that the thermistor is connected correctly between either terminal 53 or 54 (analog voltage input) and terminal 50 (+10 V supply). Also check that the terminal switch for 53 or 54 is set for voltage. Check that *parameter 1-93 Thermistor Source* selects terminal 53 or 54.
- When using terminal 18, 19, 32, or 33 (digital inputs), check that the thermistor is connected correctly between the digital input terminal used (digital input PNP only) and terminal 50. Select the terminal to use in *parameter 1-93 Thermistor Source*.

WARNING/ALARM 12, Torque limit
The torque has exceeded the value in *parameter 4-16 Torque Limit Motor Mode* or the value in *parameter 4-17 Torque Limit Generator Mode*.
Parameter 14-25 Trip Delay at Torque Limit can change this warning from a warning-only condition to a warning followed by an alarm.

Troubleshooting

- If the motor torque limit is exceeded during ramp-up, extend the ramp-up time.
- If the generator torque limit is exceeded during ramp-down, extend the ramp-down time.
- If torque limit occurs while running, increase the torque limit. Make sure that the system can operate safely at a higher torque.
- Check the application for excessive current draw on the motor.

WARNING/ALARM 13, Over current
The inverter peak current limit (approximately 200% of the rated current) is exceeded. The warning lasts about 5 s, then the frequency converter trips and issues an alarm. Shock loading or fast acceleration with high-inertia loads can cause this fault.

Troubleshooting

- Remove power and check if the motor shaft can be turned.
- Check that the motor size matches the frequency converter.
- Check *parameters 1-20 to 1-25* for correct motor data.

ALARM 14, Earth (ground) fault
There is current from the output phases to ground, either in the cable between the frequency converter and the motor, or in the motor itself.

Troubleshooting

- Remove power to the frequency converter and repair the ground fault.
- Check for ground faults in the motor by measuring the resistance to ground of the motor cables and the motor with a megohmmeter.

ALARM 16, Short circuit
There is short-circuiting in the motor or motor wiring.

- Remove power to the frequency converter and repair the short circuit.

WARNING/ALARM 17, Control word timeout
There is no communication to the frequency converter.
The warning is only active when *parameter 8-04 Control Word Timeout Function* is NOT set to *[0] Off*.
If *parameter 8-04 Control Word Timeout Function* is set to *[5] Stop and Trip*, a warning appears. The frequency converter then ramps down until it trips, while giving an alarm.
Parameter 8-03 Control Timeout Time could possibly be increased.

Troubleshooting

- Check connections on the serial communication cable.
- Increase *parameter 8-03 Control Word Timeout Time*.
- Check the operation of the communication equipment.
- Verify a proper installation based on EMC requirements.

ALARM 25, Brake resistor short circuit
The brake resistor is monitored during start-up. If a short circuit occurs, the brake function is disabled and the alarm appears. The frequency converter is tripped.

Troubleshooting

- Remove the power to the frequency converter and check the connection of the brake resistor.

WARNING/ALARM 26, Brake resistor power limit
The power transmitted to the brake resistor is calculated as a mean value over the last 120 s of run time. The calculation is based on the DC-link voltage and the brake resistor value set in *parameter 2-11 Brake Resistor (ohm)*. The warning is active when the dissipated braking power is higher than the value set in *parameter 2-12 Brake Power Limit (kW)*. The frequency converter trips if the warning keeps for 1200 s.

Troubleshooting

- Decrease brake energy via lower speed or longer ramp time.

ALARM 27, Brake IGBT/brake chopper short circuited
The brake transistor is monitored during start-up. If a short circuit occurs, the brake function is disabled, and an alarm is issued. The frequency converter is tripped.

Troubleshooting

- Remove the power to the frequency converter and remove the brake resistor.

ALARM 28, Brake check
The brake resistor is not connected or not working.

Troubleshooting

- Check if brake resistor is connected or it is too large for the frequency converter.

ALARM 30, Motor phase U missing
Motor phase U between the frequency converter and the motor is missing.

Troubleshooting

- Remove power from the frequency converter and check motor phase U.

ALARM 31, Motor phase V missing
Motor phase V between the frequency converter and the motor is missing.

Troubleshooting

- Remove power from the frequency converter and check motor phase V.

ALARM 32, Motor phase W missing
Motor phase W between the frequency converter and the motor is missing.

Troubleshooting

- Remove power from the frequency converter and check motor phase W.

WARNING/ALARM 34, Fieldbus communication fault
The fieldbus on the communication option card is not working.

ALARM 35, Option fault
An option alarm is received. The alarm is option-specific. The most likely cause is a power-up or a communication fault.

WARNING/ALARM 36, Mains failure
This warning/alarm is only active if the supply voltage to the frequency converter is lost and *parameter 14-10 Mains Failure* is not set to *[0] No Function*.

Troubleshooting

- Check the fuses to the frequency converter and mains supply to the unit.

ALARM 38, Internal fault
When an internal fault occurs, a code number is shown.

Troubleshooting
See *Table 4.4* for the causes and solutions for different internal faults. If the fault persists, contact the Danfoss supplier or service department for assistance.

Fault number	Cause	Solution
140–142	Power board EEPROM data error	Upgrade the software in the frequency converter to the latest version.
176	The firmware in the frequency converter does not match the frequency converter.	Upgrade the software in the frequency converter to the latest version.
256	Flash ROM checksum error	Upgrade the software in the frequency converter to the latest version.
2304	Firmware mismatch between the control card and the power card.	Upgrade the software in the frequency converter to the latest version.
2560	Communication error between the control card and the power card.	Upgrade the software in the frequency converter to the latest version. If the alarm occurs again, check the connection between the control card and the power card.
3840	Serial flash version error	Upgrade the software in the frequency converter to the latest version.
4608	Frequency converter power size error	Upgrade the software in the frequency converter to the latest version. If the alarm occurs again, contact a Danfoss supplier.
5632	Option hardware version error	The hardware version of the option or the fieldbus variant is not compatible with the frequency converter software.

Fault number	Cause	Solution
5888	Option software version error	The software version of the option or the fieldbus variant is not compatible with the frequency converter software. Change either the fieldbus software or the frequency converter software.
6144	The option is not supported	Check if the product supports this option.
6400	The option combination error	Remove the option.
Other	Other internal faults	Power cycle the frequency converter. If the alarm occurs again, contact a Danfoss supplier.

Table 4.4 Internal Fault List

WARNING 40, Overload of digital output terminal 27
Check the load connected to terminal 27 or remove the short circuit connection. Check *parameter 5-00 Digital I/O Mode* and *parameter 5-01 Terminal 27 Mode*.

ALARM 46, Power card supply
The supply for the gate drive on the power card is out of range. It is generated by the switch mode supply (SMPS) on the power card.

Troubleshooting

- Check for a defective power card.

WARNING 47, 24 V supply low
The 24 V DC is measured on the control card. This alarm appears when the detected voltage of terminal 12 is lower than 18 V.

Troubleshooting

- Check for a defective control card.

WARNING 49, Speed limit
When the speed is below the specified limit in *parameter 1-87 Compressor Min. Speed for Trip [Hz]* (except when starting or stopping) over 2 s, the frequency converter trips with this alarm.

ALARM 50, AMA calibration failed
A calibration error has occurred. Contact a Danfoss supplier or the Danfoss Service Department.

ALARM 51, AMA check U_{nom} and I_{nom}
The settings for motor voltage, motor current, and motor power are wrong.

Troubleshooting

- Check the settings in *parameters 1-20* to *1-25*.

ALARM 52, AMA low I_{nom}
The motor current is too low.

Troubleshooting

- Check the setting in *parameter 1-24 Motor Current*.

ALARM 53, AMA motor too big
The motor is too large for the AMA to operate.

ALARM 54, AMA motor too small
The motor is too small for the AMA to operate.

ALARM 55, AMA parameter out of range
The parameter values of the motor are outside of the acceptable range. AMA does not run.

ALARM 56, AMA interrupted by user
The AMA is manually interrupted.

ALARM 57, AMA internal fault
Try to restart AMA again. Repeated restarts can overheat the motor.

ALARM 58, AMA Internal fault
Contact a Danfoss supplier.

WARNING 59, Current limit
The current is higher than the value in *parameter 4-18 Current Limit*.

Troubleshooting

- Ensure that motor data in *parameters 1-20* to *1-25* are set correctly.
- Possibly increase the current limit.
- Be sure that the system can operate safely at a higher limit.

WARNING 60, External interlock
A digital input signal indicates a fault condition external to the frequency converter. An external interlock has commanded the frequency converter to trip.

Troubleshooting

- Clear the external fault condition.
- To resume normal operation, apply 24 V DC to the terminal programmed for external interlock.
- Reset the frequency converter.

WARNING/ALARM 61, Feedback error
An error between calculated speed and speed measurement from feedback device.

Troubleshooting

- Check the settings for warning/alarm/disabling in *parameter 4-30 Motor Feedback Loss Function*.
- Set the tolerable error in *parameter 4-31 Motor Feedback Speed Error*.
- Set the tolerable feedback loss time in *parameter 4-32 Motor Feedback Loss Timeout*.

ALARM 63, Mechanical brake low
The actual motor current has not exceeded the release brake current within the start delay time window.

WARNING/ALARM 65, Control card over temperature
The cutout temperature of the control card has exceeded the upper limit.

Troubleshooting

- Check that the ambient operating temperature is within the limits.
- Check the fan operation.
- Check the control card.

ALARM 67, Option module configuration has changed
One or more options have either been added or removed since the last power-down. Check that the configuration change is intentional and reset the unit.

WARNING/ALARM 68, Safe Torque Off
Safe Torque Off (STO) is activated. If STO is in manual restart mode (default), to resume normal operation, apply 24 V DC to terminals 37 and 38, and initiate a reset signal (via fieldbus, digital I/O, or [Reset]/[Off Reset] key). If STO is in automatic restart mode, applying 24 V DC to terminals 37 and 38 automatically resumes the frequency converter to normal operation.

WARNING/ALARM 69, Power card temperature
The cutout temperature of the power card has exceeded the upper limit.

Troubleshooting

- Check that the ambient operating temperature is within limits.
- Check fan operation.
- Check the power card.

ALARM 80, Drive initialised to default value
Parameter settings are initialized to default settings after a manual reset.

Troubleshooting

- To clear the alarm, reset the unit.

WARNING 87, Auto DC-Braking
Occurs in IT mains when the frequency converter 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*.

ALARM 88, Option detection
A new option configuration has been detected. Set *parameter 14-89 Option Detection* to *[1] Enable Option Change*, and power cycle the frequency converter to accept the new configuration.

ALARM 95, Broken belt
Torque is below the torque level set for no load, indicating a broken belt. *Parameter 22-60 Broken Belt Function* is set for alarm.

Troubleshooting

- Troubleshoot the system and reset the frequency converter after clearing the fault.

ALARM 99, Locked rotor
The rotor is blocked. It is only enabled for PM motor control.

Troubleshooting

- Check if the motor shaft is locked.
- Check if the start current triggers the current limit set in *parameter 4-18 Current Limit*.
- Check if it increases the value in *parameter 30-23 Locked Rotor Detection Time [s]*.

ALARM 126, Motor rotating
During AMA start-up, the motor is rotating. It is only valid for PM motor.

Troubleshooting

- Check if the motor is rotating before starting AMA.

WARNING 127, Back EMF too high
This warning applies to PM motors only. When the back EMF exceeds 90% x U_{invmax} (overvoltage threshold), and does not drop to normal level within 5 s, this warning is reported. The warning remains until the back EMF returns to a normal level.

ALARM 188, STO function fault
24 V DC supply is connected to only 1 of the 2 STO terminals (37 and 38), or a failure in STO channels is detected. Make sure that both terminals are connected to 24 V DC supply, and the discrepancy between the signals at the 2 terminals is less than 12 ms. If the fault still occurs, contact the local Danfoss supplier.

5 Frequency Converter and Motor Applications

5.1 Torque Limit, Current Limit, and Unstable Motor Operation

Excessive loading of the frequency converter can result in warning or tripping on torque limit, overcurrent, or inverter overload. Avoid this situation by sizing the frequency converter properly for the application. Ensure that intermittent load conditions cause anticipated operation in torque limit or an occasional trip. Pay attention to the following parameters when matching the frequency converter to the motor for optimum operation.

Parameters 1-20 to *1-25* configure the frequency converter for the connected motor.

These parameters set:

- Motor power.
- Voltage.
- Frequency.
- Current.
- Nominal motor speed.

It is important to set these parameters accurately. Enter the motor data required as listed on the motor nameplate. The frequency converter relies on this information for accurate motor control in dynamic loading applications.

Parameter 1-29 Automatic Motor Adaption (AMA) activates the automatic motor adaptation (AMA) function. When AMA is performed, the frequency converter measures the electrical characteristics of the motor and sets various frequency converter parameters based on the findings. This function sets the following parameter values:

- *Parameter 1-30 Stator Resistance (Rs)*
- *Parameter 1-31 Rotor Resistance (Rr)*
- *Parameter 1-33 Stator Leakage Reactance (X1)*
- *Parameter 1-35 Main Reactance (Xh)*
- *Parameter 1-37 d-axis Inductance (Ld)*

If motor operation is unstable, perform AMA if this operation has not already been performed. AMA can only be performed on single-motor applications within the programming range of the frequency converter. Refer to the *operating guide/quick guide* for more information on this function.

Set *parameter 1-30 Stator Resistance (Rs)* and *parameter 1-35 Main Reactance (Xh)* parameters for the AMA function. Use factory default values, or values that are supplied by the motor manufacturer.

NOTICE

Never adjust these parameters to random values even though it seems to improve operation. Such adjustments can result in unpredictable operation under changing conditions.

5.1.1 Overvoltage Trips

Overvoltage trip occurs when the DC-bus voltage reaches its overvoltage limit (see *chapter 1.9.2 DC Voltage Levels*). Before tripping, the frequency converter shows an overvoltage warning. Mostly, fast deceleration ramps regarding load inertia causes an overvoltage condition. During deceleration of the load, inertia of the system acts to sustain the running speed. Once the motor frequency drops below the running speed, the load begins overhauling the motor. The motor then becomes a generator and starts returning energy to the frequency converter. This action is called regeneration. Regeneration occurs when the speed of the load is greater than the commanded speed. The diodes in the IGBT modules rectify this return and raise the DC-bus voltage. If the returned voltage is too high, the frequency converter trips.

Avoiding overvoltage trip

- To extend the deceleration time, reduce the deceleration rate. Normally, the frequency converter can only decelerate the load slightly faster than it would take for the load to coast to a stop naturally.
- Allow the overvoltage control function (*parameter 2-17 Over-voltage Control*) to control the deceleration ramp. When enabled, the overvoltage control function regulates deceleration at a rate that maintains the DC-bus voltage at an acceptable level.

NOTICE

Overvoltage control does not correct unrealistic ramp rates. If the DC-bus voltage exceeds a certain voltage, the overvoltage control increases the frequency.

For example, the deceleration ramp has to be 100 s due to the inertia, and the ramp rate is set at 3 s. Overvoltage control initially engages, then disengages and allows the frequency converter to trip. This action is purposely done so the operation is not misinterpreted.

- Use an AC brake, which increases the loss in motor and reduces the DC-bus voltage.
- Use a brake resistor as this is the most efficient way to handle overvoltage issues. Refer to the *operating guide/quick guide* and the *design guide* for more details.

5.1.2 Mains Phase Loss Trips

The frequency converter monitors phase loss by monitoring the amount of ripple voltage on the DC bus. Ripple voltage on the DC bus is a product of a phase loss and can cause overheating in the DC-bus capacitors and the DC coil. If the ripple voltage on the DC bus is unchecked, the lifetime of the capacitors is drastically reduced.

When the input voltage becomes unbalanced or a phase disappears completely, the ripple voltage increases. This increase causes the frequency converter to trip and issue *alarm 4, Mains Phase Loss*. In addition to missing phase voltage, a line disturbance or imbalance can cause an increased bus ripple.

Possible sources of disturbance

- Line notching.
- Defective transformers.
- Other loads that can affect the form factor of the AC waveform.

Mains imbalances which exceed 3% cause sufficient DC-bus ripple to initiate a trip.

Other causes of increased ripple voltage on the DC bus are:

- Output disturbance.
- Missing or lower than normal output voltage on 1 phase.

Checks

When a mains imbalance trip occurs, check both the input and output voltage of the frequency converter.
Severe imbalance of supply voltage or phase loss is detectable with a voltmeter. View line disturbances through an oscilloscope. Conduct tests for:

- Input imbalance of supply voltage.
- Input waveform.
- Output imbalance of supply voltage.

See details in *chapter 6.3 Dynamic Test Procedures*.

5.1.3 Control Logic Problems

Problems with control logic can often be difficult to diagnose, since there is usually no associated fault indication. Typically, the frequency converter does not respond to a given command.

To obtain an output, provide these basic commands to the frequency converter:

- Start command: To execute.
- Reference or speed command: To identify the speed of execution.

The frequency converters are designed to accept various signals.

First determine which of these signals the frequency converter is receiving:

- Digital inputs (18, 19, 27, 29, 32, 33).
- STO inputs (37, 38).
- Analog outputs (42).
- 10 V output.
- Analog inputs (53, 54).
- Serial communication bus (68, 69).

The presence of a correct reading indicates that the microprocessor of the frequency converter has detected the required signal. See *chapter 3.2 Frequency Converter Inputs and Outputs*.

This data can also be read in *parameter group 16-6* Inputs & Outputs*.

If there is no correct indication, check if the signal is present at the input terminals of the frequency converter. Use a voltmeter or oscilloscope in accordance with *chapter 6.3.11 Input Terminal Signal Tests*.

If the signal is present at the terminal, the control card is defective and must be replaced. If the signal is not present, the problem is external to the frequency converter. The circuitry providing the signal along with its associated wiring must then be checked.

5.1.4 Programming Problems

Difficulty with operation of the frequency converter can be a result of improper programming of the frequency converter parameters.

Three areas where programming errors can affect frequency converter and motor operation are:

- Motor settings.
- References and limits.
- I/O configuration.

See *chapter 3.2 Frequency Converter Inputs and Outputs*.

Set up the frequency converter correctly for the motor or motors connected to it. Parameters must have data from the motor nameplate entered into the frequency converter. These data enable the frequency converter processor to match the frequency converter to power characteristics of the motor. Inaccurate motor data can cause the motor to draw higher than normal amounts of current when performing a task. In such cases, setting the correct values to these parameters and performing the AMA function usually solves the problem.

Any references or limits set incorrectly result in less than acceptable frequency converter performance. For instance, if maximum reference is set too low, the motor is unable to reach full speed. Set these parameters according to the requirements of the particular installation. References are set in *parameter group 3-0* Reference Limits*.

Incorrectly set I/O configuration usually results in the frequency converter not responding to the function as commanded. Remember that for every control terminal input or output there are corresponding parameter settings. These settings determine how the frequency converter responds to an input signal or the type of signal present at that output. Utilizing an I/O function involves a 2-step process. Wire the wanted I/O terminal properly, and set the corresponding parameter accordingly. Control terminals are programmed in *parameter group 5-0* Digital I/O Mode* and *parameter group 6-0* Analog I/O Mode*.

5.1.5 Motor/Load Problems

Problems with the motor, motor wiring, or mechanical load on the motor can develop in several ways. The motor or motor wiring can develop a phase-to-phase or phase-to-ground short circuit resulting in an alarm indication. Check whether the problem is in the motor wiring or the motor itself.

A motor with unbalanced, or asymmetrical, impedances on all 3-phases can result in uneven or rough operation, or unbalanced output currents. For measurements, use a clamp-on style ammeter to determine whether the current is balanced on the 3 output phases. See *chapter 6.3.10 Output Imbalance of Motor Supply Voltage Test*.

Usually, a current limit warning indicates an incorrect mechanical load. If possible, disconnect the motor from the load to determine if the load is incorrect.

Often, the indications of motor problems are similar to the problems of a defect in the frequency converter itself. To determine whether the problem is internal or external to the frequency converter, disconnect the motor from the frequency converter motor terminals. Perform the initial procedure with no motor connection on all 3-phases with an analog voltmeter, see *chapter 6.3.10 Output Imbalance of Motor Supply Voltage Test*. If the 3 voltage measurements are balanced, the frequency converter is functioning correctly. Hence, the problem is external to the frequency converter.

If the voltage measurements are not balanced, the frequency converter is malfunctioning. Typically, 1 or more output IGBTs are not functioning correctly. This problem can be a result of a defective IGBT or gate signal.

5.2 Internal Frequency Converter Problems

5.2.1 Overtemperature Faults

If an overtemperature indication is shown, determine whether this condition actually exists within the frequency converter, or whether the thermal sensor is defective.

5

5.2.2 Current Sensor Faults

When a current sensor fails, an overcurrent alarm is sometimes issued. The alarm cannot be reset, even with the motor cables disconnected. However, the frequency converter experiences frequent false ground fault trips. This is due to the DC offset failure mode of the sensors.

The simplest method of determining whether a current sensor is defective is to disconnect the motor from the frequency converter. Then observe the current in the frequency converter display. With the motor disconnected, the current should be 0. A frequency converter with a defective current sensor indicates some current flow. An indication of a fraction of 1 amp is tolerable. However, that value should be considerably less than 1 amp. If the display shows more than 1 amp of current, there is a defective current sensor.

5.2.3 Signal and Power Wiring Considerations for Electromagnetic Compatibility

This section provides an overview of general signal and power wiring considerations when addressing the electromagnetic compatibility (EMC) concerns for typical commercial and industrial equipment. Only certain high-frequency phenomena (such as RF emissions, RF immunity) are discussed. Low-frequency phenomena (such as harmonics, mains voltage imbalance, notching) are not covered.

5.2.4 Effects of EMI

While electromagnetic interference-related (EMI) disturbances to the operation of the frequency converter are uncommon, the following detrimental EMI effects sometimes occur:

- Motor speed fluctuations.
- Serial communication transmission errors.
- Frequency converter CPU exception faults.
- Unexplained frequency converter trips.

A disturbance resulting from other nearby equipment is more common. Generally, other industrial control equipment has a high level of EMI immunity. However, non-industrial, commercial, and consumer equipment is often susceptible to lower levels of EMI.

Detrimental effects to these systems include the following:

- Pressure/flow/temperature signal transmitter signal distortion or aberrant behavior.
- Radio and TV interference.
- Telephone interference.
- Computer network data loss.
- Digital control system faults.

5.2.5 Sources of EMI

Modern frequency converters (see *Illustration 5.1*) utilize IGBTs to provide an efficient and cost-effective way to create the pulse-width modulated (PWM) output waveform necessary for accurate motor control. These devices rapidly switch the fixed DC-bus voltage creating a variable frequency, and variable voltage PWM waveform. This high rate of voltage change (dU/dt) is the primary source of the frequency converter generated EMI.

The high rate of voltage change caused by the IGBT switching creates high-frequency EMI.

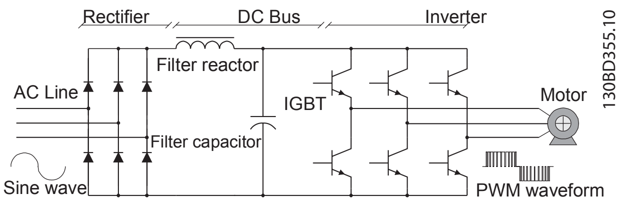
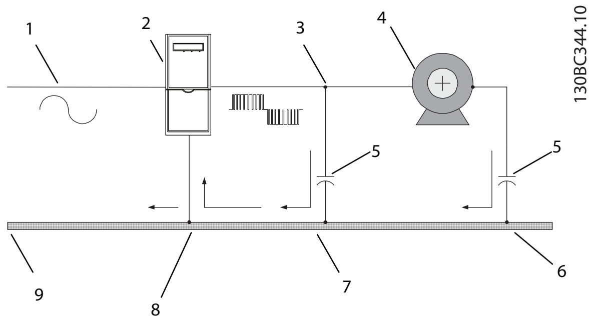


Illustration 5.1 Frequency Converter Functionality Diagram

5.2.6 EMI Propagation

Frequency converter generated EMI is both conducted to the mains and radiated to nearby conductors. See *Illustration 5.2*.



1	AC line
2	Frequency converter
3	Motor cable
4	Motor
5	Stray capacitance
6	Signal wiring
7	Signal wiring
8	Signal wiring
9	Ground

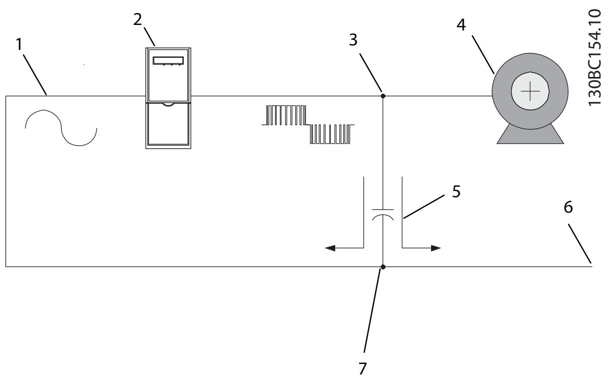
Illustration 5.2 Ground Currents

NOTICE

Stray capacitance between the motor conductors, equipment ground, and other nearby conductors results in induced high frequency currents.

High ground circuit impedance at high frequencies results in an instant voltage at points reputed to be at ground potential. This voltage can appear throughout a system as a common mode signal that can interfere with control signals.

Theoretically, these currents return to the DC-bus via the ground circuit and a high frequency (HF) bypass network within the frequency converter itself. However, imperfections in the frequency converter grounding or the equipment ground system can cause some of the currents to travel out to the power network.



1	AC line
2	Frequency converter
3	Motor cable
4	Motor
5	Stray capacitance
6	AC line, to BMS
7	Signal wiring

Illustration 5.3 Signal Conductor Currents

NOTICE

Unprotected or poorly routed signal conductors located close to or in parallel to motor and mains conductors are susceptible to EMI.

Signal conductors are especially vulnerable when they run in parallel to the power conductors for any distance. EMI coupled into these conductors can affect either the frequency converter or the interconnected control device. See *Illustration 5.3*.

While these currents tend to travel back to the frequency converter, imperfections in the system cause some current to flow in undesirable paths. This flow exposes other locations to the EMI.

NOTICE

High frequency currents can be coupled into the mains supplying the frequency converter, when the mains conductors are located close to the motor cables.

5.2.7 Preventive Measures

EMI-related problems are more effectively alleviated during the design and installation phases rather than after the system is in service. Many of the listed steps can be implemented at a relatively low cost compared to the cost of identifying and fixing the problem later.

Grounding

Ground the frequency converter and motor solidly to the equipment frame. A good high-frequency connection is necessary to allow the high frequency currents to return to the frequency converter instead of traveling through the power network. The ground connection is ineffective if it has high impedance to high frequency currents. Therefore, it must be as short and direct as possible. Flat-braided cable has lower high frequency impedance than round cable. Mounting the frequency converter or motor onto a painted surface creates an effective ground connection. In addition, running a separate ground conductor directly between the frequency converter and the running motor is recommended.

5

Cable routing

Avoid parallel routing of:

- Motor wiring.
- Mains wiring.
- Signal wiring.

If parallel routing is unavoidable, preferably maintain a separation of 200 mm (6–8 in) between the cables or separate them with a grounded conductive partition. Avoid routing cables through free air.

Signal cable selection

Single conductor 600 V rated wires provide the least protection from EMI. Twisted pair and shielded twisted-pair cables are available which are designed to minimize the effects of EMI. While unshielded twisted-pair cables are often adequate, shielded twisted-pair cables provide another degree of protection. Terminate the signal cable shield in a manner that is appropriate for the connected equipment. Avoid terminating the shield through a pigtail connection as it increases the high frequency impedance and spoils the effectiveness of the shield.

A simple alternative is to twist the existing single conductors to provide a balanced capacitive and inductive coupling. This operation cancels differential mode interference. While not as effective as true twisted-pair cable, it can be implemented in the field using the materials at hand.

Motor cable selection

Motor conductors have the greatest influence on the EMI characteristics of the system. These conductors must receive the highest attention whenever EMI is a problem. Single conductor wires provide the least protection from EMI emissions. Often, if these conductors are routed separately from the signal and mains wiring, no further consideration is needed. If the conductors are routed close to other susceptible conductors, or if the system is suspected to cause EMI problems, consider alternate motor wiring methods.

Installing shielded power cable is the most effective way to alleviate EMI problems. The cable shield forces the noise current to flow directly back to the frequency converter.

Thus, the noise current cannot get back into the power network or take other undesirable high frequency paths. Unlike most signal wiring, the shielding on the motor cable must be terminated at both ends.

If a shielded motor cable is not available, then 3-phase conductors along with ground in a conduit provides some degree of protection. This technique is not as effective as shielded cable due to the unavoidable contact of the conduit with various points within the equipment.

Serial communications cable selection

There are various serial communication interfaces and protocols in the market. Each of these interfaces recommends 1 or more specific types of twisted pair, shielded twisted pair, or proprietary cables. Refer to the manufacturer's documentation when selecting these cables. Similar recommendations apply to serial communication cables as to other signal cables. Using twisted-pair cables and routing them away from power conductors is encouraged. While shielded cable provides extra EMI protection, the shield capacitance may reduce the maximum allowable cable length at high data rates.

6 Test Procedures

6.1 Introduction

WARNING

PERSONAL INJURY RISK

Touching electrical parts of the frequency converter may be fatal even after equipment has been disconnected from AC power.

- **Before touching any potentially live parts of the frequency converter, refer to *chapter 2 Safety*.**
- **Wait for the frequency converter components to discharge fully. See *Table 2.1* or the label on the frequency converter for specific discharge time.**

This section contains detailed procedures for testing frequency converters. Previous sections of this guide provide symptoms, alarms, and other conditions which require more test procedures to diagnose the frequency converter further. The results of these tests indicate the appropriate repair actions.

Among other things, the frequency converter monitors:

- Input and output signals.
- Motor conditions.
- AC and DC power.

This monitoring function helps stating the source of fault conditions existing outside of the frequency converter.

Frequency converter testing is divided into static tests and dynamic tests. Static tests are conducted without power applied to the frequency converter. Most frequency converter problems can be diagnosed simply with these tests. Static tests are performed with little or no disassembly. The purpose of static testing is to check for shorted power components. Perform these tests on any unit suspected of containing faulty power components before applying power.

CAUTION

SHOCK AND INJURY HAZARD

All devices and supplies connected to mains are energized at rated voltage. Contact with powered components could result in electrical shock and personal injury.

- **Use extreme caution when conducting tests on a powered frequency converter.**
- **Do not touch energized parts of the frequency converter when connected to mains.**

Dynamic tests are performed with power applied to the frequency converter. Dynamic testing traces signal circuitry to isolate faulty components.

Tools for dynamic test procedures include:

- Digital Volt-Ohm meter capable of reading real RMS.
- Analog volt meter.
- Oscilloscope.
- Current meter.

6.2 Static Test Procedures

6.2.1 Zero Voltage DC-Link Test

1. After power off, wait for discharge of the DC-link before taking the measurement. For duration of discharge time, see *Table 2.1*.
2. Set the multimeter to the DC voltage position.
3. Check the DC-link for remaining charge by measuring the voltage on the DC terminals.
4. Measure from terminal (-DC) to terminal (+DC).

When the voltage reading is 0 V, it is safe to proceed with the static tests.

The purpose of performing static testing is to check for any short circuit of the power components.

For all tests, use a meter capable of testing diodes. Use a digital Volt-Ohm Meter (VOM) set on the diode scale or an analog ohmmeter set on Rx100 scale.

Before making any checks, disconnect all connections for:

- Input.
- Motor.
- Brake resistor.

Ensure that the frequency converter is disconnected from power, before performing static tests.

WARNING

SHOCK HAZARD

Disconnection of the input cable while the frequency converter is powered could result in electrical shock causing death or personal injury.

- **Do not disconnect the input cable while the frequency converter is powered.**

6

6.2.2 Pre-requisite

⚠CAUTION

ELECTROSTATIC DISCHARGE

Failure to follow the ESD regulations can cause personal injury and property damage.

- **Prepare the work area according to the ESD regulations.**
- **Ground ESD mat and wrist strap. Ensure that the ground connection between body, ESD mat, and frequency converter is always present while servicing the frequency converter.**
- **Handle disassembled electronic parts carefully and always protected from ESD.**

- Perform the static test before powering up the fault unit.
- Perform static test after completing the repair and assembly of the frequency converter.
- Connect the frequency converter to the mains only after completion of static tests.
- Complete all necessary precautions for system start-up before applying power to frequency converter.

6.2.3 Rectifier Circuit Tests

Pay close attention to the polarity of the meter leads to ensure the identification of any faulty component in case an incorrect reading appears.

NOTICE

The illustrations used for describing the rectifier circuit tests are samples. The looks of the various enclosure sizes differ, but it is the mains terminals and the UDC- and UDC+ terminals that are important for the tests.

Rectifier test part 1

1. Connect the positive (+) meter lead to the positive (+) DC bus terminal on the 6-pole connector.
2. Connect the negative (-) meter lead to terminals L1, L2, L3 in turn on the 3-pole mains connector.

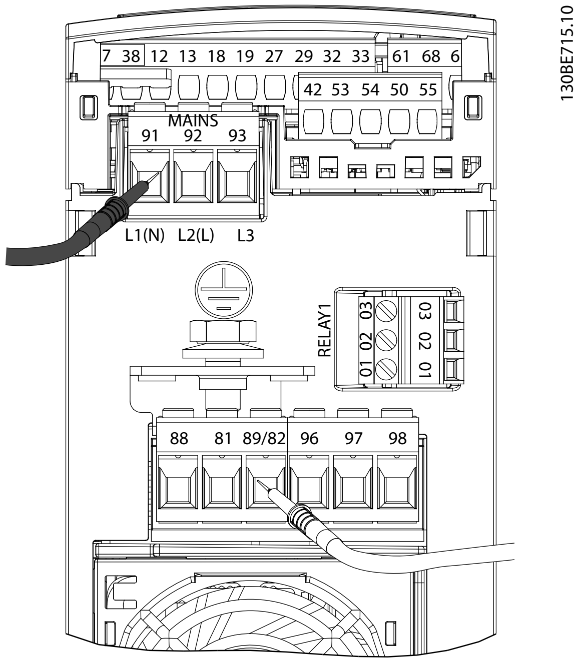


Illustration 6.1 Connecting Meter Leads for Rectifier Test, Part 1

Each reading should show infinity directly in diode measuring mode. In Ω measuring mode, the meter starts at a low value and slowly climbs towards infinity due to capacitance within the frequency converter, being charged by the meter.

Rectifier test part 2

3. Reverse the meter leads by connecting the negative (-) meter lead to the positive (+) DC bus terminal.
4. Connect the positive (+) meter lead to terminals L1, L2, and L3 in turn.

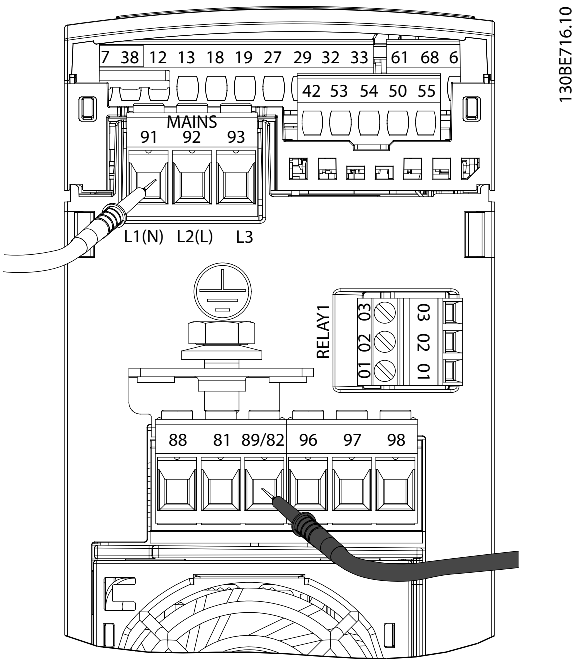


Illustration 6.2 Connecting Meter Leads for Rectifier Test, Part 2

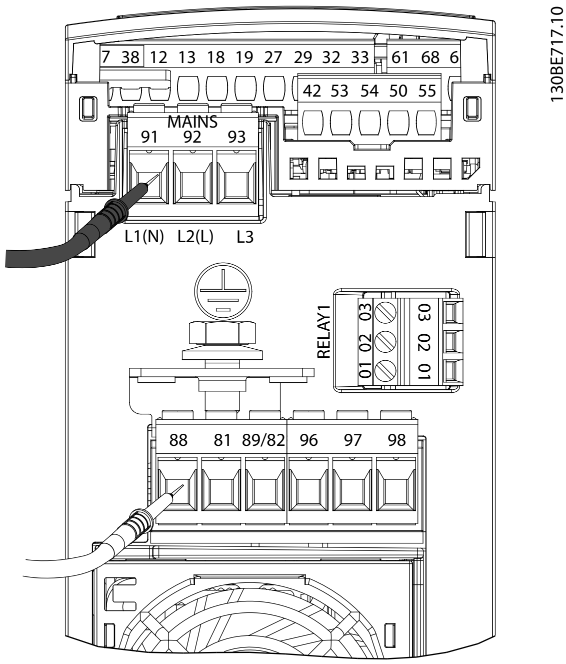


Illustration 6.3 Connecting Meter Leads for Rectifier Test, Part 3

Each reading should show a diode drop of approximately 0.7 V.

Rectifier test part 3

5. Connect the positive (+) meter lead to the negative (-) DC bus terminal.
6. Connect the negative (-) meter lead to terminals L1, L2, L3 in turn.

Each reading should show a diode drop of approximately 0.7 V.

Rectifier test part 4

7. Reverse the meter leads by connecting the negative (-) meter lead to the negative (-) DC bus terminal.
8. Connect the positive (+) meter lead to terminals L1, L2, L3 in turn.

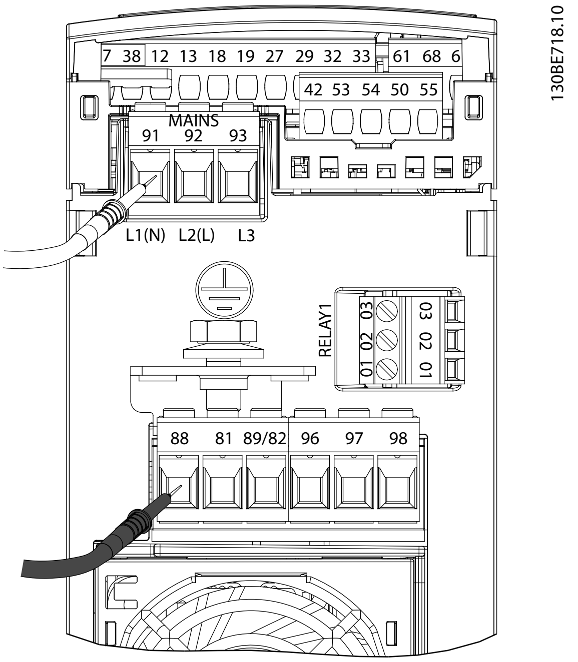


Illustration 6.4 Connecting Meter Leads for Rectifier Test, Part 4

Each reading should show infinity directly in diode measuring mode. In Ω measuring mode, the meter starts at a low value and slowly climbs towards infinity due to capacitance within the frequency converter being charged by the meter.

6.3 Dynamic Test Procedures

6.3.1 Safety Warnings

See *chapter 2 Safety* for general safety instructions.

- Take all the necessary safety precautions for system start-up before applying power to the frequency converter.
- Test procedures in this section are numbered for reference only. Tests do not need to be performed in this order. Perform tests only as necessary.

⚠CAUTION

SHOCK AND INJURY HAZARD

For dynamic test procedures, mains input power is required and all devices and supplies connected to mains are energized at rated voltage. Contact with powered components could result in electrical shock and personal injury.

- **Do not touch energized parts of the frequency converter when connected to mains.**

⚠CAUTION

SHOCK HAZARD

Disconnection of input cabling with mains power applied can result in personal injury. Contact with powered components could result in electrical shock and personal injury.

- **When power is applied, do not disconnect input cabling.**

6.3.2 Access to Terminals U, V, and W for Dynamic Tests

For dynamic tests, access terminals U, V, and W externally at the base of the frequency converter.

6.3.3 Zero Voltage DC-Link Test

1. After power off, wait for discharge of DC-link before taking the measurement. For duration of discharge time, see *Table 2.1*.
2. Set the multimeter to the DC voltage position.
3. Check the DC-link for remaining charge by measuring the voltage on the DC terminals.
4. Measure from terminal (UDC-) to terminal (UDC+).

When the voltage reading is 0 V, it is safe to proceed with the dynamic tests.

6.3.4 Dynamic Test on IGBT

Dynamic tests are performed with power applied to the frequency converter. Dynamic testing traces signal circuitry to isolate faulty components.

Preparation

1. Close the cover on the frequency converter.
2. Disconnect the motor from the frequency converter.
3. Ensure that the frequency converter is powered up.
4. Program the frequency converter to approximately 50 Hz on start.
5. Set the multimeter to 1000 V AC.

Procedure for dynamic test on the IGBT

NOTICE

Short-circuiting the U, V, W terminals, or any terminal of U, V, W, UDC+, UDC- to PE, can damage the frequency converter permanently. Do not touch more than 1 terminal at a time with the measuring probes.

1. Connect the positive terminal of the multimeter lead to the U connector, and connect the negative terminal to the V terminal.
2. Connect the positive terminal of the multimeter lead to the U connector, and connect the negative terminal to the W terminal.
3. Connect the positive terminal of the multimeter lead to the V connector, and connect the negative terminal to the W terminal.

The meter reading is 450 V ±25 V when performing the dynamic test at 400 V mains. With PM motors the reading may differ. Contact hotline for help.

The reading must be within ±1.5%.

6.3.5 No Display Test (Display is Optional)

A frequency converter with no display in the LCP can be the result of several causes. First, verify that there is no display. A single character in the display or a dot in the upper corner of the display indicates a communication error. Check that all option cards are properly installed. When this condition occurs, the green power-on LED is illuminated.

If the LCD display is dark and the green power-on LED is not lit, proceed with the following tests.

First test for proper input voltage.

6.3.6 Input Voltage Test

1. Apply power to frequency converter.
2. Use the DVM to measure the input mains voltage between the frequency converter input terminals in sequence:
   L1 to L2.
   L1 to L3.
   L2 to L3.

For 380–500 V frequency converters, all measurements must be within the range of 342–528 V AC. Readings of less than 342 V AC indicate problems with the input mains voltage.

In addition to the actual voltage reading, the balance of the voltage between the phases is also important. The frequency converter can operate within specifications as long as the imbalance of supply voltage is not more than 3%.

Danfoss calculates mains imbalance according to an IEC specification.

$$\text{Imbalance}=0.67 \text{ X } (V_{max}–V_{min})/V_{avg}$$

For example, if 3-phase readings were taken and the results were 500 V AC, 478.5 V AC, and 478.5 V AC; then 500 V AC is V_{max}, 478.5 V AC is V_{min}, and 485.7 V AC is V_{avg}, resulting in an imbalance of 3%.

Although the frequency converter can operate at higher mains imbalances, the lifetime of components, such as DC-bus capacitors, is shortened.

NOTICE

Open (blown) input fuses or tripped circuit breakers usually indicate a more serious problem. Before replacing fuses or resetting breakers, perform static tests.

An incorrect reading here requires further investigation of the main supply.

Check for:

- Open (blown) input fuses or tripped circuit breakers.
- Open disconnects or line side contactors.
- Problems with the power distribution system.

If this test was successful, check for voltage to the control card.

6.3.7 Basic Control Card Voltage Test

1. Measure the control voltage at terminal 12 with reference to terminal 55.
   The meter must read 21–27 V DC.

An incorrect reading here could indicate that a fault in the customer connections loads down the supply. Disconnect control wiring and repeat the test. If this test is successful, then continue. Remember to check the customer connections. If still unsuccessful, replace the unit.

2. Measure the 10 V DC control voltage at terminal 50 with reference to terminal 55. The meter must read between 9.2 and 11.2 V DC.

An incorrect reading here could indicate that a fault in the customer connections loads down the supply. Disconnect control wiring and repeat the test. If this test is successful, then continue. Remember to check the customer connections. If still unsuccessful, replace the unit.

6

6.3.8 Input Imbalance of Supply Voltage Test

Theoretically, the current drawn on all 3 input phases must be equal. Some imbalance may be seen, however, due to variations in the phase-to-phase input voltage, and single-phase loads within the frequency converter.

A current measurement of each phase reveals the balanced condition of the line. To obtain an accurate reading, the frequency converter must run at its rated load, or at a load of not less than 40%.

1. Perform the input voltage test before checking the current, in accordance with procedure. Voltage imbalances automatically result in a corresponding current imbalance.
2. Apply power to the frequency converter and place it in run.
3. Using a clamp-on ammeter (analog preferred), read the current on each of 3 input lines at L1 (R), L2 (S), and L3 (T).
   Typically, the current should not vary from phase-to-phase by more than 5%. If a greater current variation exists, it indicates a possible problem with the mains supply to the frequency converter, or a problem within the frequency converter. One way to determine if the mains supply is at fault is to swap 2 of the incoming phases. This assumes that 2 phases read 1 current while the 3rd deviates by more than 5%. If all 3-phases are different from one another, swap the phase with the highest current with the phase with the lowest current:
   - 3a Remove power to the frequency converter.
   - 3b Swap the phase that appears to be incorrect with 1 of the other 2 phases.
   - 3c Reapply power to the frequency converter and place it in run.
   - 3d Repeat the current measurements.

If the imbalance of supply voltage moves with swapping the leads, the mains supply is suspect. Otherwise, it may indicate a problem with the gating of the rectifiers.

6.3.9 Input Waveform Test

Testing the current waveform on the input of the frequency converter can help troubleshooting mains phase loss conditions or suspected problems with the diodes in rectifier. Phase loss caused by the mains supply can be easily detected. If a diode in the rectifier becomes defective, the frequency converter responds with a phase loss.

The following measurements require an oscilloscope with voltage and current probes.

Under normal operating conditions, the waveform of a single phase of input AC voltage to the frequency converter appears as in *Illustration 6.5*.

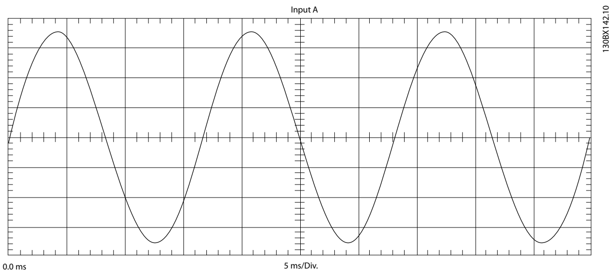


Illustration 6.5 Normal AC Input Voltage Waveform

The waveform shown in *Illustration 6.6* shows the input current waveform for the same phase as shown in *Illustration 6.5* while the frequency converter is running at 40% load. The 2 positive and 2 negative jumps are typical for any 6-diode bridge.

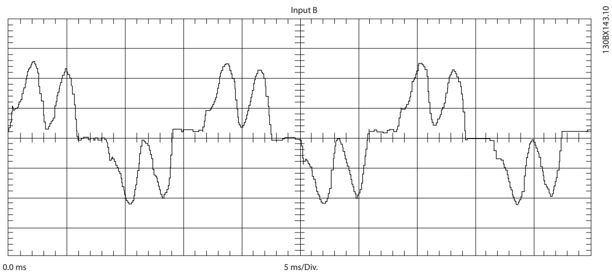


Illustration 6.6 AC Input Current Waveform with Diode Bridge

With a phase loss, the current waveform of the remaining phases would take on the appearance shown in *Illustration 6.7*.

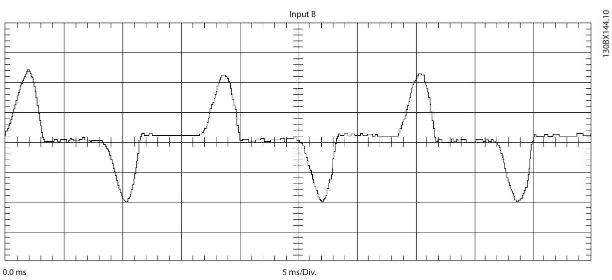


Illustration 6.7 Input Current Waveform with Phase Loss

Always verify the condition of the input voltage waveform before forming a conclusion. The current waveform follows the voltage waveform. If the voltage waveform is incorrect, proceed to investigate the reason for the AC supply problem. If the voltage waveform on all 3 phases is correct, but the current waveform is not, the input rectifier circuit in the frequency converter is suspect. Perform the static soft charge and rectifier tests and also the dynamic diode module test.

6.3.10 Output Imbalance of Motor Supply Voltage Test

Check the balance of the output voltage and current to measure the electrical functioning between the frequency converter and the motor. In testing the phase-to-phase output, both voltage and current are monitored. Conduct static tests on the inverter section of the frequency converter before this procedure.

If the voltage is balanced, but the current is not, it indicates that the motor is drawing an uneven load. This could be the result of a defective motor, a poor connection in the wiring between the frequency converter and the motor, or a defective motor overload.

If the output current and the voltage are unbalanced, it indicates that the frequency converter is not working properly. It could be the result of a defective power card or an improper connection of the output circuitry.

NOTICE

Use an analog voltmeter for monitoring output voltage. Digital voltmeters are sensitive to waveform and switching frequencies and commonly return erroneous readings.

Perform the initial test with the motor connected and running its load.

If suspect readings are recorded, then:

- Stop the motor and wait until the motor has stopped rotating.
- Set the frequency converter to coast.
- Disconnect the motor cables to isolate the problem further.

Then:

1. Using a voltmeter, measure AC output voltage at frequency converter motor terminals U, V, and W. Measure phase-to-phase checking U to V, then U to W, and then V to W.
   All 3 readings must be within 8 V AC of each other. The actual value of the voltage depends on the speed at which the frequency converter is running. The V/Hz ratio is relatively linear (except in VT mode). For example, if the rated motor frequency is 60 Hz, the voltage should be approximately equal to the applied mains voltage. At 30 Hz, it is about half of the applied mains voltage for any other speed selected. The exact voltage reading is less important than balance between phases.
2. Stop the frequency converter and disconnect mains.
3. Reconnect the motor to the frequency converter.
4. Connect mains to the frequency converter, and start the frequency converter.
5. Monitor current on the 3 output phases at the motor terminals U, V, and W, using the clamp-on ammeter. An analog device is preferred. To achieve an accurate reading, run the frequency converter above 40 Hz as this is normally the frequency limitation of such meters.

The output current must be balanced from phase-to-phase, and no phase must be more than 2–3% different from another. If these tests are successful, the frequency converter is operating normally.

6. If the imbalance is greater than described previously, disconnect the motor cables and repeat the voltage balance test.
7. Stop the motor and disconnect mains from the frequency converter.

Since the current follows the voltage, it is necessary to differentiate between a load problem and a frequency converter problem. When a voltage imbalance in the output is detected with the motor disconnected, the inverter is faulty. Exchange the frequency converter.

6.3.11 Input Terminal Signal Tests

The presence of signals on either the digital or analog input terminals of the frequency converter can be verified on the frequency converter display. Digital or analog input status can be selected or read in *parameter 16-60 Digital Input* to *parameter 16-64 Analog Input AI54*.

Digital inputs

From right side to left, bits 0, 1, 2, 3, 4, 5, and 10 represent digital inputs 33, 32, 29, 27, 19, 18, and 31.

If the required signal is not present in the display, the problem is either in the external control wiring to the frequency converter or a faulty control card. To determine the fault location, use a voltmeter to test for voltage at the control terminals.

6

Verify that the control voltage supply is correct as follows.

1. Use a voltmeter for measuring voltage at control card terminal 12 with reference to terminal 55. The meter should read 21–27 V DC.

If the 24 V supply voltage is not present, test the control card as described in *chapter 6.3.7 Basic Control Card Voltage Test*.

If 24 V is present, proceed with checking the individual inputs as follows.

2. Connect the (-) negative meter lead to reference terminal 55.
3. Connect the (+) positive meter lead to the terminals in sequence.

The presence of a signal at the wanted terminal must correspond to the digital input display readout. A reading of 24 V DC indicates the presence of a signal. A reading of 0 V DC indicates that no signal is present.

Analog inputs

The value of signals on analog input terminals 53 and 54 can also be shown. The voltage or current in mA, depending on the switch setting, is shown in line 2 of the display.

If the required signal is not present in the display, the problem is either in the external control wiring to the frequency converter, or a faulty control card. To determine the fault location, use a voltmeter to test for a signal at the control terminals.

Verify that the reference voltage supply is correct as follows.

1. Use a voltmeter for measuring the voltage at control card terminal 50 with reference to terminal 55. The meter must read 9.2–11.2 V DC.

If the 10 V supply voltage is not present, conduct *chapter 6.3.7 Basic Control Card Voltage Test* earlier in this section.

If 10 V is present, proceed with checking the individual inputs as follows.

2. Connect the (-) negative meter lead to reference terminal 55.
3. Connect the (+) positive meter lead to wanted terminal 53 or 54.

Analog input terminals 53 and 54 require a DC voltage between 0 and +10 V DC to match the analog signal sent to the frequency converter. A reading of 0.9–4.8 V DC corresponds to a 4–20 mA signal.

NOTICE

A (-) minus sign preceding any reading above indicates a reversed polarity. In this case, reverse the wiring to the analog terminals.

6.4 Initial Start-up or After-repair Tests

Perform these tests under the following conditions:

- Starting a frequency converter for the first time.
- Approaching a frequency converter that is suspected of being faulty.
- After repair of the frequency converter.

Following this procedure ensures that all circuitry in the frequency converter is functioning properly before putting it into operation.

1. Perform visual inspection procedures as described in *Table 4.1*.
2. Perform static test procedures to ensure that the frequency converter is safe to start.
3. Disconnect motor cables from output terminals (U, V, W) of the frequency converter.
4. Apply AC power to frequency converter.
5. Give the frequency converter a run command and slowly increase reference (speed command) to approximately 40 Hz.
6. Use an analog voltmeter or a DVM capable of measuring true RMS to measure phase-to-phase output voltage on all 3-phases: U to V, U to W, V to W. All voltages must be balanced within 8 V. If measuring unbalanced voltage, refer to *chapter 6.3.10 Output Imbalance of Motor Supply Voltage Test*.
7. Stop the frequency converter and remove input power. Wait for the discharge time listed in *Table 2.1* to allow DC capacitors to discharge fully.
8. Reconnect motor cables to frequency converter output terminals (U, V, W).
9. Reapply power and restart the frequency converter. Adjust motor speed to a nominal level.
10. Set load to 50%.
11. Using a clamp-on ammeter, measure output current on each output phase. All currents must be balanced.
12. The correct measurement is 50% rated current.

6.5 Flashing of Frequency Converter after Control Card Replacement

After replacing the control card, flash the frequency converter via the MCT 10 Set-up Software.

1. Select MCT 10 Set-up Software in the *Start* menu.
2. Select *Configure bus*.
3. Fill in the relevant data in the *Serial fieldbus configuration*-window.
4. Click the *Scan bus*-icon and find the frequency converter.
    - 4a The frequency converter appears in the *ID*-view.
5. Click *Software upgrader*.
6. Select the oss file.
7. In the dialog window, tick *Force upgrade* and then click *Start upgrade*.
    - 7a The firmware flashes.
8. Click *Done* when the upgrade is complete.

7 Disassembly and Assembly Instructions

7.1 Electrostatic Discharge (ESD)

⚠CAUTION

ELECTROSTATIC DISCHARGE

Failure to follow the ESD regulations can cause personal injury and property damage.

- **Prepare the work area according to the ESD regulations.**
- **Ground ESD mat and wrist strap. Ensure that the ground connection between body, ESD mat, and frequency converter is always present while servicing the frequency converter.**
- **Handle disassembled electronic parts carefully and always protected from ESD.**

7.2 General Disassembly Procedure

This procedure explains how to remove the outer parts of the frequency converter that are common for all enclosure sizes. When this procedure is completed, the inside components are accessible.

7.2.1 Removing LCP

Remove the LCP with a flat-edged screwdriver (accessed from the top).

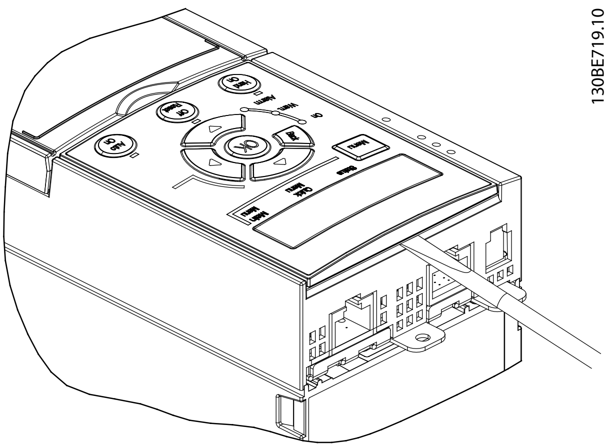


Illustration 7.1 Remove LCP

7.2.2 Removing Plastic Cover

Remove the plastic cover beneath the LCP by pushing down the lock lever with a flat-edged screwdriver and lift the plastic cover upwards.

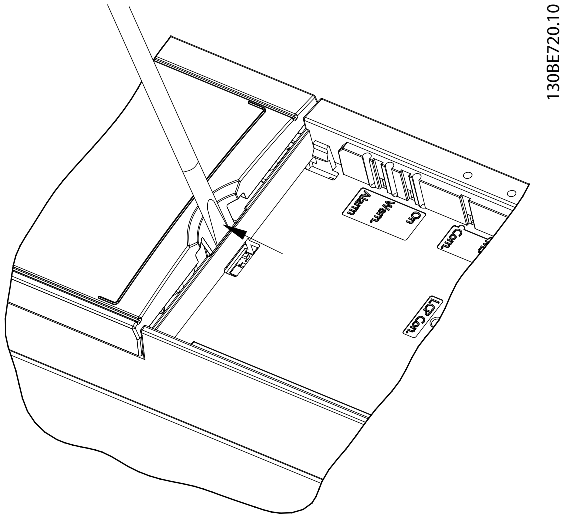


Illustration 7.2 Remove Cover

7.3 Control Card Cassette Replacement

7.3.1 Replacement Procedure

1. Remove the LCP and the plastic cover beneath it.
2. Loosen the control card cassette by removing the 2 screws (T10, M3x6) on the left side, as shown in *Illustration 7.3*.

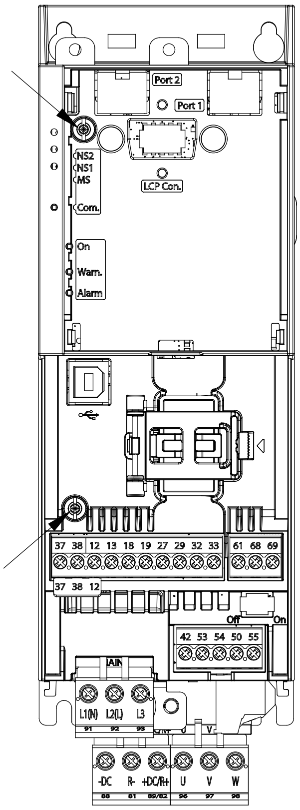


Illustration 7.3 Loosen the Control Card Cassette

3. Slide the control card cassette upwards to release it from the power section.
4. Remove the 2 connection cables from the control card cassette, as shown in *Illustration 7.4*.

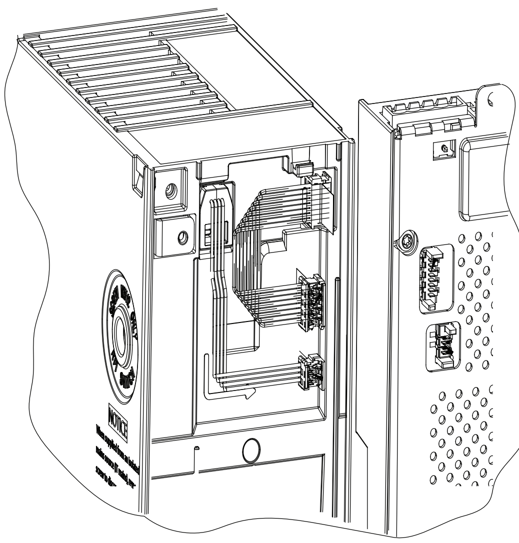


Illustration 7.4 Connection Cable for Control Card Cassette

5. Install a new control card cassette in reverse order. The reference screw torque is 0.7–1.0 Nm (6.2–8.9 in-lb).

Flash the frequency converter after a new control card cassette is installed. For more details, see *chapter 6.5 Flashing of Frequency Converter after Control Card Replacement*.

7.4 Fan Replacement

7.4.1 Replacement Procedure for K1 and K2

1. Grab the center handle and release the retaining lever at the backplate using a flat-edged screwdriver.
2. Dismount the fan from the power section.

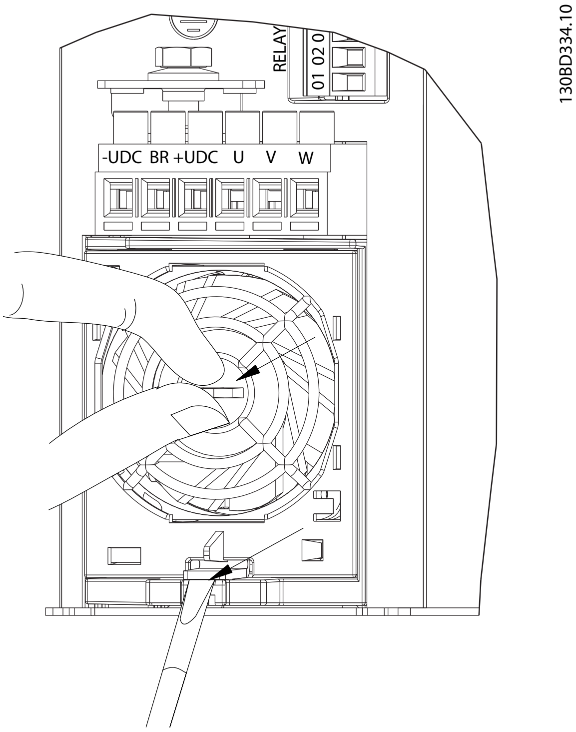


Illustration 7.5 Center Handle

3. Unplug the fan cable.

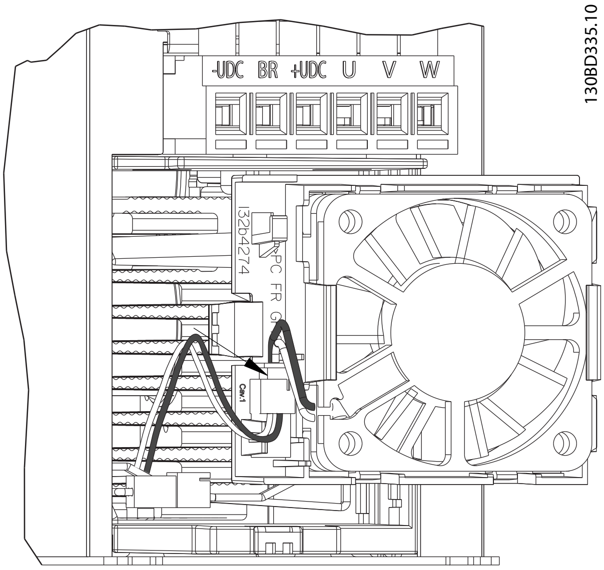


Illustration 7.6 Fan Cable Plug

NOTICE

For VLT® Midi Drive FC 280, the fan cable has 3 wires.

4. Remove the fan completely.
5. Install a new fan in reverse order.

7.4.2 Replacement Procedure for K3

1. Remove the screw (M3x6) in the bottom right corner of the frequency converter.

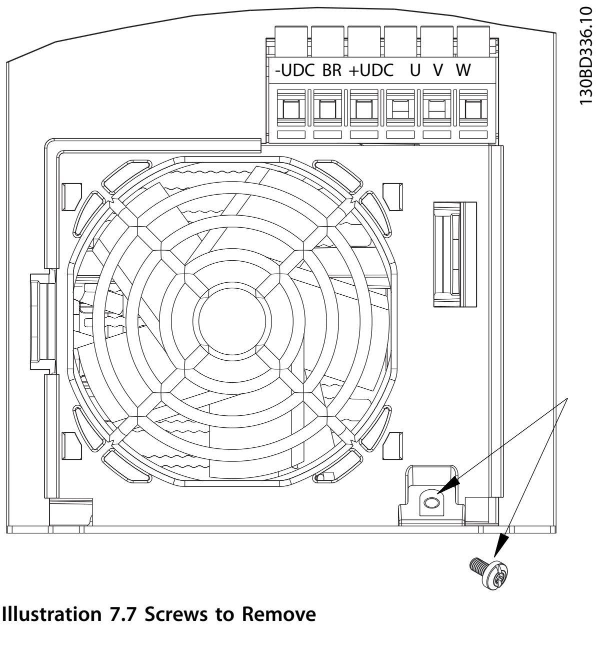


Illustration 7.7 Screws to Remove

2. Press the 2 levers on each side of the fan and pull it outwards.

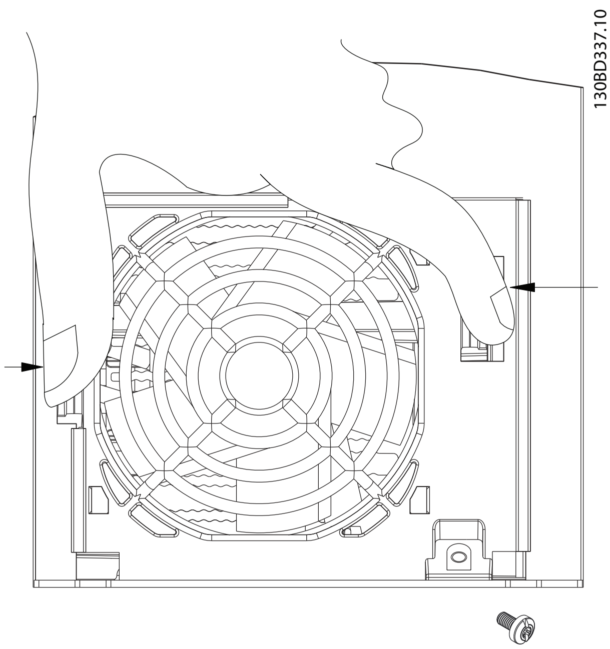


Illustration 7.8 Levers for Releasing the Fan

3. Unplug the fan cable.

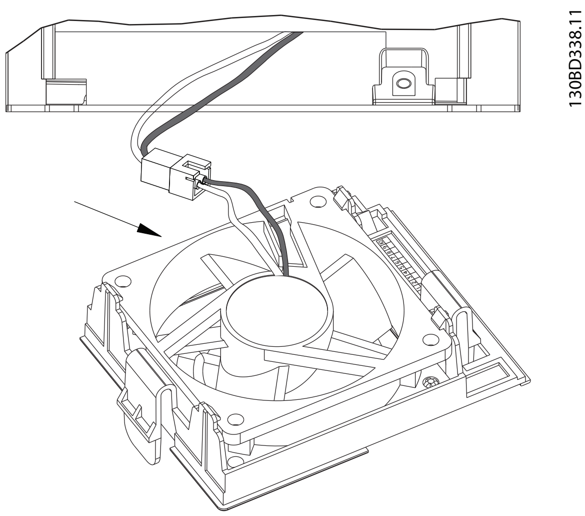


Illustration 7.9 Fan Cable Plug

NOTICE

For VLT® Midi Drive FC 280, the fan cable has 3 wires.

4. Remove the fan.
5. Install a new fan in reverse order. The reference screw torque is 0.4–0.6 Nm (3.5–5.3 in-lb).

7.4.3 Replacement Procedure for K4

1. Remove the fan from the power section by grabbing the center handle and using a flat-edged screwdriver to release the retaining lever at the plate.

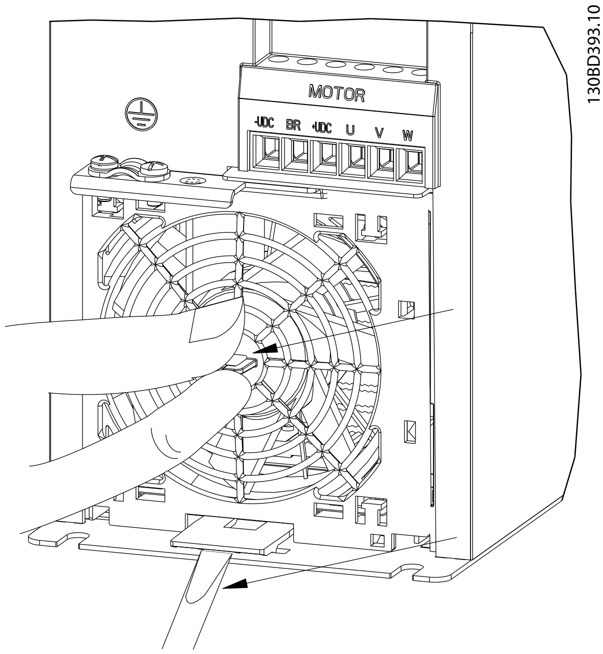


Illustration 7.10 Grabbing Center Handle and Releasing Lever

2. Unplug the fan cable.

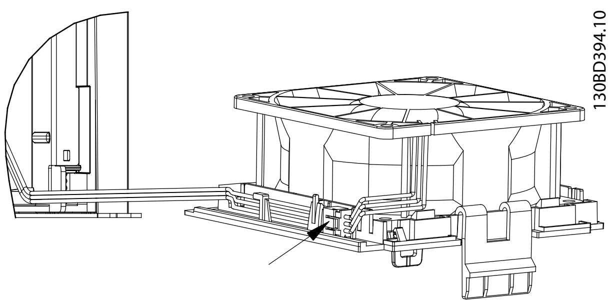


Illustration 7.11 Fan Cable Plug

3. Remove the fan.
4. Install a new fan in reverse order.

7.4.4 Replacement Procedure for K5

1. Unscrew the 2 M4x50 screws in the upper left and bottom right corners and grab the center handle to remove the fan from the power section.

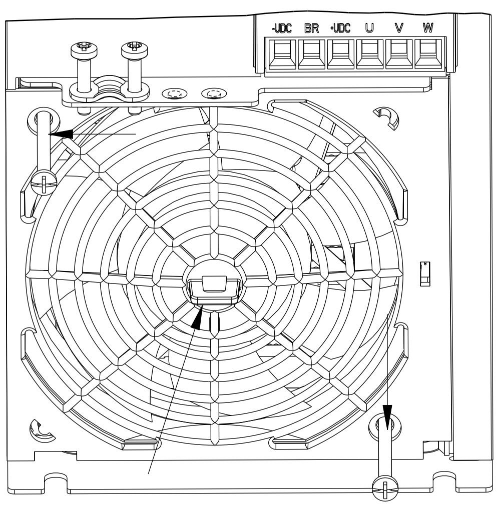


Illustration 7.12 Screws and Center Handle

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2. Unplug the fan cable.

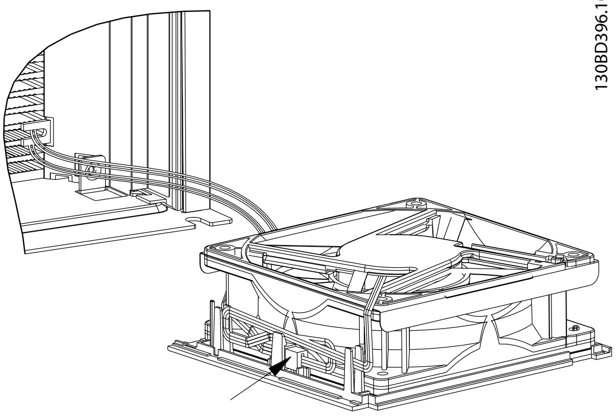

Illustration 7.13 Fan Cable Plug

NOTICE

For VLT® Midi Drive FC 280, the fan cable has 3 wires.

3. Remove the fan.
4. Install a new fan in reverse order. The reference screw torque is 0.4–0.6 Nm (3.5–5.3 in-lb).

8 Specifications

8.1 Electrical Data

Frequency converter typical shaft output [kW (hp)]	PK37 0.37 (0.5)	PK55 0.55 (0.74)	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]	0.37	0.55	0.75	1.1	1.5	2.2	3
Continuous (3x380–440 V) [A]	1.2	1.7	2.2	3	3.7	5.3	7.2
Continuous (3x441–480 V) [A]	1.1	1.6	2.1	2.8	3.4	4.8	6.3
Intermittent (60 s overload) [A]	1.9	2.7	3.5	4.8	5.9	8.5	11.5
Continuous kVA (400 V AC) [kVA]	0.9	1.2	1.5	2.1	2.6	3.7	5.0
Continuous kVA (480 V AC) [kVA]	0.9	1.3	1.7	2.5	2.8	4.0	5.2
Maximum input current							
Continuous (3x380–440 V) [A]	1.2	1.6	2.1	2.6	3.5	4.7	6.3
Continuous (3x441–480 V) [A]	1.0	1.2	1.8	2.0	2.9	3.9	4.3
Intermittent (60 s overload) [A]	1.9	2.6	3.4	4.2	5.6	7.5	10.1
More specifications							
Maximum cable cross-section (mains, motor, brake, and load sharing) [mm^2 (AWG)]	4 (12)						
Estimated power loss at rated maximum load [W][1)]	20.9	25.2	30	40	52.9	74	94.8
Weight, enclosure protection rating IP20 [kg (lb)]	2.3 (5.1)	2.3 (5.1)	2.3 (5.1)	2.3 (5.1)	2.3 (5.1)	2.5 (5.5)	3.6 (7.9)
Efficiency [%][2)]	96.0	96.6	96.8	97.2	97.0	97.5	98.0

Table 8.1 Mains Supply 3x380–480 V AC

Frequency converter typical shaft output [kW (hp)]	P4K0 4 (5.4)	P5K5 5.5 (7.4)	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	4	5.5	7.5	11	15	18.5	22
Continuous (3x380–440 V) [A]	9	12	15.5	23	31	37	42.5
Continuous (3x441–480 V) [A]	8.2	11	14	21	27	34	40
Intermittent (60 s overload) [A]	14.4	19.2	24.8	34.5	46.5	55.5	63.8
Continuous kVA (400 V AC) [kVA]	6.2	8.3	10.7	15.9	21.5	25.6	29.5
Continuous kVA (480 V AC) [kVA]	6.8	9.1	11.6	17.5	22.4	28.3	33.3
Maximum input current							
Continuous (3x380–440 V) [A]	8.3	11.2	15.1	22.1	29.9	35.2	41.5
Continuous (3x441–480 V) [A]	6.8	9.4	12.6	18.4	24.7	29.3	34.6
Intermittent (60 s overload) [A]	13.3	17.9	24.2	33.2	44.9	52.8	62.3
More specifications							
Maximum cable cross-section (mains, motor, brake, and load sharing) [mm^2 (AWG)]	4 (12)			16 (6)			
Estimated power loss at rated maximum load [W][1)]	115.5	157.5	192.8	289.5	393.4	402.8	467.5
Weight enclosure protection rating IP20 [kg (lb)]	3.6 (7.9)	3.6 (7.9)	4.1 (9.0)	9.4 (20.7)	9.5 (20.9)	12.3 (27.1)	12.5 (27.6)
Efficiency [%][2)]	98.0	97.8	97.7	98.0	98.1	98.0	98.0

Table 8.2 Mains Supply 3x380–480 V AC

Frequency converter typical shaft output [kW (hp)]	PK37 0.37 (0.5)	PK55 0.55 (0.74)	PK75 0.75 (1.0)	P1K1 1.1 (1.5)	P1K5 1.5 (2.0)	P2K2 2.2 (3.0)	P3K7 3.7 (5.0)
Enclosure protection rating IP20	K1	K1	K1	K1	K1	K2	K3
Output current							
Continuous (3x200–240 V) [A]	2.2	3.2	4.2	6	6.8	9.6	15.2
Intermittent (60 s overload) [A]	3.5	5.1	6.7	9.6	10.9	15.4	24.3
Continuous kVA (230 V AC) [kVA]	0.9	1.3	1.7	2.4	2.7	3.8	6.1
Maximum input current							
Continuous (3x200–240 V) [A]	1.8	2.7	3.4	4.7	6.3	8.8	14.3
Intermittent (60 s overload) [A]	2.9	4.3	5.4	7.5	10.1	14.1	22.9
More specifications							
Maximum cable cross-section (mains, motor, brake, and load sharing) [mm^2 (AWG)]	4 (12)						
Estimated power loss at rated maximum load [W][1)]	29.4	38.5	51.1	60.7	76.1	96.1	147.5
Weight enclosure protection rating IP20 [kg (lb)]	2.3 (5.1)	2.3 (5.1)	2.3 (5.1)	2.3 (5.1)	2.3 (5.1)	2.5 (5.5)	3.6 (7.9)
Efficiency [%][2)]	96.4	96.6	96.3	96.6	96.5	96.7	96.7

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Table 8.3 Mains Supply 3x200–240 V AC

Frequency converter typical shaft output [kW (hp)]	PK37 0.37 (0.5)	PK55 0.55 (0.74)	PK75 0.75 (1.0)	P1K1 1.1 (1.5)	P1K5 1.5 (2.0)	P2K2 2.2 (3.0)
Enclosure protection rating IP20	K1	K1	K1	K1	K1	K2
Output current						
Continuous (1x200–240 V) [A]	2.2	3.2	4.2	6	6.8	9.6
Intermittent (60 s overload) [A]	3.5	5.1	6.7	9.6	10.9	15.4
Continuous kVA (230 V AC) [kVA]	0.9	1.3	1.7	2.4	2.7	3.8
Maximum input current						
Continuous (1x200–240 V) [A]	2.9	4.4	5.5	7.7	10.4	14.4
Intermittent (60 s overload) [A]	4.6	7.0	8.8	12.3	16.6	23.0
More specifications						
Maximum cable cross-section (mains, motor, brake, and load sharing) [mm^2 (AWG)]	4 (12)					
Estimated power loss at rated maximum load [W][1)]	37.7	46.2	56.2	76.8	97.5	121.6
Weight enclosure protection rating IP20 [kg (lb)]	2.3 (5.1)	2.3 (5.1)	2.3 (5.1)	2.3 (5.1)	2.3 (5.1)	2.5 (5.5)
Efficiency [%][2)]	94.4	95.1	95.1	95.3	95.0	95.4

Table 8.4 Mains Supply 1x200–240 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 frequency converter, and motors with high efficiency reduce power loss.
Applies to dimensioning of frequency converter cooling. If the switching frequency is higher than the default setting, the power losses sometimes rise. LCP and typical control card power consumptions are included. Further options and customer load sometimes add up to 30 W to the losses (though typically only 4 W extra for a fully loaded control card or fieldbus).
For power loss data according to EN 50598-2, refer to 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 8.4 Ambient Conditions. For part load losses, see www.danfoss.com/vltenergyefficiency.

8.2 Mains Supply

Mains supply (L1/N, L2/L, L3)	
Supply terminals	(L1/N, L2/L, L3)
Supply voltage	380–480 V: -15% (-25%)[1] to +10%
Supply voltage	200–240 V: -15% (-25%)[1] to +10%

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

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

8.3 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. It is 150% for 11–22 kW (15–30 hp) frequency converters.

8.4 Ambient Conditions

Ambient conditions	
Enclosure protection rating, frequency converter	IP20
Enclosure protection rating, conversion kit	IP21/Type 1
Vibration test, all enclosure sizes	1.14 g
Relative humidity	5–95% (IEC 721-3-3; Class 3K3 (non-condensing) during operation)
Ambient temperature (at DPWM switching mode)	
- with derating	Maximum 55 °C (131 °F)[1)2)3)]
- at full constant output current	Maximum 45 °C (113 °F)[4)]
Minimum ambient temperature during full-scale operation	0 °C (32 °F)
Minimum ambient temperature at reduced performance	-10 °C (14 °F)
Temperature during storage/transport	-25 to +65/70 °C (-13 to +149/158 °F)
Maximum altitude above sea level without derating	1000 m (3280 ft)
Maximum altitude above sea level with derating	3000 m (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[5)]	IE2

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

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

2) To prevent control card overtemperature on PROFIBUS, PROFINET, and EtherNet/IP variants of VLT® Midi Drive FC 280, avoid full digital/analog I/O load at ambient temperature higher than 45 °C (113 °F).
3) Ambient temperature for K1S2 with derating is maximun 50 °C (122 °F).
4) Ambient temperature for K1S2 at full constant output current is maximun 40 °C (104 °F).
5) Determined according to EN 50598-2 at:

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

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8.5 Cable Specifications

Cable lengths and cross-sections[1]	
Maximum motor cable length, shielded	50 m (164 ft)
Maximum motor cable length, unshielded	75 m (246 ft)
Maximum cross-section of control terminals, flexible/rigid wire	2.5 mm^2/14 AWG
Minimum cross-section of control terminals	0.55 mm^2/30 AWG
Maximum STO input cable length, unshielded	20 m (66 ft)

1) For power cables, see Table 8.1, Table 8.2, Table 8.3 and Table 8.4.

8.6 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 range	4–32 kHz
(Duty cycle) minimum pulse width	4.5 ms
Input resistance, R_i	Approximately 4 kΩ

1) Terminal 27 can also be programmed as output.

STO inputs	
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

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.

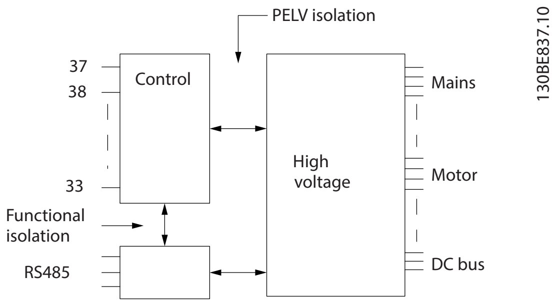

Illustration 8.1 Galvanic Isolation

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NOTICE

HIGH ALTITUDE

For installation at altitudes above 2000 m (6562 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	Maximum error: 0.1% 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.

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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 earth. Use only an isolated laptop as PC connection to the USB connector on the frequency converter.

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.

8.7 Fuse Specifications

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 frequency converter (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 8.5 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 and damage to the frequency converter and other equipment.

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

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 frequency converter.

Danfoss recommends using the fuses and circuit breakers in *Table 8.5* to ensure compliance with UL 508C or IEC 61800-5-1. For non-UL applications, design circuit breakers for protection in a circuit capable of delivering a maximum of 50000 A_{rms} (symmetrical), 240 V/400 V maximum. The frequency converter short-circuit current rating (SCCR) is suitable for use on a circuit capable of delivering not more than 100000 A_{rms}, 240 V/480 V maximum when protected by T-Class fuses.

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<table>
<tr><th colspan="2">Enclosure size</th><th>Power [kW (hp)]</th><th>Non-UL fuse</th><th>Non-UL circuit breaker (Eaton)</th><th>UL fuse (Bussmann, class T)</th></tr>
<tr><td rowspan="8">3-phase 380–480 V</td><td rowspan="4">K1</td><td>0.37 (0.5)</td><td rowspan="2">gG-10</td><td rowspan="4">PKZM0-16</td><td rowspan="2">JJS-6</td></tr>
<tr><td>0.55–0.75 (0.74–1.0)</td></tr>
<tr><td>1.1–1.5 (1.48–2.0)</td><td rowspan="2">gG-20</td><td>JJS-10</td></tr>
<tr><td>2.2 (3.0)</td><td>JJS-15</td></tr>
<tr><td>K2</td><td>3.0–5.5 (4.0–7.5)</td><td rowspan="2">gG-25</td><td>PKZM0-20</td><td rowspan="2">JJS-25</td></tr>
<tr><td>K3</td><td>7.5 (10)</td><td>PKZM0-25</td></tr>
<tr><td>K4</td><td>11–15 (15–20)</td><td>gG-50</td><td>–</td><td>JJS-50</td></tr>
<tr><td>K5</td><td>18.5–22 (25–30)</td><td>gG-80</td><td>–</td><td>JJS-80</td></tr>
<tr><td rowspan="7">3-phase 200–240 V</td><td rowspan="5">K1</td><td>0.37 (0.5)</td><td>gG-10</td><td rowspan="5">PKZM0-16</td><td>JJN-6</td></tr>
<tr><td>0.55 (0.74)</td><td rowspan="4">gG-20</td><td>JJN-10</td></tr>
<tr><td>0.75 (1.0)</td><td>JJN-15</td></tr>
<tr><td>1.1 (1.48)</td><td rowspan="2">JJN-20</td></tr>
<tr><td>1.5 (2.0)</td></tr>
<tr><td>K2</td><td>2.2 (3.0)</td><td rowspan="2">gG-25</td><td>PKZM0-20</td><td rowspan="2">JJN-25</td></tr>
<tr><td>K3</td><td>3.7 (5.0)</td><td>PKZM0-25</td></tr>
<tr><td rowspan="6">Single-phase 200–240 V</td><td rowspan="5">K1</td><td>0.37 (0.5)</td><td>gG-10</td><td rowspan="5">PKZM0-16</td><td>JJN-6</td></tr>
<tr><td>0.55 (0.74)</td><td rowspan="4">gG-20</td><td>JJN-10</td></tr>
<tr><td>0.75 (1.0)</td><td>JJN-15</td></tr>
<tr><td>1.1 (1.48)</td><td rowspan="2">JJN-20</td></tr>
<tr><td>1.5 (2.0)</td></tr>
<tr><td>K2</td><td>2.2 (3.0)</td><td>gG-25</td><td>PKZM0-20</td><td>JJN-25</td></tr>
</table>

Table 8.5 Fuse and Circuit Breaker

8.8 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)]					
		Mains	Motor	DC connection	Brake	Ground	Control/relay
K1	0.37–2.2 (0.5–3.0)	0.8 (7.1)	0.8 (7.1)	0.8 (7.1)	0.8 (7.1)	1.6 (14.2)	0.5 (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 8.6 Tightening Torques

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