ENGINEERING TOMORROW

Quick Guide
VLT® HVAC Basic Drive FC 111

vlt-drives.danfoss.com

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1 Introduction

1.1 Purpose of the Quick Guide

The quick guide provides information for safe installation and commissioning of the frequency converter.

The quick guide is intended for use by qualified personnel. Read and follow the quick guide to use the frequency converter safely and professionally, and pay particular attention to the safety instructions and general warnings. Keep this quick guide available with the frequency converter.
VLT® is a registered trademark.

1.2 Additional Resources

- *VLT® HVAC Basic Drive FC 101 Programming Guide* provides information on how to program and includes complete parameter descriptions.
- *VLT® HVAC Basic Drive FC 101 Design Guide* provides all technical information about the frequency converter, customer design, and applications. It also lists options and accessories.

The technical documentation is available in electronic form online at *drives.danfoss.com/knowledge-center/technical-documentation/*.

MCT 10 Set-up Software Support
Download the software from *www.danfoss.com/BusinessAreas/DrivesSolutions/Software+MCT10/MCT10+Downloads.htm*.

During the installation process of the software, enter access code 81462700 to activate the VLT® HVAC Basic Drive FC 111 functionality. A licence key is not required for using the VLT® HVAC Basic Drive FC 111 functionality.

The latest software does not always contain the latest updates for frequency converters. Contact the local sales office for the latest frequency converter updates (in the form of *.OSS files).

1.3 Manual and Software Version

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

Edition	Remarks	Software version
MG18F6xx	Update due to new SW & HW version.	4.0x

From software version 4.0x and later (production week 33 2017 and after), the variable speed heat sink cooling fan function is implemented in the frequency converter for power sizes 22 kW (30 hp) 400 V IP20 and below, and 18.5 kW (25 hp) 400 V IP54 and below. This function requires software and hardware updates and introduces restrictions with regards to backwards compatibility for H1–H5 and I2–I4 enclosure sizes. Refer to *Table 1.1* for the limitations.

Software compatibility	**Old control card (production week 31 2017 or before)**	**New control card (production week 33 2017 or after)**
Old software (OSS-file version 3.xx and below)	Yes	No
New software (OSS-file version 4.xx or higher)	No	Yes
Hardware compatibility	**Old control card (production week 31 2017 or before)**	**New control card (production week 33 2017 or after)**
Old power card (production week 31 2017 or before)	Yes (only software version 3.xx or below)	Yes (MUST update software to version 4.xx or higher)
New power card (production week 33 2017 or after)	Yes (MUST update software to version 3.xx or below, the fan continuously runs at full speed)	Yes (only software version 4.xx or higher)

Table 1.1 Software and Hardware Compatibility

1.4 Disposal

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

2 Safety

2

2.1 Safety Symbols

The following symbols are used in this document:

⚠WARNING

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

⚠CAUTION

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

NOTICE

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

2.2 Qualified Personnel

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

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

2.3 Safety Precautions

⚠WARNING

HIGH VOLTAGE

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

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

⚠WARNING

UNINTENDED START

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

- **Disconnect the frequency converter from the mains.**
- **Press [Off/Reset] on the LCP before programming parameters.**
- **Ensure that the frequency converter is fully wired and assembled when it is connected 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 power 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 duration of 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)
3x400	0.37–7.5 (0.5–10)	4
3x400	11–90 (15–125)	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 manual.**

⚠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.**

2.4 Motor Thermal Protection

Set *parameter 1-90 Motor Thermal Protection* to *[4] ETR trip 1* to enable the motor thermal protection function.

3 Installation

3.1 Mechanical Installation

3

3.1.1 Side-by-side Installation

The frequency converter can be mounted side by side but requires clearance above and below for cooling, see *Table 3.1*.

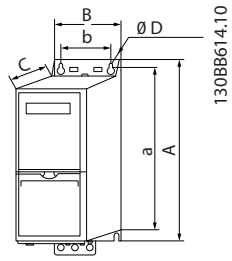
		Power [kW (hp)]	Clearance above/ below [mm (in)]
Size	IP class	3x380–480 V	
H1	IP20	0.37–1.5 (0.5–2)	100 (4)
H2	IP20	2.2–4 (3–5)	100 (4)
H3	IP20	5.5–7.5 (7.5–10)	100 (4)
H4	IP20	11–15 (15–20)	100 (4)
H5	IP20	18.5–22 (25–30)	100 (4)
H6	IP20	30–45 (40–60)	200 (7.9)
H7	IP20	55–75 (70–100)	200 (7.9)
H8	IP20	90 (125)	225 (8.9)

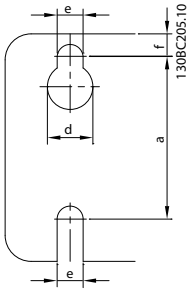
Table 3.1 Clearance Required for Cooling

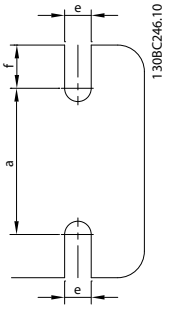
NOTICE

When the IP21/NEMA Type1 option kit is mounted, ensure a distance of 50 mm (2 in) between the units.

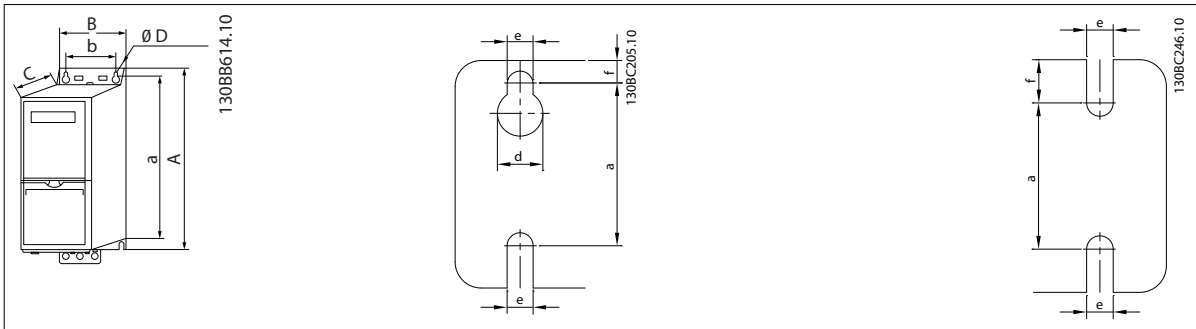
3.1.2 Frequency Converter Dimensions







Enclosure		Power [kW (hp)]	Height [mm (in)]			Width [mm (in)]		Depth [mm (in)]	Mounting hole [mm (in)]			Maximum weight
Size	IP class	3x380–480 V	A	A[1)]	a	B	b	C	d	e	f	kg (lb)
H1	IP20	0.37–1.5 (0.5–2)	195 (7.7)	273 (10.7)	183 (7.2)	75 (3.0)	56 (2.2)	168 (6.6)	9 (0.35)	4.5 (0.18)	5.3 (0.21)	2.1 (4.6)
H2	IP20	2.2–4.0 (3–5)	227 (8.9)	303 (11.9)	212 (8.3)	90 (3.5)	65 (2.6)	190 (7.5)	11 (0.43)	5.5 (0.22)	7.4 (0.29)	3.4 (7.5)
H3	IP20	5.5–7.5 (7.5–10)	255 (10.0)	329 (13.0)	240 (9.4)	100 (3.9)	74 (2.9)	206 (8.1)	11 (0.43)	5.5 (0.22)	8.1 (0.32)	4.5 (9.9)
H4	IP20	11–15 (15–20)	296 (11.7)	359 (14.1)	275 (10.8)	135 (5.3)	105 (4.1)	241 (9.5)	12.6 (0.50)	7 (0.28)	8.4 (0.33)	7.9 (17.4)
H5	IP20	18.5–22 (25–30)	334 (13.1)	402 (15.8)	314 (12.4)	150 (5.9)	120 (4.7)	255 (10)	12.6 (0.50)	7 (0.28)	8.5 (0.33)	9.5 (20.9)
H6	IP20	30–45 (40–60)	518 (20.4)	595 (23.4)/635 (25) (45 kW)	495 (19.5)	239 (9.4)	200 (7.9)	242 (9.5)	–	8.5 (0.33)	15 (0.6)	24.5 (54)



Enclosure		Power [kW (hp)]	Height [mm (in)]			Width [mm (in)]		Depth [mm (in)]	Mounting hole [mm (in)]			Maximum weight
Size	IP class	3x380–480 V	A	A[1)]	a	B	b	C	d	e	f	kg (lb)
H7	IP20	55–75 (70–100)	550 (21.7)	630 (24.8)/690 (27.2) (75 kW)	521 (20.5)	313 (12.3)	270 (10.6)	335 (13.2)	–	8.5 (0.33)	17 (0.67)	36 (79)
H8	IP20	90 (125)	660 (26)	800 (31.5)	631 (24.8)	375 (14.8)	330 (13)	335 (13.2)	–	8.5 (0.33)	17 (0.67)	51 (112)

1) Including decoupling plate

The dimensions are only for the physical units.

NOTICE

When installing in an application, allow space above and below the units for cooling. The amount of space for free air passage is listed in *Table 3.1*.

Table 3.2 Dimensions, Enclosure Sizes H1–H8

3.2 Electrical Installation

3.2.1 Electrical Installation in General

All cabling must comply with national and local regulations on cable cross-sections and ambient temperature. Copper conductors are required. 75 °C (167 °F) is recommended.

Power [kW (hp)]			Torque [Nm (in-lb)]					
Enclosure size	IP class	3x380–480 V	Mains	Motor	DC connection	Control terminals	Ground	Relay
H1	IP20	0.37–1.5 (0.5–2)	0.8 (7)	0.8 (7)	0.8 (7)	0.5 (4)	0.8 (7)	0.5 (4)
H2	IP20	2.2–4.0 (3–5)	0.8 (7)	0.8 (7)	0.8 (7)	0.5 (4)	0.8 (7)	0.5 (4)
H3	IP20	5.5–7.5 (7.5–10)	0.8 (7)	0.8 (7)	0.8 (7)	0.5 (4)	0.8 (7)	0.5 (4)
H4	IP20	11–15 (15–20)	1.2 (11)	1.2 (11)	1.2 (11)	0.5 (4)	0.8 (7)	0.5 (4)
H5	IP20	18.5–22 (25–30)	1.2 (11)	1.2 (11)	1.2 (11)	0.5 (4)	0.8 (7)	0.5 (4)
H6	IP20	30–45 (40–60)	4.5 (40)	4.5 (40)	–	0.5 (4)	3 (27)	0.5 (4)
H7	IP20	55 (70)	10 (89)	10 (89)	–	0.5 (4)	3 (27)	0.5 (4)
H7	IP20	75 (100)	14 (124)	14 (124)	–	0.5 (4)	3 (27)	0.5 (4)
H8	IP20	90 (125)	24 (212)[1)]	24 (212)[1)]	–	0.5 (4)	3 (27)	0.5 (4)

Table 3.3 Tightening Torques for Enclosure Sizes H1–H8, 3x380–480 V

1) Cable dimensions >95 mm²

3

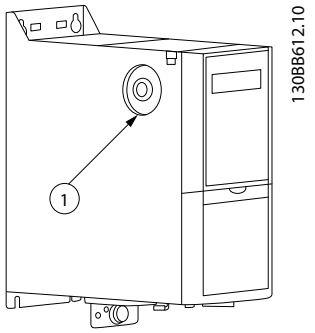
3.2.2 IT Mains

⚠CAUTION

IT Mains

Installation on isolated mains source, that is, IT mains. Ensure that the supply voltage does not exceed 440 V (3x380–480 V units) when connected to mains.

For 380–480 V, IP20, 0.37–22 kW (0.5–30 hp) units, open the RFI switch by removing the screw on the side of the frequency converter when at IT grid.



1	EMC screw

Illustration 3.1 IP20, 0.37–22 kW (0.5–30 hp), 380–480 V

For 380–480 V, 30–90 kW (40–125 hp) units, set *parameter 14-50 RFI Filter* to *[0] Off* when operating in IT mains.

NOTICE

If reinserted, use only M3x12 screw.

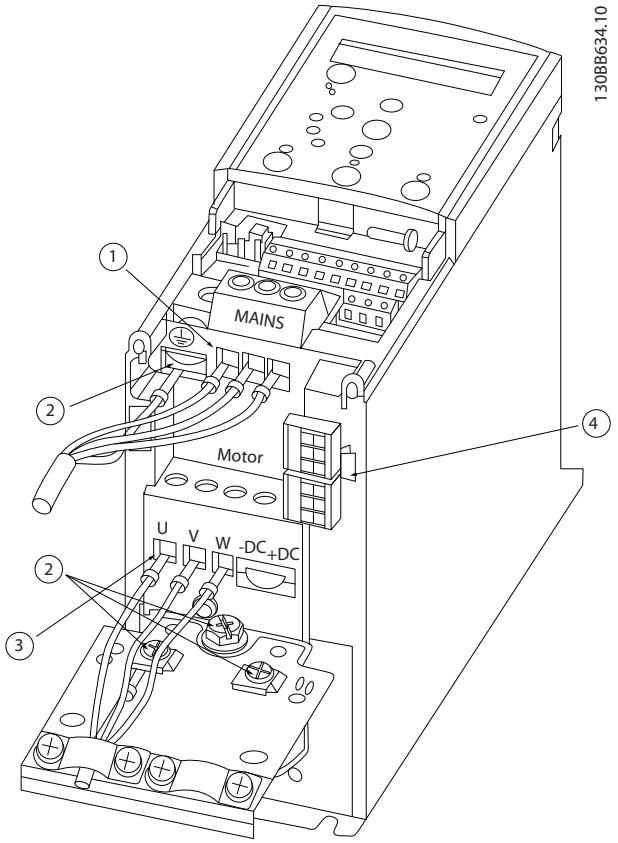
3.2.3 Connecting to Mains and Motor

The frequency converter is designed to operate all standard 3-phase asynchronous motors. For maximum cross-section on cables, see *chapter 7.4 General Technical Data*.

- Use a shielded/armored motor cable to comply with EMC emission specifications, and connect this cable to both the decoupling plate and the motor.
- Keep the motor cable as short as possible to reduce the noise level and leakage currents.
- For further details on mounting the decoupling plate, see *VLT® HVAC Basic Drive FC 101 Decoupling Plate Mounting Instruction*.
- Also see *chapter 3.2.5 EMC-correct Electrical Installation*.

1. Mount the ground cables to the ground terminal.
2. Connect the motor to terminals U, V, and W, and tighten the screws according to the torques specified in *chapter 3.2.1 Electrical Installation in General*.
3. Connect the mains supply to terminals L1, L2, and L3, and tighten the screws according to the torques specified in *chapter 3.2.1 Electrical Installation in General*.

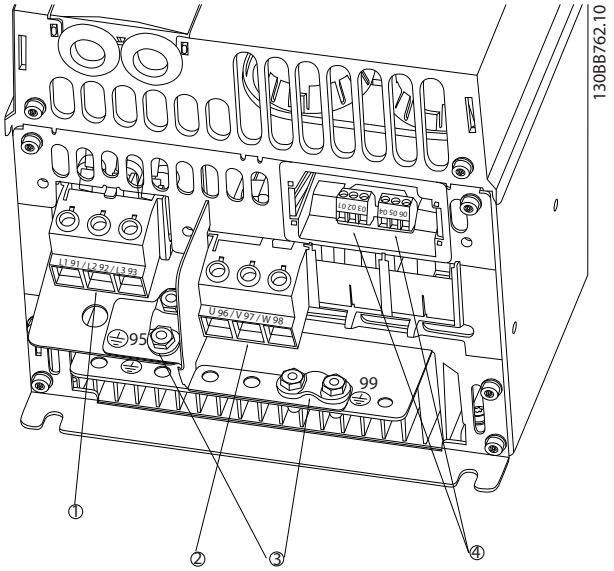
Relays and terminals on enclosure sizes H1–H5



1	Mains
2	Ground
3	Motor
4	Relays

Illustration 3.2 Enclosure Sizes H1–H5
IP20, 380–480 V, 0.37–22 kW (0.5–30 hp)

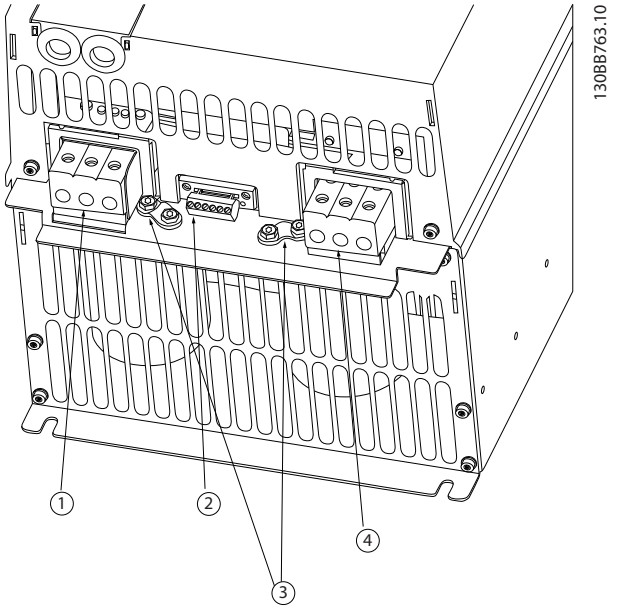
Relays and terminals on enclosure size H6



1	Mains
2	Motor
3	Ground
4	Relays

Illustration 3.3 Enclosure Size H6
IP20, 380–480 V, 30–45 kW (40–60 hp)

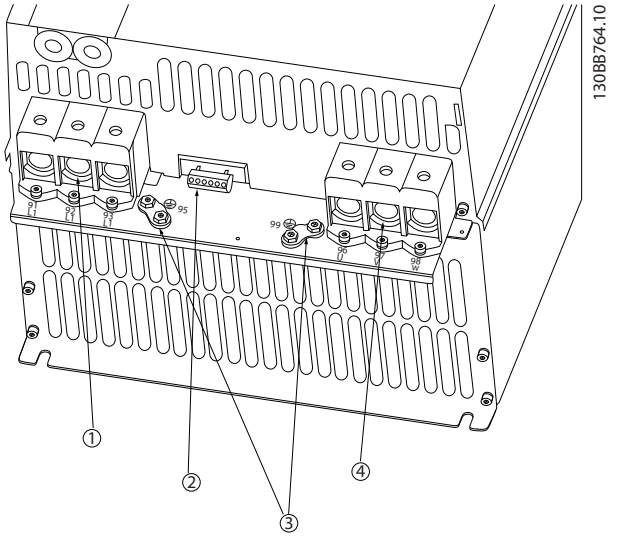
Relays and terminals on enclosure size H7



1	Mains
2	Relays
3	Ground
4	Motor

Illustration 3.4 Enclosure Size H7
IP20, 380–480 V, 55–75 kW (70–100 hp)

Relays and terminals on enclosure size H8



1	Mains
2	Relays
3	Ground
4	Motor

Illustration 3.5 Enclosure Size H8
IP20, 380–480 V, 90 kW (125 hp)

3.2.4 Fuses and Circuit Breakers

Branch circuit protection
To prevent fire hazards, protect the branch circuits in an installation - switch gear, machines, and so on - against short circuits and overcurrent. Follow national and local regulations.

Short-circuit protection
To protect service personnel and equipment if an internal failure in the unit or a short circuit on the DC-link occurs, Danfoss recommends using the fuses and circuit breakers listed in *Table 3.4*. The frequency converter provides full protection against short circuit on the motor.

Overcurrent protection
Provide overload protection to avoid overheating of the cables in the installation. Carry out overcurrent protection according to local and national regulations. Design circuit breakers and fuses for protection in a circuit capable of supplying a maximum of 100000 A_{rms} (symmetrical), 480 V maximum.

UL/non-UL compliance
Use the circuit breakers or fuses listed in *Table 3.4* to ensure compliance with UL or IEC 61800-5-1.
Design circuit breakers for protection in a circuit capable of supplying a maximum of 10000 A_{rms} (symmetrical), 480 V maximum.

NOTICE

If malfunction occurs, failure to follow the protection recommendation may result in damage to the frequency converter.

	Circuit breaker		Fuse				
	UL	Non-UL	UL				Non-UL
			Bussmann	Bussmann	Bussmann	Bussmann	Maximum fuse
Power [kW(hp)]	–		Type RK5	Type RK1	Type J	Type T	Type G
3x380–480 V IP20							
0.37 (0.5)	–	–	FRS-R-10	KTS-R10	JKS-10	JJS-10	10
0.75 (1)			FRS-R-10	KTS-R10	JKS-10	JJS-10	10
1.5 (2)			FRS-R-10	KTS-R10	JKS-10	JJS-10	10
2.2 (3)			FRS-R-15	KTS-R15	JKS-15	JJS-15	16
3 (4)			FRS-R-15	KTS-R15	JKS-15	JJS-15	16
4 (5)			FRS-R-15	KTS-R15	JKS-15	JJS-15	16
5.5 (7.5)			FRS-R-25	KTS-R25	JKS-25	JJS-25	25
7.5 (10)			FRS-R-25	KTS-R25	JKS-25	JJS-25	25
11 (15)			FRS-R-50	KTS-R50	JKS-50	JJS-50	50
15 (20)			FRS-R-50	KTS-R50	JKS-50	JJS-50	50
18.5 (25)			FRS-R-80	KTS-R80	JKS-80	JJS-80	65
22 (30)			FRS-R-80	KTS-R80	JKS-80	JJS-80	65
30 (40)	Cutler-Hammer EGE3125FFG	Moeller NZMB1-A125	FRS-R-125	KTS-R125	JKS-R125	JJS-R125	80
37 (50)			FRS-R-125	KTS-R125	JKS-R125	JJS-R125	100
45 (60)			FRS-R-125	KTS-R125	JKS-R125	JJS-R125	125
55 (70)	Cutler-Hammer JGE3200FFG	Moeller NZMB1-A200	FRS-R-200	KTS-R200	JKS-R200	JJS-R200	150
75 (100)			FRS-R-200	KTS-R200	JKS-R200	JJS-R200	200
90 (125)	Cutler-Hammer JGE3250FFG	Moeller NZMB2-A250	FRS-R-250	KTS-R250	JKS-R250	JJS-R250	250

Table 3.4 Circuit Breakers and Fuses

3.2.5 EMC-correct Electrical Installation

General points to be observed to ensure EMC-correct electrical installation:

- Use only shielded/armored motor cables and shielded/armored control cables.
- Ground the shield at both ends.
- Avoid installation with twisted shield ends (pigtails), because it reduces the shielding effect at high frequencies. Use the cable clamps provided.
- Ensure the same potential between the frequency converter and the ground potential of PLC.
- Use star washers and galvanically conductive installation plates.

3

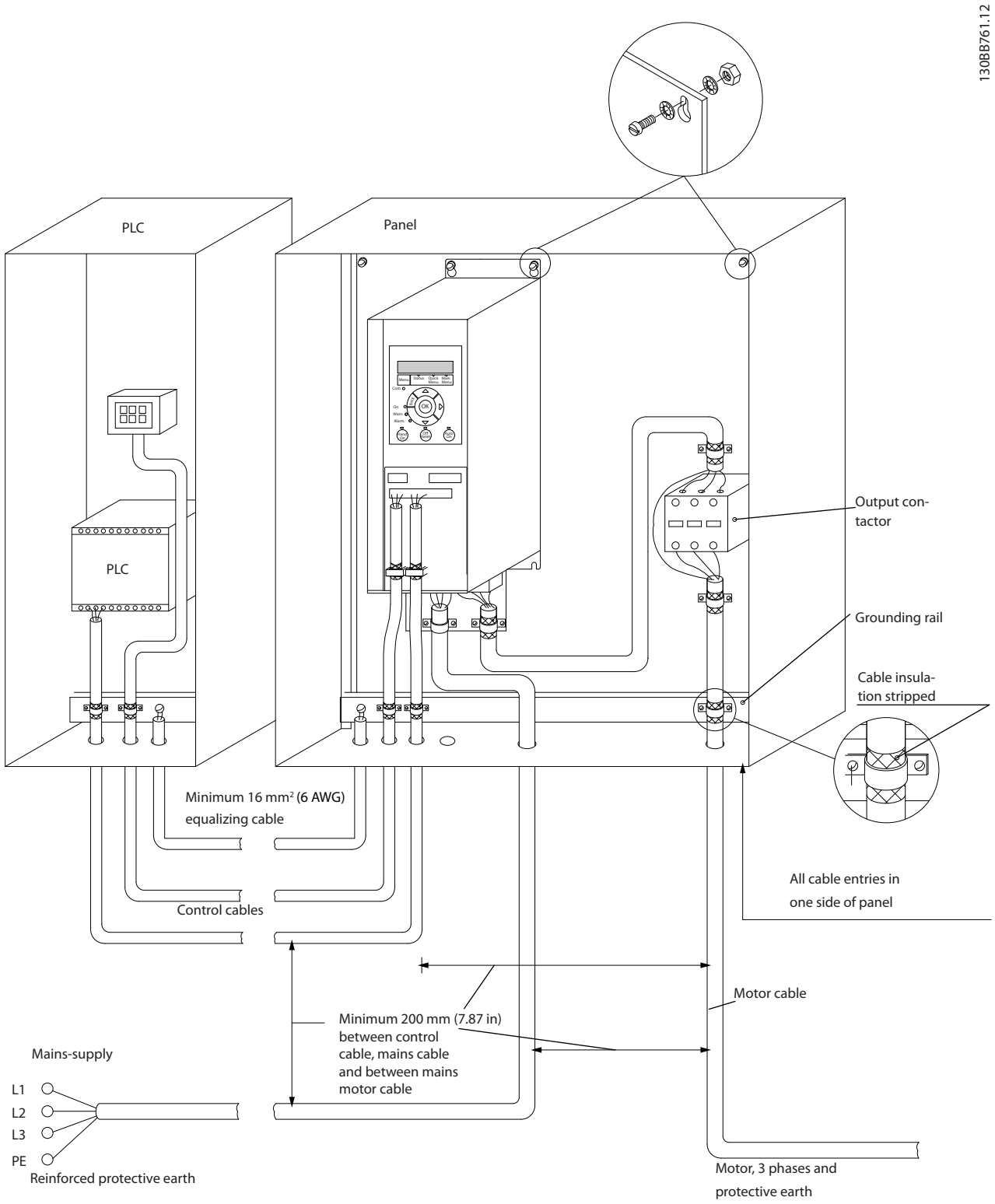


Illustration 3.6 EMC-correct Electrical Installation

3.2.6 Control Terminals

Remove the terminal cover to access the control terminals.

Use a flat-edged screwdriver to push down the lock lever of the terminal cover under the LCP, then remove the terminal cover, as shown in *Illustration 3.7*.

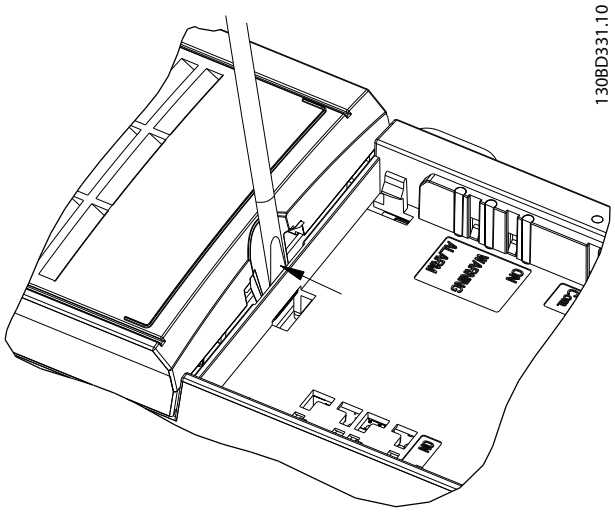


Illustration 3.7 Removing the Terminal Cover

Illustration 3.8 shows all the frequency converter control terminals. Applying start (terminal 18), connection between terminals 12–27, and an analog reference (terminal 53 or 54 and terminal 55) make the frequency converter run.

The digital input mode of terminal 18, 19, and 27 is set in *parameter 5-00 Digital Input Mode* (PNP is default value). The digital input mode for terminal 29 is set in *parameter 5-03 Digital Input 29 Mode* (PNP is default value).

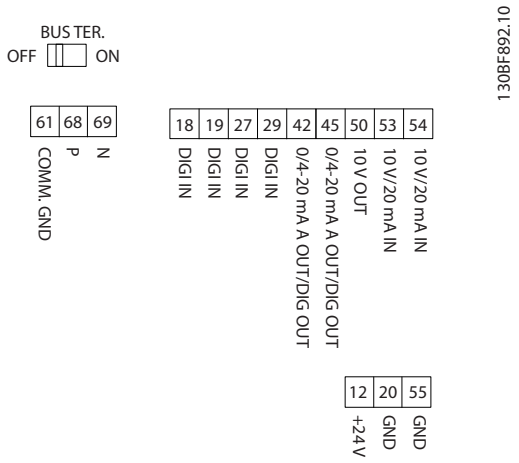


Illustration 3.8 Control Terminals

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3.2.7 Electrical Wiring

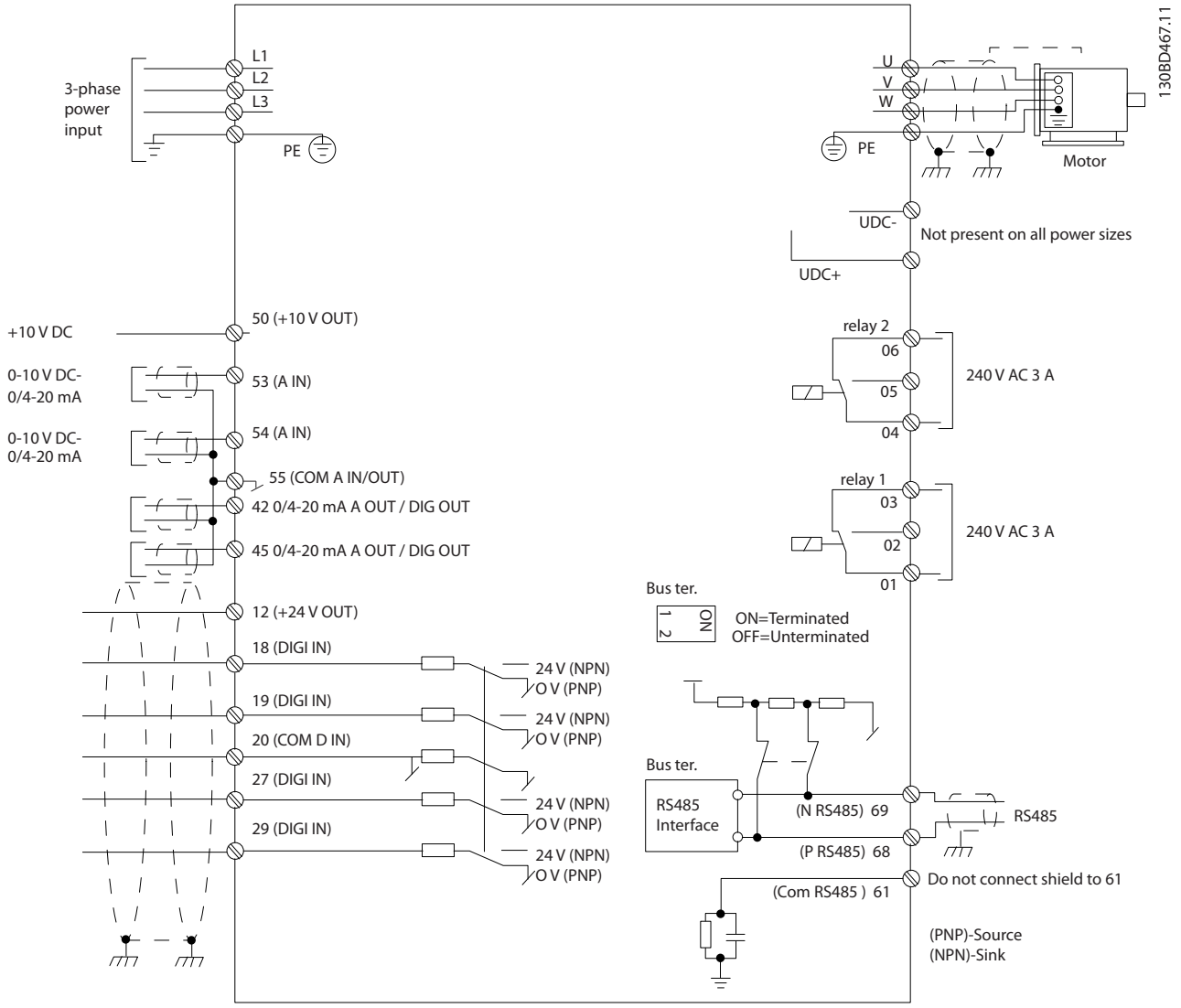

Illustration 3.9 Basic Wiring Schematic Drawing

NOTICE

There is no access to UDC- and UDC+ on the following units:

- **IP20, 380–480 V, 30–90 kW (40–125 hp)**

3.2.8 Acoustic Noise or Vibration

If the motor or the equipment driven by the motor - for example, a fan - is making noise or vibrations at certain frequencies, configure the following parameters or parameter groups to reduce or eliminate the noise or vibrations:

- *Parameter group 4-6* Speed Bypass*.
- Set *parameter 14-03 Overmodulation* to *[0] Off*.
- Switching pattern and switching frequency *parameter group 14-0* Inverter Switching*.
- *Parameter 1-64 Resonance Dampening*.

4 Programming

4.1 Local Control Panel (LCP)

The frequency converter can be programmed from the LCP or from a PC via the RS485 COM port by installing the MCT 10 Set-up Software. Refer to *chapter 1.2 Additional Resources* for more details about the software.

The LCP is divided into 4 functional sections.

A. Display

B. Menu key

C. Navigation keys and indicator lights

D. Operation keys and indicator lights

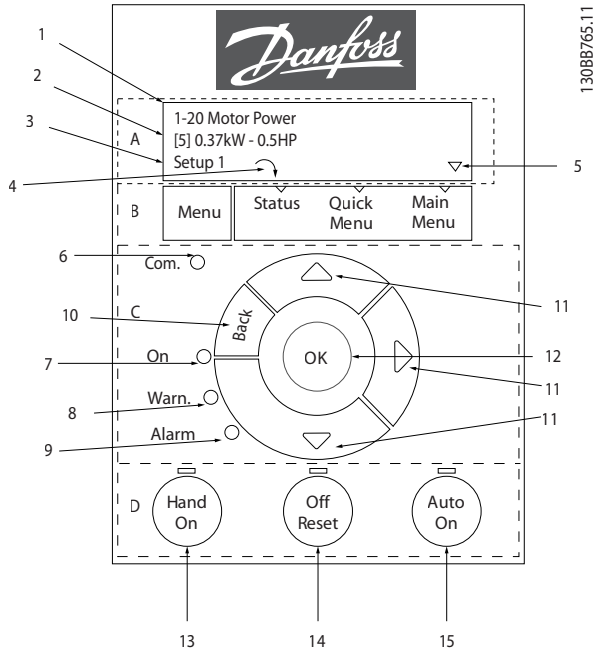

Illustration 4.1 Local Control Panel (LCP)

A. Display

The LCD-display is illuminated with 2 alphanumeric lines. All data is shown on the LCP.

Illustration 4.1 describes the information that can be read from the display.

1	Parameter number and name.
2	Parameter value.
3	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 (set-up 12). The number flashing, indicates the edit set-up.
4	Motor direction is shown to the bottom left of the display – indicated by a small arrow pointing either clockwise or counterclockwise.
5	The triangle indicates if the LCP is in Status, Quick Menu, or Main Menu.

Table 4.1 Legend to *Illustration 4.1*, Part I

B. Menu key

Press [Menu] to select among Status, Quick Menu, or Main Menu.

C. Navigation keys and indicator lights

6	Com. LED: Flashes during bus communication.
7	Green LED/On: Control section is working correctly.
8	Yellow LED/Warn.: Indicates a warning.
9	Flashing Red LED/Alarm: Indicates an alarm.
10	[Back]: For moving to the previous step or layer in the navigation structure.
11	[▲] [▼] [►]: For navigating among parameter groups and parameters, and within parameters. They can also be used for setting local reference.
12	[OK]: For selecting a parameter and for accepting changes to parameter settings.

Table 4.2 Legend to *Illustration 4.1*, Part II

D. Operation keys and indicator lights

13	[Hand On]: Starts the motor and enables control of the frequency converter via the LCP. ***NOTICE*** ***[2] Coast inverse* is the default option for *parameter 5-12 Terminal 27 Digital Input*. If there is no 24 V supply to terminal 27, [Hand On] does not start the motor. Connect terminal 12 to terminal 27.**
14	[Off/Reset]: Stops the motor (Off). If in alarm mode, the alarm is reset.
15	[Auto On]: The frequency converter is controlled either via control terminals or serial communication.

Table 4.3 Legend to *Illustration 4.1*, Part III

4.2 Set-up Wizard

The built-in wizard menu guides the installer through the set-up of the frequency converter in a clear and structured manner for open-loop applications, closed-loop applications, and quick motor settings.

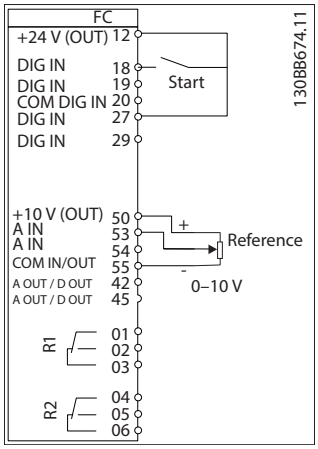

Illustration 4.2 Frequency Converter Wiring

The wizard is shown after power-up until any parameter has been changed. The wizard can always be accessed again through the quick menu. Press [OK] to start the wizard. Press [Back] to return to the status view.

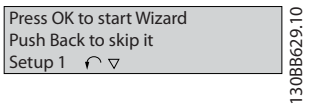

Illustration 4.3 Start-up/Quit Wizard

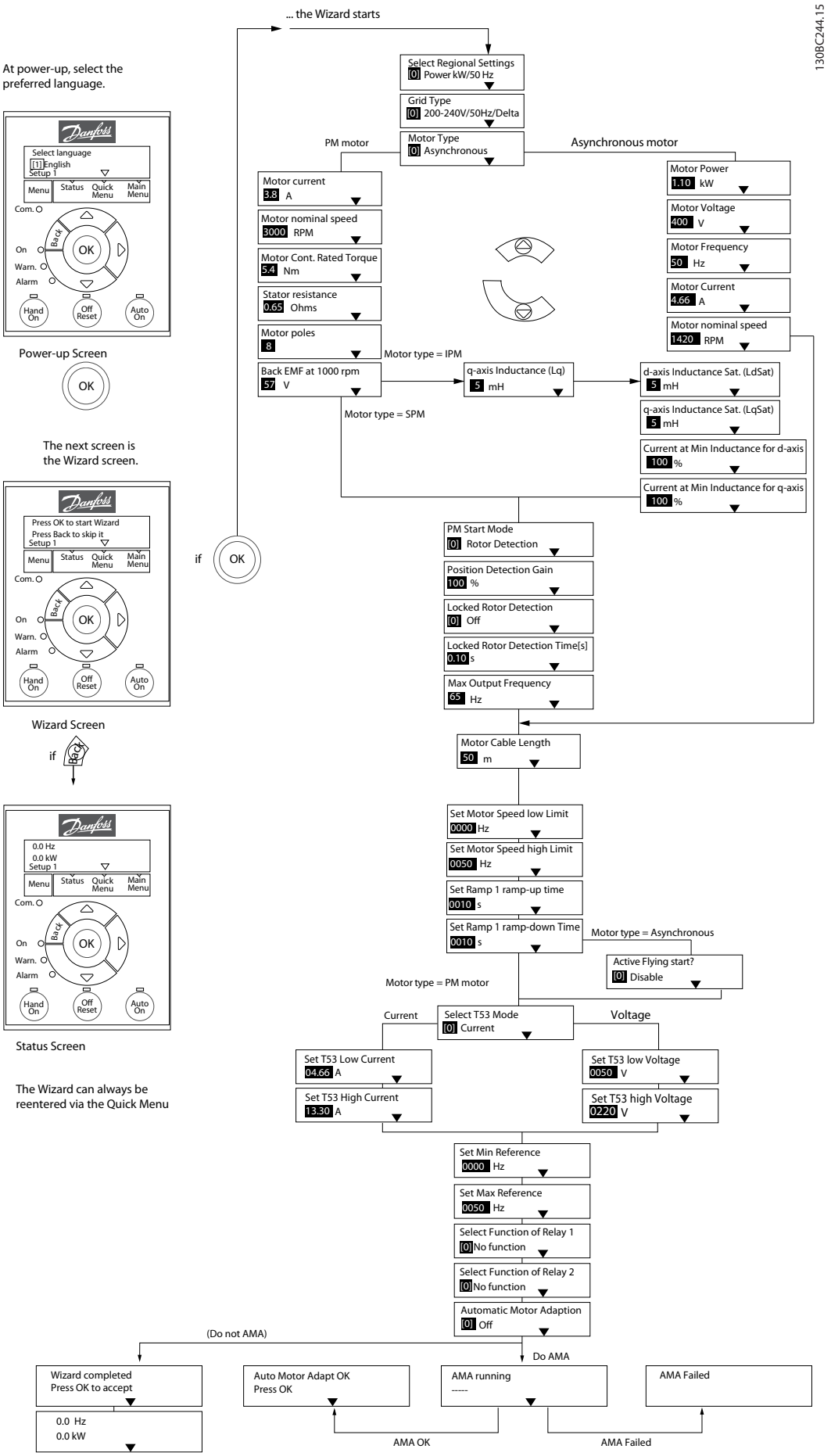

Illustration 4.4 Set-up Wizard for Open-loop Applications

4

Set-up Wizard for Open-loop Applications

Parameter	Option	Default	Usage
Parameter 0-03 Regional Settings	*[0] International* *[1] US*	*[0] International*	–
Parameter 0-06 GridType	*[0] 200–240 V/50 Hz/IT-grid* *[1] 200–240 V/50 Hz/Delta* *[2] 200–240 V/50 Hz* *[10] 380–440 V/50 Hz/IT-grid* *[11] 380–440 V/50 Hz/Delta* *[12] 380–440 V/50 Hz* *[20] 440–480 V/50 Hz/IT-grid* *[21] 440–480 V/50 Hz/Delta* *[22] 440–480 V/50 Hz* *[30] 525–600 V/50 Hz/IT-grid* *[31] 525–600 V/50 Hz/Delta* *[32] 525–600 V/50 Hz* *[100] 200–240 V/60 Hz/IT-grid* *[101] 200–240 V/60 Hz/Delta* *[102] 200–240 V/60 Hz* *[110] 380–440 V/60 Hz/IT-grid* *[111] 380–440 V/60 Hz/Delta* *[112] 380–440 V/60 Hz* *[120] 440–480 V/60 Hz/IT-grid* *[121] 440–480 V/60 Hz/Delta* *[122] 440–480 V/60 Hz* *[130] 525–600 V/60 Hz/IT-grid* *[131] 525–600 V/60 Hz/Delta* *[132] 525–600 V/60 Hz*	Size related	Select the operating mode for restart after reconnection of the frequency converter to mains voltage after power-down.

Parameter	Option	Default	Usage
Parameter 1-10 Motor Construction	**[0] Asynchron* *[1] PM, non-salient SPM* *[3] PM, salient IPM*	*[0] Asynchron*	Setting the parameter value might change these parameters: • *Parameter 1-01 Motor Control Principle.* • *Parameter 1-03 Torque Characteristics.* • *Parameter 1-08 Motor Control Bandwidth.* • *Parameter 1-14 Damping Gain.* • *Parameter 1-15 Low Speed Filter Time Const.* • *Parameter 1-16 High Speed Filter Time Const.* • *Parameter 1-17 Voltage filter time const.* • *Parameter 1-20 Motor Power.* • *Parameter 1-22 Motor Voltage.* • *Parameter 1-23 Motor Frequency.* • *Parameter 1-24 Motor Current.* • *Parameter 1-25 Motor Nominal Speed.* • *Parameter 1-26 Motor Cont. Rated Torque.* • *Parameter 1-30 Stator Resistance (Rs).* • *Parameter 1-33 Stator Leakage Reactance (X1).* • *Parameter 1-35 Main Reactance (Xh).* • *Parameter 1-37 d-axis Inductance (Ld).* • *Parameter 1-38 q-axis Inductance (Lq).* • *Parameter 1-39 Motor Poles.* • *Parameter 1-40 Back EMF at 1000 RPM.* • *Parameter 1-44 d-axis Inductance Sat. (LdSat).* • *Parameter 1-45 q-axis Inductance Sat. (LqSat).* • *Parameter 1-46 Position Detection Gain.* • *Parameter 1-48 Current at Min Inductance for d-axis.* • *Parameter 1-49 Current at Min Inductance for q-axis.* • *Parameter 1-66 Min. Current at Low Speed.* • *Parameter 1-70 Start Mode.* • *Parameter 1-72 Start Function.* • *Parameter 1-73 Flying Start.* • *Parameter 1-80 Function at Stop.* • *Parameter 1-82 Min Speed for Function at Stop [Hz].* • *Parameter 1-90 Motor Thermal Protection.* • *Parameter 2-00 DC Hold/Motor Preheat Current.* • *Parameter 2-01 DC Brake Current.* • *Parameter 2-02 DC Braking Time.* • *Parameter 2-04 DC Brake Cut In Speed.* • *Parameter 2-10 Brake Function.* • *Parameter 4-14 Motor Speed High Limit [Hz].* • *Parameter 4-19 Max Output Frequency.* • *Parameter 4-58 Missing Motor Phase Function.* • *Parameter 14-65 Speed Derate Dead Time Compensation.*

Parameter	Option	Default	Usage
Parameter 1-20 Motor Power	0.12–110 kW/0.16–150 hp	Size related	Enter the motor power from the nameplate data.
Parameter 1-22 Motor Voltage	50–1000 V	Size related	Enter the motor voltage from the nameplate data.
Parameter 1-23 Motor Frequency	20–400 Hz	Size related	Enter the motor frequency from the nameplate data.
Parameter 1-24 Motor Current	0.01–10000.00 A	Size related	Enter the motor current from the nameplate data.
Parameter 1-25 Motor Nominal Speed	50–9999 RPM	Size related	Enter the motor nominal speed from the nameplate data.
Parameter 1-26 Motor Cont. Rated Torque	0.1–1000.0 Nm	Size related	This parameter is available when *parameter 1-10 Motor Construction* is set to options that enable permanent magnet motor mode. ***NOTICE*** **Changing this parameter affects the settings of other parameters.**
Parameter 1-29 Automatic Motor Adaption (AMA)	See *parameter 1-29 Automatic Motor Adaption (AMA)*.	Off	Performing an AMA optimizes motor performance.
Parameter 1-30 Stator Resistance (Rs)	0.000–99.990 Ω	Size related	Set the stator resistance value.
Parameter 1-37 d-axis Inductance (Ld)	0.000–1000.000 mH	Size related	Enter the value of the d-axis inductance. Obtain the value from the permanent magnet motor datasheet. The d-axis inductance cannot be found by performing an AMA.
Parameter 1-38 q-axis Inductance (Lq)	0.000–1000.000 mH	Size related	Enter the value of the q-axis inductance.
Parameter 1-39 Motor Poles	2–100	4	Enter the number of motor poles.
Parameter 1-40 Back EMF at 1000 RPM	10–9000 V	Size related	Line-line RMS back EMF voltage at 1000 RPM.
Parameter 1-42 Motor Cable Length	0–100 m	50 m	Enter the motor cable length.
Parameter 1-44 d-axis Inductance Sat. (LdSat)	0.000–1000.000 mH	Size related	This parameter corresponds to the inductance saturation of Ld. Ideally, this parameter has the same value as *parameter 1-37 d-axis Inductance (Ld)*. However, if the motor supplier provides an induction curve, enter the induction value, which is 200% of the nominal current.
Parameter 1-45 q-axis Inductance Sat. (LqSat)	0.000–1000.000 mH	Size related	This parameter corresponds to the inductance saturation of Lq. Ideally, this parameter has the same value as *parameter 1-38 q-axis Inductance (Lq)*. However, if the motor supplier provides an induction curve, enter the induction value, which is 200% of the nominal current.
Parameter 1-46 Position Detection Gain	20–200%	100%	Adjusts the height of the test pulse during position detection at start.
Parameter 1-48 Current at Min Inductance for d-axis	20–200%	100%	Enter the inductance saturation point.
Parameter 1-49 Current at Min Inductance for q-axis	20–200%	100%	This parameter specifies the saturation curve of the d- and q-inductance values. From 20–100% of this parameter, the inductances are linearly approximated due to *parameter 1-37 d-axis Inductance (Ld)*, *parameter 1-38 q-axis Inductance (Lq)*, *parameter 1-44 d-axis Inductance Sat. (LdSat)*, and *parameter 1-45 q-axis Inductance Sat. (LqSat)*.
Parameter 1-70 Start Mode	*[0] Rotor Detection* *[1] Parking*	*[1] Parking*	Select the PM motor start mode.

Parameter	Option	Default	Usage
Parameter 1-73 Flying Start	*[0] Disabled* *[1] Enabled*	*[0] Disabled*	Select *[1] Enabled* to enable the frequency converter to catch a motor spinning due to mains drop-out. Select *[0] Disabled* if this function is not required. When this parameter is set to *[1] Enabled*, *parameter 1-71 Start Delay* and *parameter 1-72 Start Function* are not functional. *Parameter 1-73 Flying Start* is active in VVC+ mode only.
Parameter 3-02 Minimum Reference	-4999.000–4999.000	0	The minimum reference is the lowest value obtainable by summing all references.
Parameter 3-03 Maximum Reference	-4999.000–4999.000	50	The maximum reference is the lowest obtainable by summing all references.
Parameter 3-41 Ramp 1 Ramp Up Time	0.05–3600.00 s	Size related	If asynchronous motor is selected, the ramp-up time is from 0 to rated *parameter 1-23 Motor Frequency*. If PM motor is selected, the ramp-up time is from 0 to *parameter 1-25 Motor Nominal Speed*.
Parameter 3-42 Ramp 1 Ramp Down Time	0.05–3600.00 s	Size related	For asynchronous motors, the ramp-down time is from rated *parameter 1-23 Motor Frequency* to 0. For PM motors, the ramp-down time is from *parameter 1-25 Motor Nominal Speed* to 0.
Parameter 4-12 Motor Speed Low Limit [Hz]	0.0–400.0 Hz	0 Hz	Enter the minimum limit for low speed.
Parameter 4-14 Motor Speed High Limit [Hz]	0.0–400.0 Hz	100 Hz	Enter the maximum limit for high speed.
Parameter 4-19 Max Output Frequency	0.0–400.0 Hz	100 Hz	Enter the maximum output frequency value. If *parameter 4-19 Max Output Frequency* is set lower than *parameter 4-14 Motor Speed High Limit [Hz]*, *parameter 4-14 Motor Speed High Limit [Hz]* is set equal to *parameter 4-19 Max Output Frequency* automatically.
Parameter 5-40 Function Relay	See *parameter 5-40 Function Relay*.	*[9] Alarm*	Select the function to control output relay 1.
Parameter 5-40 Function Relay	See *parameter 5-40 Function Relay*.	*[5] Drive running*	Select the function to control output relay 2.
Parameter 6-10 Terminal 53 Low Voltage	0.00–10.00 V	0.07 V	Enter the voltage that corresponds to the low reference value.
Parameter 6-11 Terminal 53 High Voltage	0.00–10.00 V	10 V	Enter the voltage that corresponds to the high reference value.
Parameter 6-12 Terminal 53 Low Current	0.00–20.00 mA	4 mA	Enter the current that corresponds to the low reference value.
Parameter 6-13 Terminal 53 High Current	0.00–20.00 mA	20 mA	Enter the current that corresponds to the high reference value.
Parameter 6-19 Terminal 53 mode	*[0] Current* *[1] Voltage*	*[1] Voltage*	Select if terminal 53 is used for current or voltage input.
Parameter 30-22 Locked Rotor Protection	*[0] Off* *[1] On*	*[0] Off*	–
Parameter 30-23 Locked Rotor Detection Time [s]	0.05–1 s	0.10 s	–

Table 4.4 Set-up Wizard for Open-loop Applications

4

Set-up Wizard for Closed-loop Applications

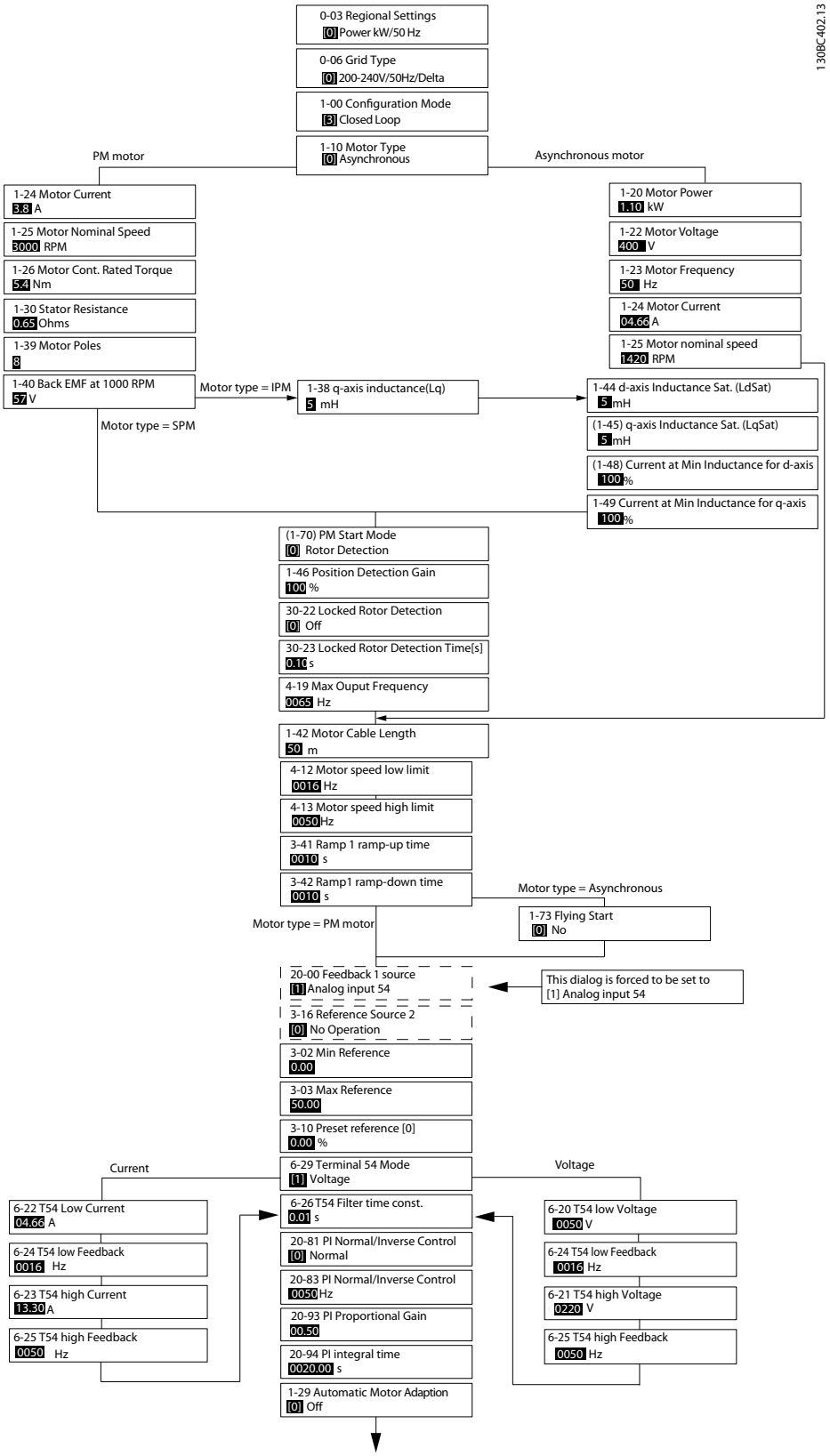

Illustration 4.5 Set-up Wizard for Closed-loop Applications

Parameter	Range	Default	Usage
Parameter 0-03 Regional Settings	*[0] International* *[1] US*	*[0] International*	–
Parameter 0-06 GridType	[0]–[132] see *Table 4.4*.	Size selected	Select the operating mode for restart after reconnection of the frequency converter to mains voltage after power-down.
Parameter 1-00 Configuration Mode	*[0] Open loop* *[3] Closed loop*	*[0] Open loop*	Select *[3] Closed loop*.

4

Parameter	Range	Default	Usage
Parameter 1-10 Motor Construction	**[0] Asynchron* *[1] PM, non-salient SPM* *[3] PM, salient IPM*	*[0] Asynchron*	Setting the parameter value might change these parameters: • *Parameter 1-01 Motor Control Principle.* • *Parameter 1-03 Torque Characteristics.* • *Parameter 1-08 Motor Control Bandwidth.* • *Parameter 1-14 Damping Gain.* • *Parameter 1-15 Low Speed Filter Time Const.* • *Parameter 1-16 High Speed Filter Time Const.* • *Parameter 1-17 Voltage filter time const.* • *Parameter 1-20 Motor Power.* • *Parameter 1-22 Motor Voltage.* • *Parameter 1-23 Motor Frequency.* • *Parameter 1-24 Motor Current.* • *Parameter 1-25 Motor Nominal Speed.* • *Parameter 1-26 Motor Cont. Rated Torque.* • *Parameter 1-30 Stator Resistance (Rs).* • *Parameter 1-33 Stator Leakage Reactance (X1).* • *Parameter 1-35 Main Reactance (Xh).* • *Parameter 1-37 d-axis Inductance (Ld).* • *Parameter 1-38 q-axis Inductance (Lq).* • *Parameter 1-39 Motor Poles.* • *Parameter 1-40 Back EMF at 1000 RPM.* • *Parameter 1-44 d-axis Inductance Sat. (LdSat).* • *Parameter 1-45 q-axis Inductance Sat. (LqSat).* • *Parameter 1-46 Position Detection Gain.* • *Parameter 1-48 Current at Min Inductance for d-axis.* • *Parameter 1-49 Current at Min Inductance for q-axis.* • *Parameter 1-66 Min. Current at Low Speed.* • *Parameter 1-70 Start Mode.* • *Parameter 1-72 Start Function.* • *Parameter 1-73 Flying Start.* • *Parameter 1-80 Function at Stop.* • *Parameter 1-82 Min Speed for Function at Stop [Hz].* • *Parameter 1-90 Motor Thermal Protection.* • *Parameter 2-00 DC Hold/Motor Preheat Current.* • *Parameter 2-01 DC Brake Current.* • *Parameter 2-02 DC Braking Time.* • *Parameter 2-04 DC Brake Cut In Speed.* • *Parameter 2-10 Brake Function.* • *Parameter 4-14 Motor Speed High Limit [Hz].* • *Parameter 4-19 Max Output Frequency.* • *Parameter 4-58 Missing Motor Phase Function.* • *Parameter 14-65 Speed Derate Dead Time Compensation.*

Parameter	Range	Default	Usage
Parameter 1-20 Motor Power	0.09–110 kW	Size related	Enter the motor power from the nameplate data.
Parameter 1-22 Motor Voltage	50–1000 V	Size related	Enter the motor voltage from the nameplate data.
Parameter 1-23 Motor Frequency	20–400 Hz	Size related	Enter the motor frequency from the nameplate data.
Parameter 1-24 Motor Current	0–10000 A	Size related	Enter the motor current from the nameplate data.
Parameter 1-25 Motor Nominal Speed	50–9999 RPM	Size related	Enter the motor nominal speed from the nameplate data.
Parameter 1-26 Motor Cont. Rated Torque	0.1–1000.0 Nm	Size related	This parameter is available when *parameter 1-10 Motor Construction* is set to options that enable permanent magnet motor mode. ***NOTICE*** **Changing this parameter affects the settings of other parameters.**
Parameter 1-29 Automatic Motor Adaption (AMA)		Off	Performing an AMA optimises motor performance.
Parameter 1-30 Stator Resistance (Rs)	0–99.990 Ω	Size related	Set the stator resistance value.
Parameter 1-37 d-axis Inductance (Ld)	0.000–1000.000 mH	Size related	Enter the value of the d-axis inductance. Obtain the value from the permanent magnet motor datasheet. The d-axis inductance cannot be found by performing an AMA.
Parameter 1-38 q-axis Inductance (Lq)	0.000–1000.000 mH	Size related	Enter the value of the q-axis inductance.
Parameter 1-39 Motor Poles	2–100	4	Enter the number of motor poles.
Parameter 1-40 Back EMF at 1000 RPM	10–9000 V	Size related	Line-line RMS back EMF voltage at 1000 RPM.
Parameter 1-42 Motor Cable Length	0–100 m	50 m	Enter the motor cable length.
Parameter 1-44 d-axis Inductance Sat. (LdSat)	0.000–1000.000 mH	Size related	This parameter corresponds to the inductance saturation of Ld. Ideally, this parameter has the same value as *parameter 1-37 d-axis Inductance (Ld)*. However, if the motor supplier provides an induction curve, enter the induction value, which is 200% of the nominal current.
Parameter 1-45 q-axis Inductance Sat. (LqSat)	0.000–1000.000 mH	Size related	This parameter corresponds to the inductance saturation of Lq. Ideally, this parameter has the same value as *parameter 1-38 q-axis Inductance (Lq)*. However, if the motor supplier provides an induction curve, enter the induction value, which is 200% of the nominal current.
Parameter 1-46 Position Detection Gain	20–200%	100%	Adjusts the height of the test pulse during position detection at start.
Parameter 1-48 Current at Min Inductance for d-axis	20–200%	100%	Enter the inductance saturation point.
Parameter 1-49 Current at Min Inductance for q-axis	20–200%	100%	This parameter specifies the saturation curve of the d- and q-inductance values. From 20–100% of this parameter, the inductances are linearly approximated due to *parameter 1-37 d-axis Inductance (Ld)*, *parameter 1-38 q-axis Inductance (Lq)*, *parameter 1-44 d-axis Inductance Sat. (LdSat)*, and *parameter 1-45 q-axis Inductance Sat. (LqSat)*.
Parameter 1-70 Start Mode	*[0] Rotor Detection* *[1] Parking*	*[1] Parking*	Select the PM motor start mode.
Parameter 1-73 Flying Start	*[0] Disabled* *[1] Enabled*	*[0] Disabled*	Select *[1] Enabled* to enable the frequency converter to catch a spinning motor in, for example, fan applications. When PM is selected, this parameter is enabled.

Parameter	Range	Default	Usage
Parameter 3-02 Minimum Reference	-4999.000–4999.000	0	The minimum reference is the lowest value obtainable by summing all references.
Parameter 3-03 Maximum Reference	-4999.000–4999.000	50	The maximum reference is the highest value obtainable by summing all references.
Parameter 3-10 Preset Reference	-100–100%	0	Enter the setpoint.
Parameter 3-41 Ramp 1 Ramp Up Time	0.05–3600.0 s	Size related	Ramp-up time from 0 to rated *parameter 1-23 Motor Frequency* for asynchronous motors. Ramp-up time from 0 to *parameter 1-25 Motor Nominal Speed* for PM motors.
Parameter 3-42 Ramp 1 Ramp Down Time	0.05–3600.0 s	Size related	Ramp-down time from rated *parameter 1-23 Motor Frequency* to 0 for asynchronous motors. Ramp-down time from *parameter 1-25 Motor Nominal Speed* to 0 for PM motors.
Parameter 4-12 Motor Speed Low Limit [Hz]	0.0–400.0 Hz	0.0 Hz	Enter the minimum limit for low speed.
Parameter 4-14 Motor Speed High Limit [Hz]	0.0–400.0 Hz	100 Hz	Enter the minimum limit for high speed.
Parameter 4-19 Max Output Frequency	0.0–400.0 Hz	100 Hz	Enter the maximum output frequency value. If *parameter 4-19 Max Output Frequency* is set lower than *parameter 4-14 Motor Speed High Limit [Hz]*, *parameter 4-14 Motor Speed High Limit [Hz]* is set equal to *parameter 4-19 Max Output Frequency* automatically.
Parameter 6-20 Terminal 54 Low Voltage	0.00–10.00 V	0.07 V	Enter the voltage that corresponds to the low reference value.
Parameter 6-21 Terminal 54 High Voltage	0.00–10.00 V	10.00 V	Enter the voltage that corresponds to the high reference value.
Parameter 6-22 Terminal 54 Low Current	0.00–20.00 mA	4.00 mA	Enter the current that corresponds to the low reference value.
Parameter 6-23 Terminal 54 High Current	0.00–20.00 mA	20.00 mA	Enter the current that corresponds to the high reference value.
Parameter 6-24 Terminal 54 Low Ref./Feedb. Value	-4999–4999	0	Enter the feedback value that corresponds to the voltage or current set in *parameter 6-20 Terminal 54 Low Voltage*/ *parameter 6-22 Terminal 54 Low Current*.
Parameter 6-25 Terminal 54 High Ref./Feedb. Value	-4999–4999	50	Enter the feedback value that corresponds to the voltage or current set in *parameter 6-21 Terminal 54 High Voltage*/ *parameter 6-23 Terminal 54 High Current*.
Parameter 6-26 Terminal 54 Filter Time Constant	0.00–10.00 s	0.01	Enter the filter time constant.
Parameter 6-29 Terminal 54 mode	*[0] Current* *[1] Voltage*	*[1] Voltage*	Select if terminal 54 is used for current or voltage input.
Parameter 20-81 PI Normal/ Inverse Control	*[0] Normal* *[1] Inverse*	*[0] Normal*	Select *[0] Normal* to set the process control to increase the output speed when the process error is positive. Select *[1] Inverse* to reduce the output speed.
Parameter 20-83 PI Start Speed [Hz]	0–200 Hz	0 Hz	Enter the motor speed to be attained as a start signal for commencement of PI control.
Parameter 20-93 PI Proportional Gain	0.00–10.00	0.01	Enter the process controller proportional gain. Quick control is obtained at high amplification. However, if amplification is too high, the process may become unstable.
Parameter 20-94 PI Integral Time	0.1–999.0 s	999.0 s	Enter the process controller integral time. Obtain quick control through a short integral time, though if the integral time is too short, the process becomes unstable. An excessively long integral time disables the integral action.
Parameter 30-22 Locked Rotor Protection	*[0] Off* *[1] On*	*[0] Off*	–

Parameter	Range	Default	Usage
Parameter 30-23 Locked Rotor Detection Time [s]	0.05–1.00 s	0.10 s	–

Table 4.5 Set-up Wizard for Closed-loop Applications

Motor set-up

The motor set-up wizard guides users through the needed motor parameters.

Parameter	Range	Default	Usage
Parameter 0-03 Regional Settings	*[0] International* *[1] US*	0	–
Parameter 0-06 GridType	[0]–[132] see *Table 4.4*.	Size related	Select the operating mode for restart after reconnection of the frequency converter to mains voltage after power-down.

Parameter	Range	Default	Usage
Parameter 1-10 Motor Construction	**[0] Asynchron* *[1] PM, non-salient SPM* *[3] PM, salient IPM*	*[0] Asynchron*	Setting the parameter value might change these parameters: • *Parameter 1-01 Motor Control Principle.* • *Parameter 1-03 Torque Characteristics.* • *Parameter 1-08 Motor Control Bandwidth.* • *Parameter 1-14 Damping Gain.* • *Parameter 1-15 Low Speed Filter Time Const.* • *Parameter 1-16 High Speed Filter Time Const.* • *Parameter 1-17 Voltage filter time const.* • *Parameter 1-20 Motor Power.* • *Parameter 1-22 Motor Voltage.* • *Parameter 1-23 Motor Frequency.* • *Parameter 1-24 Motor Current.* • *Parameter 1-25 Motor Nominal Speed.* • *Parameter 1-26 Motor Cont. Rated Torque.* • *Parameter 1-30 Stator Resistance (Rs).* • *Parameter 1-33 Stator Leakage Reactance (X1).* • *Parameter 1-35 Main Reactance (Xh).* • *Parameter 1-37 d-axis Inductance (Ld).* • *Parameter 1-38 q-axis Inductance (Lq).* • *Parameter 1-39 Motor Poles.* • *Parameter 1-40 Back EMF at 1000 RPM.* • *Parameter 1-44 d-axis Inductance Sat. (LdSat).* • *Parameter 1-45 q-axis Inductance Sat. (LqSat).* • *Parameter 1-46 Position Detection Gain.* • *Parameter 1-48 Current at Min Inductance for d-axis.* • *Parameter 1-49 Current at Min Inductance for q-axis.* • *Parameter 1-66 Min. Current at Low Speed.* • *Parameter 1-70 Start Mode.* • *Parameter 1-72 Start Function.* • *Parameter 1-73 Flying Start.* • *Parameter 1-80 Function at Stop.* • *Parameter 1-82 Min Speed for Function at Stop [Hz].* • *Parameter 1-90 Motor Thermal Protection.* • *Parameter 2-00 DC Hold/Motor Preheat Current.* • *Parameter 2-01 DC Brake Current.* • *Parameter 2-02 DC Braking Time.* • *Parameter 2-04 DC Brake Cut In Speed.* • *Parameter 2-10 Brake Function.* • *Parameter 4-14 Motor Speed High Limit [Hz].* • *Parameter 4-19 Max Output Frequency.* • *Parameter 4-58 Missing Motor Phase Function.* • *Parameter 14-65 Speed Derate Dead Time Compensation.*

Parameter	Range	Default	Usage
Parameter 1-20 Motor Power	0.12–110 kW/0.16–150 hp	Size related	Enter the motor power from the nameplate data.
Parameter 1-22 Motor Voltage	50–1000 V	Size related	Enter the motor voltage from the nameplate data.
Parameter 1-23 Motor Frequency	20–400 Hz	Size related	Enter the motor frequency from the nameplate data.
Parameter 1-24 Motor Current	0.01–10000.00 A	Size related	Enter the motor current from the nameplate data.
Parameter 1-25 Motor Nominal Speed	50–9999 RPM	Size related	Enter the motor nominal speed from the nameplate data.
Parameter 1-26 Motor Cont. Rated Torque	0.1–1000.0 Nm	Size related	This parameter is available when *parameter 1-10 Motor Construction* is set to options that enable permanent magnet motor mode. ***NOTICE*** **Changing this parameter affects the settings of other parameters.**
Parameter 1-30 Stator Resistance (Rs)	0–99.990 Ω	Size related	Set the stator resistance value.
Parameter 1-37 d-axis Inductance (Ld)	0.000–1000.000 mH	Size related	Enter the value of the d-axis inductance. Obtain the value from the permanent magnet motor datasheet. The d-axis inductance cannot be found by performing an AMA.
Parameter 1-38 q-axis Inductance (Lq)	0.000–1000.000 mH	Size related	Enter the value of the q-axis inductance.
Parameter 1-39 Motor Poles	2–100	4	Enter the number of motor poles.
Parameter 1-40 Back EMF at 1000 RPM	10–9000 V	Size related	Line-line RMS back EMF voltage at 1000 RPM.
Parameter 1-42 Motor Cable Length	0–100 m	50 m	Enter the motor cable length.
Parameter 1-44 d-axis Inductance Sat. (LdSat)	0.000–1000.000 mH	Size related	This parameter corresponds to the inductance saturation of Ld. Ideally, this parameter has the same value as *parameter 1-37 d-axis Inductance (Ld)*. However, if the motor supplier provides an induction curve, enter the induction value, which is 200% of the nominal current.
Parameter 1-45 q-axis Inductance Sat. (LqSat)	0.000–1000.000 mH	Size related	This parameter corresponds to the inductance saturation of Lq. Ideally, this parameter has the same value as *parameter 1-38 q-axis Inductance (Lq)*. However, if the motor supplier provides an induction curve, enter the induction value, which is 200% of the nominal current.
Parameter 1-46 Position Detection Gain	20–200%	100%	Adjusts the height of the test pulse during position detection at start.
Parameter 1-48 Current at Min Inductance for d-axis	20–200%	100%	Enter the inductance saturation point.
Parameter 1-49 Current at Min Inductance for q-axis	20–200%	100%	This parameter specifies the saturation curve of the d- and q-inductance values. From 20–100% of this parameter, the inductances are linearly approximated due to *parameter 1-37 d-axis Inductance (Ld)*, *parameter 1-38 q-axis Inductance (Lq)*, *parameter 1-44 d-axis Inductance Sat. (LdSat)*, and *parameter 1-45 q-axis Inductance Sat. (LqSat)*.
Parameter 1-70 Start Mode	*[0] Rotor Detection* *[1] Parking*	*[1] Parking*	Select the PM motor start mode.
Parameter 1-73 Flying Start	*[0] Disabled* *[1] Enabled*	*[0] Disabled*	Select *[1] Enabled* to enable the frequency converter to catch a spinning motor.
Parameter 3-41 Ramp 1 Ramp Up Time	0.05–3600.0 s	Size related	Ramp-up time from 0 to rated *parameter 1-23 Motor Frequency*.

Parameter	Range	Default	Usage
Parameter 3-42 Ramp 1 Ramp Down Time	0.05–3600.0 s	Size related	Ramp-down time from rated *parameter 1-23 Motor Frequency* to 0.
Parameter 4-12 Motor Speed Low Limit [Hz]	0.0–400.0 Hz	0.0 Hz	Enter the minimum limit for low speed.
Parameter 4-14 Motor Speed High Limit [Hz]	0.0–400.0 Hz	100.0 Hz	Enter the maximum limit for high speed.
Parameter 4-19 Max Output Frequency	0.0–400.0 Hz	100.0 Hz	Enter the maximum output frequency value. If *parameter 4-19 Max Output Frequency* is set lower than *parameter 4-14 Motor Speed High Limit [Hz]*, *parameter 4-14 Motor Speed High Limit [Hz]* is set equal to *parameter 4-19 Max Output Frequency* automatically.
Parameter 30-22 Locked Rotor Protection	*[0] Off* *[1] On*	*[0] Off*	–
Parameter 30-23 Locked Rotor Detection Time [s]	0.05–1.00 s	0.10 s	–

Table 4.6 Motor Set-up Wizard Settings

Changes made

The changes made function lists all parameters changed from default settings.

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

Changing parameter settings

1. To enter the Quick Menu, press the [Menu] key until the indicator in the display is placed above Quick Menu.
2. Press [▲] [▼] to select the wizard, closed-loop set-up, motor set-up, or changes made.
3. Press [OK].
4. Press [▲] [▼] to browse through the parameters in the Quick Menu.
5. Press [OK] to select a parameter.
6. Press [▲] [▼] to change the value of a parameter setting.
7. Press [OK] to accept the change.
8. Press either [Back] twice to enter Status, or press [Menu] once to enter the Main Menu.

The main menu accesses all parameters

1. Press the [Menu] key until the indicator in the display is placed above Main Menu.
2. Press [▲] [▼] to browse through the parameter groups.
3. Press [OK] to select a parameter group.
4. Press [▲] [▼] to browse through the parameters in the specific group.
5. Press [OK] to select the parameter.
6. Press [▲] [▼] to set/change the parameter value.

4.3 Parameter List

- **0-** Operation / Display**
  - **0-0* Basic Settings**
    - 0-01 Language
    - 0-03 Regional Settings
    - 0-04 Operating State at Power-up
    - 0-06 GridType
    - 0-07 Auto DC Braking
  - **0-1* Set-up Operations**
    - 0-10 Active Set-up
    - 0-11 Programming Set-up
    - 0-12 Link Setups
  - **0-3* LCP Custom Readout**
    - 0-30 Custom Readout Unit
    - 0-31 Custom Readout Min Value
    - 0-32 Custom Readout Max Value
    - 0-37 Display Text 1
    - 0-38 Display Text 2
    - 0-39 Display Text 3
  - **0-4* LCP Keypad**
    - 0-40 [Hand on] Key on LCP
    - 0-42 [Auto on] Key on LCP
    - 0-44 [Off/Reset] Key on LCP
  - **0-5* Copy/Save**
    - 0-50 LCP Copy
    - 0-51 Set-up Copy
  - **0-6* Password**
    - 0-60 Main Menu Password
    - 0-61 Access to Main Menu w/o Password
- **1-** Load and Motor**
  - **1-0* General Settings**
    - 1-00 Configuration Mode
    - 1-01 Motor Control Principle
    - 1-03 Torque Characteristics
    - 1-06 Clockwise Direction
    - 1-08 Motor Control Bandwidth
  - **1-1* Motor Selection**
    - 1-10 Motor Construction
    - 1-14 Damping Gain
    - 1-15 Low Speed Filter Time Const.
    - 1-16 High Speed Filter Time Const.
    - 1-17 Voltage filter time const.
  - **1-2* Motor Data**
    - 1-20 Motor Power
    - 1-22 Motor Voltage
    - 1-23 Motor Frequency
    - 1-24 Motor Current
    - 1-25 Motor Nominal Speed
    - 1-26 Motor Cont. Rated Torque
    - 1-29 Automatic Motor Adaption (AMA)
  - **1-3* Adv. Motor Data**
    - 1-30 Stator Resistance (Rs)
    - 1-33 Stator Leakage Reactance (X1)
    - 1-35 Main Reactance (Xh)
    - 1-37 d-axis Inductance (Ld)
    - 1-38 q-axis Inductance (Lq)
    - 1-39 Motor Poles
  - **1-4* Adv. Motor Data II**
    - 1-40 Back EMF at 1000 RPM
    - 1-42 Motor Cable Length
    - 1-43 Motor Cable Length Feet
    - 1-44 d-axis Inductance Sat. (LdSat)
    - 1-45 q-axis Inductance Sat. (LqSat)
    - 1-46 Position Detection Gain
    - 1-48 Current at Min Inductance for d-axis
    - 1-49 Current at Min Inductance for q-axis
  - **1-5* Load Indep. Setting**
    - 1-50 Motor Magnetisation at Zero Speed
    - 1-52 Min Speed Normal Magnetising [Hz]
    - 1-55 U/f Characteristic - U
    - 1-56 U/f Characteristic - F
  - **1-6* Load Depen. Setting**
    - 1-62 Slip Compensation
    - 1-63 Slip Compensation Time Constant
    - 1-64 Resonance Dampening
    - 1-65 Resonance Dampening Time Constant
    - 1-66 Min. Current at Low Speed
  - **1-7* Start Adjustments**
    - 1-70 Start Mode
    - 1-71 Start Delay
    - 1-72 Start Function
    - 1-73 Flying Start
  - **1-8* Stop Adjustments**
    - 1-80 Function at Stop
    - 1-82 Min Speed for Function at Stop [Hz]
    - 1-88 AC Brake Gain
  - **1-9* Motor Temperature**
    - 1-90 Motor Thermal Protection
    - 1-93 Thermistor Source
- **2-** Brakes**
  - **2-0* DC-Brake**
    - 2-00 DC Hold/Motor Preheat Current
    - 2-01 DC Brake Current
    - 2-02 DC Braking Time
    - 2-04 DC Brake Cut In Speed
    - 2-06 Parking Current
    - 2-07 Parking Time
  - **2-1* Brake Energy Funct.**
    - 2-10 Brake Function
    - 2-16 AC Brake, Max current
    - 2-17 Over-voltage Control
    - 2-19 Over-voltage Gain
- **3-** Reference / Ramps**
  - **3-0* Reference Limits**
    - 3-02 Minimum Reference
    - 3-03 Maximum Reference
  - **3-1* References**
    - 3-10 Preset Reference
    - 3-11 Jog Speed [Hz]
    - 3-14 Preset Relative Reference
    - 3-15 Reference 1 Source
    - 3-16 Reference 2 Source
    - 3-17 Reference 3 Source
  - **3-4* Ramp 1**
    - 3-41 Ramp 1 Ramp Up Time
    - 3-42 Ramp 1 Ramp Down Time
  - **3-5* Ramp 2**
    - 3-51 Ramp 2 Ramp Up Time
    - 3-52 Ramp 2 Ramp Down Time
  - **3-8* Other Ramps**
    - 3-80 Jog Ramp Time
    - 3-81 Quick Stop Ramp Time
- **4-** Limits / Warnings**
  - **4-1* Motor Limits**
    - 4-10 Motor Speed Direction
    - 4-12 Motor Speed Low Limit [Hz]
    - 4-14 Motor Speed High Limit [Hz]
    - 4-18 Current Limit
    - 4-19 Max Output Frequency
  - **4-4* Adj. Warnings 2**
    - 4-40 Warning Freq. Low
    - 4-41 Warning Freq. High
  - **4-5* Adj. Warnings**
    - 4-50 Warning Current Low
    - 4-51 Warning Current High
    - 4-54 Warning Reference Low
    - 4-55 Warning Reference High
    - 4-56 Warning Feedback Low
    - 4-57 Warning Feedback High
    - 4-58 Missing Motor Phase Function
  - **4-6* Speed Bypass**
    - 4-61 Bypass Speed From [Hz]
    - 4-63 Bypass Speed To [Hz]
    - 4-64 Semi-Auto Bypass Set-up
- **5-** Digital In/Out**
  - **5-0* Digital I/O mode**
    - 5-00 Digital Input Mode
    - 5-01 Terminal 27 Mode
    - 5-02 Terminal 29 Mode
    - 5-03 Digital Input 29 Mode
  - **5-1* Digital Inputs**
    - 5-10 Terminal 18 Digital Input
    - 5-11 Terminal 19 Digital Input
    - 5-12 Terminal 27 Digital Input
    - 5-13 Terminal 29 Digital Input
  - **5-3* Digital Outputs**
    - 5-30 Terminal 27 Digital Output
    - 5-31 Terminal 29 Digital Output
    - 5-34 On Delay, Digital Output
    - 5-35 Off Delay, Digital Output
  - **5-4* Relays**
    - 5-40 Function Relay
    - 5-41 On Delay, Relay
    - 5-42 Off Delay, Relay
  - **5-5* Pulse Input**
    - 5-50 Term. 29 Low Frequency
    - 5-51 Term. 29 High Frequency
    - 5-52 Term. 29 Low Ref./Feedb. Value
    - 5-53 Term. 29 High Ref./Feedb. Value
  - **5-9* Bus Controlled**
    - 5-90 Digital & Relay Bus Control
- **6-** Analog In/Out**
  - **6-0* Analog I/O Mode**
    - 6-00 Live Zero Timeout Time
    - 6-01 Live Zero Timeout Function
    - 6-02 Fire Mode Live Zero Timeout Function
  - **6-1* Analog Input 53**
    - 6-10 Terminal 53 Low Voltage
    - 6-11 Terminal 53 High Voltage
    - 6-12 Terminal 53 Low Current
    - 6-13 Terminal 53 High Current
    - 6-14 Terminal 53 Low Ref./Feedb. Value
    - 6-15 Terminal 53 High Ref./Feedb. Value
    - 6-16 Terminal 53 Filter Time Constant
    - 6-19 Terminal 53 mode
  - **6-2* Analog Input 54**
    - 6-20 Terminal 54 Low Voltage
    - 6-21 Terminal 54 High Voltage
    - 6-22 Terminal 54 Low Current
    - 6-23 Terminal 54 High Current
    - 6-24 Terminal 54 Low Ref./Feedb. Value
    - 6-25 Terminal 54 High Ref./Feedb. Value
    - 6-26 Terminal 54 Filter Time Constant
    - 6-29 Terminal 54 mode
  - **6-7* Analog/Digital Output 45**
    - 6-70 Terminal 45 Mode
    - 6-71 Terminal 45 Analog Output
    - 6-72 Terminal 45 Digital Output
    - 6-73 Terminal 45 Output Min Scale
    - 6-74 Terminal 45 Output Max Scale
    - 6-76 Terminal 45 Output Bus Control
  - **6-9* Analog/Digital Output 42**
    - 6-90 Terminal 42 Mode
    - 6-91 Terminal 42 Analog Output
    - 6-92 Terminal 42 Digital Output
    - 6-93 Terminal 42 Output Min Scale
    - 6-94 Terminal 42 Output Max Scale
    - 6-96 Terminal 42 Output Bus Control
- **8-** Comm. and Options**
  - **8-0* General Settings**
    - 8-01 Control Site
    - 8-02 Control Source
    - 8-03 Control Timeout Time
    - 8-04 Control Timeout Function
  - **8-3* FC Port Settings**
    - 8-30 Protocol
    - 8-31 Address
    - 8-32 Baud Rate
    - 8-33 Parity / Stop Bits
    - 8-35 Minimum Response Delay
    - 8-36 Maximum Response Delay
    - 8-37 Maximum Inter-char delay
  - **8-4* FC MC protocol set**
    - 8-42 PCD Write Configuration
    - 8-43 PCD Read Configuration
  - **8-5* Digital/Bus**
    - 8-50 Coasting Select
    - 8-51 Quick Stop Select
    - 8-52 DC Brake Select
    - 8-53 Start Select
    - 8-54 Reversing Select
    - 8-55 Set-up Select
    - 8-56 Preset Reference Select
  - **8-7* BACnet**
    - 8-70 BACnet Device Instance
    - 8-72 MS/TP Max Masters
    - 8-73 MS/TP Max Info Frames
    - 8-74 "I am" Service
    - 8-75 Intialisation Password
    - 8-79 Protocol Firmware version
  - **8-8* FC Port Diagnostics**
    - 8-80 Bus Message Count
    - 8-81 Bus Error Count
    - 8-82 Slave Messages Rcvd
    - 8-83 Slave Error Count
    - 8-84 Slave Messages Sent
    - 8-85 Slave Timeout Errors
    - 8-88 Reset FC port Diagnostics
  - **8-9* Bus Feedback**
    - 8-94 Bus Feedback 1
    - 8-95 Bus Feedback 2
- **13-** Smart Logic**
  - **13-0* SLC Settings**
    - 13-00 SL Controller Mode
    - 13-01 Start Event
    - 13-02 Stop Event
    - 13-03 Reset SLC
  - **13-1* Comparators**
    - 13-10 Comparator Operand
    - 13-11 Comparator Operator
    - 13-12 Comparator Value
  - **13-2* Timers**
    - 13-20 SL Controller Timer
  - **13-4* Logic Rules**
    - 13-40 Logic Rule Boolean 1
    - 13-41 Logic Rule Operator 1
    - 13-42 Logic Rule Boolean 2
    - 13-43 Logic Rule Operator 2
    - 13-44 Logic Rule Boolean 3
  - **13-5* States**
    - 13-51 SL Controller Event
    - 13-52 SL Controller Action
- **14-** Special Functions**
  - **14-0* Inverter Switching**
    - 14-01 Switching Frequency
    - 14-03 Overmodulation
    - 14-07 Dead Time Compensation Level
    - 14-08 Damping Gain Factor
    - 14-09 Dead Time Bias Current Level
  - **14-1* Mains Failure**
    - 14-10 Mains Failure
    - 14-11 Mains Fault Voltage Level
    - 14-12 Response to Mains Imbalance
  - **14-2* Reset Functions**
    - 14-20 Reset Mode
    - 14-21 Automatic Restart Time
    - 14-22 Operation Mode
    - 14-27 Action At Inverter Fault
    - 14-29 Service Code
  - **14-3* Current Limit Ctrl.**
    - 14-30 Current Lim Ctrl, Proportional Gain
    - 14-31 Current Lim Ctrl, Integration Time
    - 14-32 Current Lim Ctrl, Filter Time
  - **14-4* Energy Optimising**
    - 14-40 VT Level
    - 14-41 AEO Minimum Magnetisation

14-44 d-axis current optimization for IPM
14-5* Environment
14-50 RFI Filter
14-51 DC-Link Voltage Compensation
14-52 Fan Control
14-53 Fan Monitor
14-55 Output Filter
14-6* Auto Derate
14-61 Function at Inverter Overload
14-63 Min Switch Frequency
14-64 Dead Time Compensation Zero Current Level
14-65 Speed Derate Dead Time Compensation
14-9* Fault Settings
14-90 Fault Level
15- Drive Information**
15-0* Operating Data
15-00 Operating hours
15-01 Running Hours
15-02 kWh Counter
15-03 Power Up's
15-04 Over Temp's
15-05 Over Volt's
15-06 Reset kWh Counter
15-07 Reset Running Hours Counter
15-3* Alarm Log
15-30 Alarm Log: Error Code
15-31 InternalFaultReason
15-4* Drive Identification
15-40 FC Type
15-41 Power Section
15-42 Voltage
15-43 Software Version
15-44 Ordered TypeCode
15-45 Actual Typecode String
15-46 Drive Ordering No
15-48 LCP Id No
15-49 SW ID Control Card
15-50 SW ID Power Card
15-51 Drive Serial Number
15-53 Power Card Serial Number
15-59 Filename
16- Data Readouts**
16-0* General Status
16-00 Control Word
16-01 Reference [Unit]
16-02 Reference [%]
16-03 Status Word
16-05 Main Actual Value [%]
16-09 Custom Readout
16-1* Motor Status
16-10 Power [kW]
16-11 Power [hp]
16-12 Motor Voltage
16-13 Frequency
16-14 Motor current
16-15 Frequency [%]
16-16 Torque [Nm]
16-17 Speed [RPM]
16-18 Motor Thermal
16-22 Torque [%]
16-26 Power Filtered [kW]
16-27 Power Filtered [hp]
16-3* Drive Status
16-30 DC Link Voltage
16-34 Heatsink Temp.
16-35 Inverter Thermal
16-36 Inv. Nom. Current
16-37 Inv. Max. Current
16-38 SL Controller State
16-5* Ref. & Feedb.
16-50 External Reference
16-52 Feedback[Unit]
16-54 Feedback 1 [Unit]
16-55 Feedback 2 [Unit]
16-6* Inputs & Outputs
16-60 Digital Input
16-61 Terminal 53 Setting
16-62 Analog input 53
16-63 Terminal 54 Setting
16-64 Analog input 54
16-65 Analog output 42 [mA]
16-66 Digital Output
16-67 Pulse input 29 [Hz]
16-71 Relay output
16-72 Counter A
16-73 Counter B
16-79 Analog output 45 [mA]
16-8* Fieldbus & FC Port
16-86 FC Port REF 1
16-9* Diagnosis Readouts
16-90 Alarm Word
16-91 Alarm Word 2
16-92 Warning Word
16-93 Warning Word 2
16-94 Ext. Status Word
16-95 Ext. Status Word 2
18- Info & Readouts**
18-1* Fire Mode Log
18-10 FireMode Log:Event
18-5* Ref. & Feedb.
18-50 Sensorless Readout [unit]
20- Drive Closed Loop**
20-0* Feedback
20-00 Feedback 1 Source
20-01 Feedback 1 Conversion
20-03 Feedback 2 Source
20-04 Feedback 2 Conversion
20-12 Reference/Feedback Unit
20-2* Feedback/Setpoint
20-20 Feedback Function
20-21 Setpoint 1
20-6* Sensorless
20-60 Sensorless Unit
20-69 Sensorless Information
20-7* PI Autotuning
20-70 Closed Loop Type
20-71 PI Performance
20-72 PI Output Change
20-73 Minimum Feedback Level
20-74 Maximum Feedback Level
20-79 PI Autotuning
20-8* PI Basic Settings
20-81 PI Normal/ Inverse Control
20-83 PI Start Speed [Hz]
20-84 On Reference Bandwidth
20-9* PI Controller
20-91 PI Anti Windup
20-93 PI Proportional Gain
20-94 PI Integral Time
20-97 PI Feed Forward Factor
22- Appl. Functions**
22-0* Miscellaneous
22-01 Power Filter Time
22-02 Sleepmode CL Control Mode
22-2* No-Flow Detection
22-23 No-Flow Function
22-24 No-Flow Delay
22-3* No-Flow Power Tuning
22-30 No-Flow Power
22-31 Power Correction Factor
22-33 Low Speed [Hz]
22-34 Low Speed Power [kW]
22-37 High Speed [Hz]
22-38 High Speed Power [kW]
22-4* Sleep Mode
22-40 Minimum Run Time
22-41 Minimum Sleep Time
22-43 Wake-Up Speed [Hz]
22-44 Wake-Up Ref./FB Diff
22-45 Setpoint Boost
22-46 Maximum Boost Time
22-47 Sleep Speed [Hz]
22-48 Sleep Delay Time
22-49 Wake-Up Delay Time
22-6* Broken Belt Detection
22-60 Broken Belt Function
22-61 Broken Belt Torque
22-62 Broken Belt Delay
22-8* Flow Compensation
22-80 Flow Compensation
22-81 Square-linear Curve Approximation
22-82 Work Point Calculation
22-84 Speed at No-Flow [Hz]
22-86 Speed at Design Point [Hz]
22-87 Pressure at No-Flow Speed
22-88 Pressure at Rated Speed
22-89 Flow at Design Point
22-90 Flow at Rated Speed
24- Appl. Functions 2**
24-0* Fire Mode
24-00 FM Function
24-01 Fire Mode Configuration
24-05 FM Preset Reference
24-06 Fire Mode Reference Source
24-07 Fire Mode Feedback Source
24-09 FM Alarm Handling
24-1* Drive Bypass
24-10 Drive Bypass Function
24-11 Drive Bypass Delay Time
25- Cascade Controller**
25-0* System Settings
25-00 Cascade Controller
25-04 Pump Cycling
25-05 Fixed Lead Pump
25-06 Number of Pumps
25-2* Bandwidth Settings
25-20 Staging Bandwidth
25-21 Override Bandwidth
25-22 Fixed Speed Bandwidth
25-23 SBW Staging Delay
25-24 SBW Destaging Delay
25-25 OBW Time
25-27 Stage Function
25-28 Stage Function Time
25-29 Destage Function
25-30 Destage Function Time
25-4* Staging Settings
25-42 Staging Threshold
25-43 Destaging Threshold
25-45 Staging Speed [Hz]
25-47 Destaging Speed [Hz]
25-5* Alternation Settings
25-50 Lead Pump Alternation
25-51 Alternation Event
25-52 Alternation Time Interval
25-53 Alternation Timer Value
25-55 Alternate if Load <= 50%
25-56 Staging Mode at Alternation
25-57 Relays per Pump
25-58 Run Next Pump Delay
25-59 Run on Mains Delay
25-8* Status
25-80 Cascade Status
25-81 Pump Status
25-82 Lead Pump
25-84 Pump ON Time
25-9* Service
25-90 Pump Interlock
30- Special Features**
30-2* Adv. Start Adjust
30-22 Locked Rotor Protection
30-23 Locked Rotor Detection Time [s]

5 Cascade Controller

5.1 Introduction

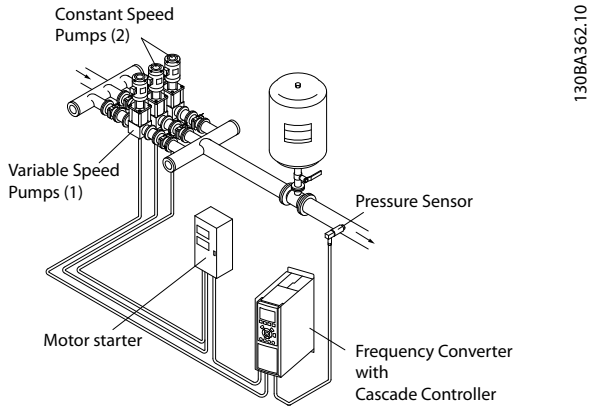

Illustration 5.1 Cascade Controller

The cascade controller is used for pump applications where a certain pressure (head) or level needs to be maintained over a wide dynamic range. Running a large pump at variable speed over a wide range is not an ideal solution because of low pump efficiency, and because there is a practical limit of about 25% rated full load speed for running a pump.

In the cascade controller, the frequency converter controls a variable speed motor as the variable speed pump (lead) and can stage up to 2 additional constant speed pumps on and off. By varying the speed of the initial pump, variable speed control of the entire system is provided, which maintains constant pressure while eliminating pressure surges, resulting in reduced system stress and quieter operation in pumping systems.

Fixed lead pump
The motors must be of equal size. The cascade controller allows the frequency converter to control up to 5 equal size pumps using the 2 built-in relays of the frequency converter and terminals 27, 29 (digital input/digital output). When the variable pump (lead) is connected directly to the frequency converter, the other 4 pumps are controlled by the 2 built-in relays and terminals 27, 29 (digital input/digital output). Lead pump alternation cannot be selected when lead pump is fixed.

Lead pump alternation
The motors must be of equal size. This function makes it possible to cycle the frequency converter between the pumps in the system (when *parameter 25-57 Relays per Pump* = 1, the maximum number of pumps is 4. When *parameter 25-57 Relays per Pump* = 2, the maximum number of pumps is 3). In this operation, the run time between pumps is equalized reducing the required pump maintenance and increasing reliability and lifetime of the system. The alternation of the lead pump can take place at a command signal or at staging (adding lag pump).

The command can be a manual alternation or an alternation event signal. If the alternation event is selected, the lead pump alternation takes place every time the event occurs. Selections include whenever an alternation timer expires, when the lead pump goes into sleep mode. Staging is determined by the actual system load.

When *parameter 25-55 Alternate if Load <= 50%* is set to *[1] Enabled*, alternation does not happen if the load exceeds 50%. If load <50%, alternation happens. When *parameter 25-55 Alternate if Load <= 50%* is set to *[0] Disabled*, alternation happens regardless of the load. The total pump capacity is determined as lead pump plus lag speed pumps capacities.

Bandwidth management
In cascade control systems, to avoid frequent switching of fixed-speed pumps, the desired system pressure is kept within a bandwidth rather than at a constant level. The staging bandwidth provides the required bandwidth for operation. When a large and quick change in system pressure occurs, the override bandwidth overrides the staging bandwidth to prevent immediate response to a short duration pressure change. An override bandwidth timer can be programmed to prevent staging until the system pressure has stabilized and normal control established.

When the cascade controller is enabled and running normally, and the frequency converter issues a trip alarm, the system head is maintained by staging and destaging fixed-speed pumps. To prevent frequent staging and destaging, and to minimize pressure fluctuations, use a wider fixed-speed bandwidth instead of the staging bandwidth.

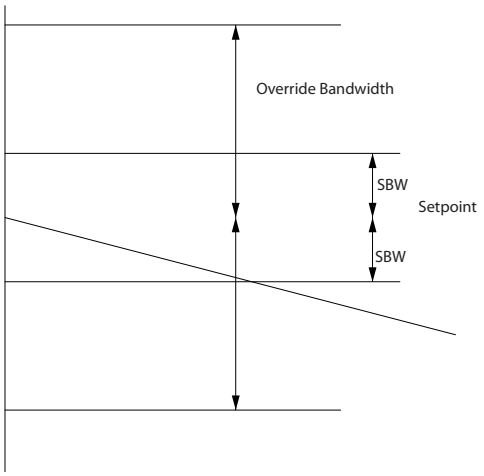

Illustration 5.2 Bandwidth

5.2 System Status and Operation

Only when lead pump is working, the frequency converter can go into sleep mode. When the cascade controller is enabled, the operation status for each pump and the cascade controller is shown in *parameter 25-81 Pump Status* and *parameter 25-80 Cascade Status* on the LCP.

The cascade controller information shown includes:

- Pumps status: A readout of the status for the relays assigned to each pump. The display shows pumps that are disabled, off, running on the frequency converter, or running on the mains/ motor starter.
- Cascade status: A readout of the status for the cascade controller. The display shows that if cascade controller is disabled, all pumps are running off, fixed-speed pumps are being staged/de-staged, and lead pump alternation is occurring.

5.3 Start/Stop Conditions

See *parameter group 5-1* Digital Inputs*.

Digital input commands	Variable speed pump (lead)	Fixed-speed pumps (lag)
Start (system start/ stop)	Ramps up (if stopped and there is a demand)	Staging (if stopped and there is a demand)
Lead oump start	Ramps up if system start is active	Not affected
Coast (emergency stop)	Coast to stop	Cut out (correspond relays, terminal 27/29 and 42/45)
External interlock	Coast to stop	Cut out (built-in relays are de-energized)

Table 5.1 Commands Assigned to Digital Inputs

LCP keys	Variable speed pump (lead)	Fixed-speed pumps (lag)
[Hand On]	Ramps up (if stopped by a normal stop command) or stays in operation if already running	Destaging (if running)
[Off]	Ramps down	Destaging
[Auto On]	Starts and stops according to commands via terminals or serial bus. The cascade controller only works when the frequency converter is in auto-on mode.	Staging/destaging

Table 5.2 LCP Key Functions

5.4 Cascade Controller Wizard

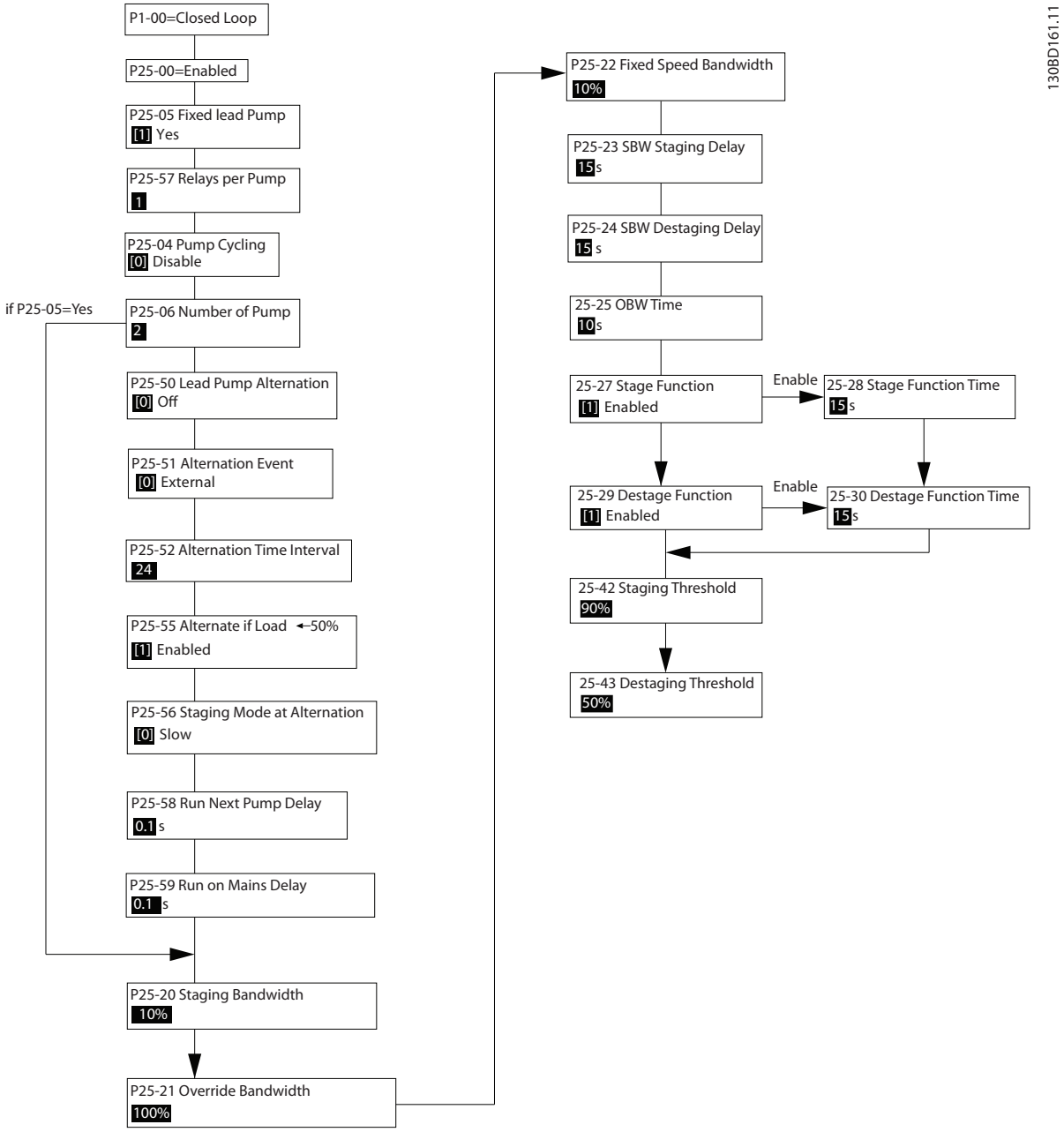

Illustration 5.3 Cascade Controller Wizard (Recommended Logistic)

5.5 Cascade Controller Connection

1 pump, 1 relay mode: When *parameter 25-57 Relays per Pump* = 1

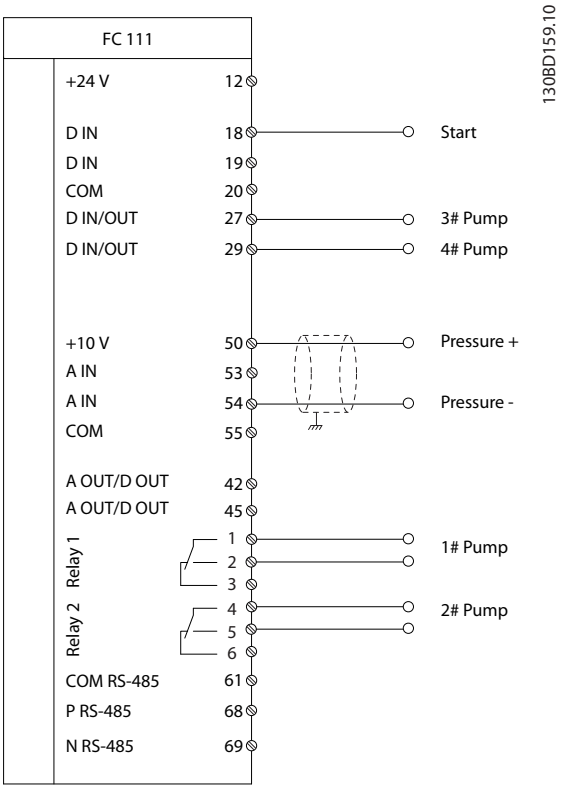

Illustration 5.4 1 Pump, 1 Relay Mode

Every pump operation is controlled by 1 output.

1. When *parameter 25-04 Pump Cycling = [0] Disable*: Maximum 5 pumps.
2. When *parameter 25-04 Pump Cycling = [1] Enable*: Maximum 4 pumps.
3. 2 relays and 2 digital outputs are available.

1 pump, 2 relay mode: When *parameter 25-57 Relays per Pump* = 2

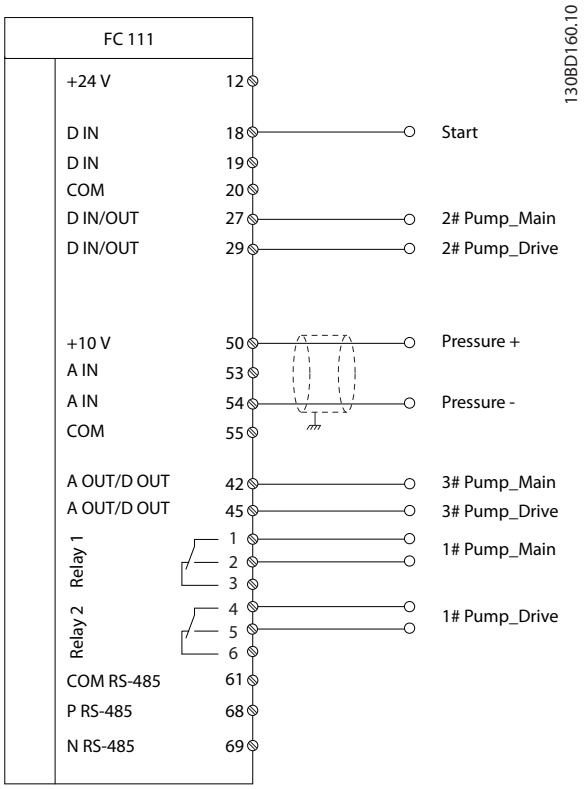

Illustration 5.5 1 Pump, 2 Relay Mode

Every pump operation is controlled by 2 outputs.

1. Dedicated PLC not necessary as control
2. When *parameter 25-04 Pump Cycling = [0] Disable*: no pump.
3. When *parameter 25-04 Pump Cycling = [1] Enable*: Maximum 3 pumps.
4. 2 relays, 2 digital outputs, and 2 analog outputs are available.

6 Warnings and Alarms

6.1 List of Warnings and Alarms

Fault number	Alarm/ warning bit number	Fault text	Warning	Alarm	Trip locked	Cause of problem
2	16	Live zero error	X	X	–	Signal on terminal 53 or 54 is less than 50% of the value set in *parameter 6-10 Terminal 53 Low Voltage*, *parameter 6-12 Terminal 53 Low Current*, *parameter 6-20 Terminal 54 Low Voltage*, or *parameter 6-22 Terminal 54 Low Current*. See also *parameter group 6-0* Analog I/O Mode*.
4	14	Mains ph. loss	X	X	X	Missing phase on the supply side or too high voltage imbalance. Check the supply voltage. See *parameter 14-12 Response to Mains Imbalance*.
7	11	DC over volt	X	X	–	DC-link voltage exceeds the limit.
8	10	DC under volt	X	X	–	DC-link voltage drops below voltage warning low-limit.
9	9	Inverter overload	X	X	–	More than 100% load for a long time.
10	8	Motor ETR over	X	X	–	The motor is too hot due to more than 100% load for a long time. See *parameter 1-90 Motor Thermal Protection*.
11	7	Motor th over	X	X	–	The thermistor or thermistor connection is disconnected. See *parameter 1-90 Motor Thermal Protection*.
13	5	Over Current	X	X	X	Inverter peak current limit is exceeded.
14	2	Earth Fault	–	X	X	Discharge from output phases to ground.
16	12	Short Circuit	–	X	X	Short circuit in motor or on motor terminals.
17	4	Ctrl. word TO	X	X	–	No communication to frequency converter. See *parameter group 8-0* General Settings*.
24	50	Fan Fault	X	X	–	The heat sink cooling fan is not working (only on 400 V, 30–90 kW (40–125 hp) units).
30	19	U phase loss	–	X	X	Motor phase U is missing. Check the phase. See *parameter 4-58 Missing Motor Phase Function*.
31	20	V phase loss	–	X	X	Motor phase V is missing. Check the phase. See *parameter 4-58 Missing Motor Phase Function*.
32	21	W phase loss	–	X	X	Motor phase W is missing. Check the phase. See *parameter 4-58 Missing Motor Phase Function*.
38	17	Internal fault	–	X	X	Contact the local Danfoss supplier.
44	28	Earth Fault	–	X	X	Discharge from output phases to ground, using the value of *parameter 15-31 Alarm Log Value* if possible.
46	33	Control Voltage Fault	–	X	X	Control voltage is low. Contact the local Danfoss supplier.
47	23	24 V supply low	X	X	X	24 V DC supply may be overloaded.
50		AMA calibration failed	–	X	–	Contact the local Danfoss supplier.
51	15	AMA U_{nom}, I_{nom}	–	X	–	The setting of motor voltage, motor current, and motor power is wrong. Check the settings.
52	–	AMA low Inom	–	X	–	The motor current is too low. Check the settings.
53	–	AMA big motor	–	X	–	The motor is too large to perform AMA.
54	–	AMA small mot	–	X	–	The motor is too small to perform AMA.
55	–	AMA par. range	–	X	–	The parameter values found from the motor are outside the acceptable range.
56	–	AMA user interrupt	–	X	–	The AMA is manually interrupted.

Fault number	Alarm/ warning bit number	Fault text	Warning	Alarm	Trip locked	Cause of problem
57	–	AMA timeout	–	X	–	Try to restart the AMA several times, until the AMA is carried out. ***NOTICE*** **Repeated runs may heat the motor to a level where the resistance R_s and R_r are increased. In most cases, this situation is not critical.**
58	–	AMA internal	X	X	–	Contact the local Danfoss supplier.
59	25	Current limit	X	–	–	The current is higher than the value in *parameter 4-18 Current Limit*.
60	44	External Interlock	–	X	–	External interlock has been activated. To resume normal operation, apply 24 V DC to the terminal programmed for external interlock and reset the frequency converter (via serial communication, digital I/O, or by pressing [Reset] on LCP).
66	26	Heat sink Temperature Low	X	–	–	This warning is based on the temperature sensor in the IGBT module (on 400 V, 30–90 kW (40–125 hp) units).
69	1	Pwr. Card Temp	X	X	X	The temperature sensor on the power card exceeds the upper or lower limits.
70	36	Illegal FC configuration	–	X	X	The control card and power card are not matched.
79	–	Illegal power section configuration	X	X	–	Internal fault. Contact the local Danfoss supplier.
80	29	Drive initialized	–	X	–	All parameter settings are initialized to default settings.
87	47	Auto DC Braking	X	–	–	The frequency converter is auto DC braking.
95	40	Broken Belt	X	X	–	Torque is below the torque level set for no load, indicating a broken belt. See *parameter group 22-6* Broken Belt Detection*.
126	–	Motor Rotating	–	X	–	High back EMF voltage. Stop the rotor of the PM motor.
200	–	Fire Mode	X	–	–	Fire mode has been activated.
202	–	Fire Mode Limits Exceeded	X	–	–	Fire mode has suppressed 1 or more warranty voiding alarms.
250	–	New spare part	–	X	X	The power or switch mode power supply has been exchanged (on 400 V, 30-90 kW (40–125 hp) units). Contact the local Danfoss supplier.
251	–	New type code	–	X	X	The frequency converter has a new type code (on 400 V, 30–90 kW (40–125 hp) units). Contact the local Danfoss supplier.

Table 6.1 Warnings and Alarms

6.2 List of LCP Errors

LCP errors are not warnings or alarms. They do not affect the operation of the frequency converter. *Illustration 6.1* shows an LCP error on the LCP.

Illustration 6.1 LCP Error Example

LCP error code	Error message	Description
Err 84	LCP comm. Lost	Communication between the LCP and the frequency converter is lost.
Err 85	Key disabled	The LCP key is disabled. One of the LCP keys has been disabled in *parameter group 0-4* LCP Keypad*.
Err 86	LCP copy failed	Data copy failure. This error occurs when data is copied from frequency converter to LCP, or from LCP to frequency converter (*parameter 0-50 LCP Copy*).
Err 88	Data not compatible	LCP data incompatible. This error occurs when data is being copied from LCP to frequency converter (*parameter 0-50 LCP Copy*). The typical reason is that data is moved between frequency converter and LCP that have major software differences.
Err 89	Read only	Parameter read only. An operation is issued via LCP to write a value to a parameter that is read-only.
Err 90	Database busy	The parameter database of the frequency converter is busy.
Err 91	Parameter invalid	The parameter value that is input via the LCP is invalid.
Err 92	Exceeds limits	The parameter value that is input via the LCP exceeds limits.
Err 93	Motor is running	The LCP copy operation cannot be performed when the frequency converter is running.
Err 95	Not while running	The parameter cannot be changed while the frequency converter is running.
Err 96	Password rejected	The password that is input via the LCP is incorrect.

Table 6.2 LCP Error List

7 Specifications

7.1 Mains Supply 3x380–480 V

Frequency converter	PK37	PK75	P1K5	P2K2	P3K0	P4K0	P5K5	P7K5	P11K	P15K
Typical shaft output [kW]	0.37	0.75	1.5	2.2	3.0	4.0	5.5	7.5	11.0	15.0
Typical shaft output [hp]	0.5	1.0	2.0	3.0	4.0	5.0	7.5	10.0	15.0	20.0
Protection rating IP20	H1	H1	H1	H2	H2	H2	H3	H3	H4	H4
Maximum cable size in terminals (mains, motor) [mm² (AWG)]	4 (10)	4 (10)	4 (10)	4 (10)	4 (10)	4 (10)	4 (10)	4 (10)	16 (6)	16 (6)
Output current - 40 °C (104 °F) ambient temperature										
Continuous (3x380–440 V) [A]	1.2	2.2	3.7	5.3	7.2	9.0	12.0	15.5	23.0	31.0
Intermittent (3x380–440 V) [A]	1.3	2.4	4.1	5.8	7.9	9.9	13.2	17.1	25.3	34.0
Continuous (3x441–480 V) [A]	1.1	2.1	3.4	4.8	6.3	8.2	11.0	14.0	21.0	27.0
Intermittent (3x441–480 V) [A]	1.2	2.3	3.7	5.3	6.9	9.0	12.1	15.4	23.1	29.7
Maximum input current										
Continuous (3x380–440 V) [A]	1.2	2.1	3.5	4.7	6.3	8.3	11.2	15.1	22.1	29.9
Intermittent (3x380–440 V) [A]	1.3	2.3	3.9	5.2	6.9	9.1	12.3	16.6	24.3	32.9
Continuous (3x441–480 V) [A]	1.0	1.8	2.9	3.9	5.3	6.8	9.4	12.6	18.4	24.7
Intermittent (3x441–480 V) [A]	1.1	2.0	3.2	4.3	5.8	7.5	10.3	13.9	20.2	27.2
Maximum mains fuses	See *chapter 3.2.4 Fuses and Circuit Breakers*.									
Estimated power loss [W], best case/typical[1)]	13/15	16/21	46/57	46/58	66/83	95/118	104/131	159/198	248/274	353/379
Weight enclosure protection rating IP20 [kg (lb)]	2.0 (4.4)	2.0 (4.4)	2.1 (4.6)	3.3 (7.3)	3.3 (7.3)	3.4 (7.5)	4.3 (9.5)	4.5 (9.9)	7.9 (17.4)	7.9 (17.4)
Efficiency [%], best case/typical[2)]	97.8/97.3	98.0/97.6	97.7/97.2	98.3/97.9	98.2/97.8	98.0/97.6	98.4/98.0	98.2/97.8	98.1/ 97.9	98.0/ 97.8
Output current - 50 °C (122 °F) ambient temperature										
Continuous (3x380–440 V) [A]	1.04	1.93	3.7	4.85	6.3	8.4	10.9	14.0	20.9	28.0
Intermittent (3x380–440 V) [A]	1.1	2.1	4.07	5.4	6.9	9.2	12.0	15.4	23.0	30.8
Continuous (3x441–480 V) [A]	1.0	1.8	3.4	4.4	5.5	7.5	10.0	12.6	19.1	24.0
Intermittent (3x441–480 V) [A]	1.1	2.0	3.7	4.8	6.1	8.3	11.0	13.9	21.0	26.4

Table 7.1 3x380–480 V AC, 0.37–15 kW (0.5–20 hp), Enclosure Sizes H1–H4

1) Applies for dimensioning of frequency converter cooling. If the switching frequency is higher than the default setting, the power losses may increase. LCP and typical control card power consumptions are included. For power loss data according to EN 50598-2, refer to www.danfoss.com/vltenergyefficiency.

2) Efficiency measured at nominal current. For energy efficiency class, see chapter 7.4.12 Ambient Conditions. For part load losses, see www.danfoss.com/vltenergyefficiency.

Frequency converter	P18K	P22K	P30K	P37K	P45K	P55K	P75K	P90K
Typical shaft output [kW]	18.5	22.0	30.0	37.0	45.0	55.0	75.0	90.0
Typical shaft output [hp]	25.0	30.0	40.0	50.0	60.0	70.0	100.0	125.0
Protection rating IP20	H5	H5	H6	H6	H6	H7	H7	H8
Maximum cable size in terminals (mains, motor) [mm^2 (AWG)]	16 (6)	16 (6)	35 (2)	35 (2)	35 (2)	50 (1)	95 (0)	120 (250MCM)
Output current - 40 °C (104 °F) ambient temperature								
Continuous (3x380–440 V) [A]	37.0	42.5	61.0	73.0	90.0	106.0	147.0	177.0
Intermittent (3x380–440 V) [A]	40.7	46.8	67.1	80.3	99.0	116.0	161.0	194.0
Continuous (3x441–480 V) [A]	34.0	40.0	52.0	65.0	80.0	105.0	130.0	160.0
Intermittent (3x441–480 V) [A]	37.4	44.0	57.2	71.5	88.0	115.0	143.0	176.0
Maximum input current								
Continuous (3x380–440 V) [A]	35.2	41.5	57.0	70.0	84.0	103.0	140.0	166.0
Intermittent (3x380–440 V) [A]	38.7	45.7	62.7	77.0	92.4	113.0	154.0	182.0
Continuous (3x441–480 V) [A]	29.3	34.6	49.2	60.6	72.5	88.6	120.9	142.7
Intermittent (3x441–480 V) [A]	32.2	38.1	54.1	66.7	79.8	97.5	132.9	157.0
Maximum mains fuses	See *chapter 3.2.4 Fuses and Circuit Breakers*.							
Estimated power loss [W], best case/typical[1)]	412/456	475/523	733	922	1067	1133	1733	2141
Weight enclosure protection rating IP20 [kg (lb)]	9.5 (20.9)	9.5 (20.9)	24.5 (54)	24.5 (54)	24.5 (54)	36.0 (79.4)	36.0 (79.4)	51.0 (112.4)
Efficiency [%], best case/typical[2)]	98.1/97.9	98.1/97.9	97.8	97.7	98	98.2	97.8	97.9
Output current - 50 °C (122 °F) ambient temperature								
Continuous (3x380–440 V) [A]	34.1	38.0	48.8	58.4	72.0	74.2	102.9	123.9
Intermittent (3x380–440 V) [A]	37.5	41.8	53.7	64.2	79.2	81.6	113.2	136.3
Continuous (3x441–480 V) [A]	31.3	35.0	41.6	52.0	64.0	73.5	91.0	112.0
Intermittent (3x441–480 V) [A]	34.4	38.5	45.8	57.2	70.4	80.9	100.1	123.2

Table 7.2 3x380–480 V AC, 18.5–90 kW (25–125 hp), Enclosure Sizes H5–H8

1) Applies for dimensioning of frequency converter cooling. If the switching frequency is higher than the default setting, the power losses may increase. LCP and typical control card power consumptions are included. For power loss data according to EN 50598-2, refer to www.danfoss.com/vltenergyefficiency.

2) Efficiency measured at nominal current. For energy efficiency class, see chapter 7.4.12 Ambient Conditions. For part load losses, see www.danfoss.com/vltenergyefficiency.

7

7.2 EMC Emission Test Results

The test results in *Table 7.3* were obtained using a system with a frequency converter, a shielded control cable, a control box with potentiometer, and a shielded motor cable.

RFI filter type	**Conduct emission. Maximum shielded cable length [m (ft)]**						**Radiated emission**			
	Industrial environment									
EN 55011	**Class A Group 2** industrial environment		**Class A Group 1** industrial environment		**Class B** Housing, trades and light industries		**Class A Group 1** industrial environment		**Class B** Housing, trades and light industries	
EN/IEC 61800-3	**Category C3** Second environment Industrial		**Category C2** First environment Home and office		**Category C1** First environment Home and office		**Category C2** First environment Home and office		**Category C1** First environment Home and office	
	Without external filter	**With external filter**	**Without external filter**	**With external filter**	**Without external filter**	**With external filter**	**Without external filter**	**With external filter**	**Without external filter**	**With external filter**
H4 RFI filter (EN55011 A1, EN/IEC61800-3 C2)										
0.37–22 kW (0.5–30 hp) 3x380–480 V IP20	–	–	25 (82)	50 (164)	–	20 (66)	Yes	Yes	–	No
H2 RFI filter (EN 55011 A2, EN/IEC 61800-3 C3)										
30–90 kW (40–121 hp) 3x380–480 V IP20	25 (82)	–	–	–	–	–	No	–	No	–
H3 RFI filter (EN55011 A1/B, EN/IEC 61800-3 C2/C1)										
30–90 kW (40–121 hp) 3x380–480 V IP20	–	–	50 (164)	–	20 (66)	–	Yes	–	No	–

Table 7.3 EMC Emission Test Results

7.3 Special Conditions

NOTICE

Do not use IP20/IP21 VLT® HVAC Basic Drive FC 111 units in dusty or humid environments. See *chapter 7.4 General Technical Data* for details.

7.3.1 Derating for Ambient Temperature and Switching Frequency

Ensure that the ambient temperature measured over 24 hours is at least 5 °C (41 °F) lower than the maximum ambient temperature that is specified for the frequency converter. If the frequency converter is operated at a high ambient temperature, decrease the continuous output current. For derating curve, see *VLT® HVAC Basic Drive FC 101 Design Guide*.

7.3.2 Derating for Low Air Pressure and High Altitudes

The cooling capability of air is decreased at low air pressure. For altitudes above 2000 m (6562 ft), contact Danfoss regarding PELV. Below 1000 m (3281 ft) altitude, derating is not necessary. For altitudes above 1000 m (3281 ft), decrease the ambient temperature or the maximum output current. Decrease the output by 1% per 100 m (328 ft) altitude above 1000 m (3281 ft) or reduce the maximum ambient temperature by 1 °C (33.8 °F) per 200 m (656 ft).

7.4 General Technical Data

Protection and features

- Electronic motor thermal protection against overload.
- Temperature monitoring of the heat sink ensures that the frequency converter trips if there is overtemperature.
- The frequency converter is protected against short circuits between motor terminals U, V, W.
- When a motor phase is missing, the frequency converter trips and issues an alarm.
- When a mains phase is missing, the frequency converter trips or issues a warning (depending on the load).
- Monitoring of the DC-link voltage ensures that the frequency converter trips when the DC-link voltage is too low or too high.
- The frequency converter is protected against ground faults on motor terminals U, V, W.

7.4.1 Mains Supply (L1, L2, L3)

Mains supply (L1, L2, L3)	
Supply voltage	380–480 V ±10%
Supply frequency	50/60 Hz
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 (cosφ) near unity	(>0.98)
Switching on the input supply L1, L2, L3 (power-ups) enclosure sizes H1–H5, I2, I3, I4	Maximum 1 time/30 s
Switching on the input supply L1, L2, L3 (power-ups) enclosure sizes H6–H10, I6–I8	Maximum 1 time/minute
Environment according to EN 60664-1	Overvoltage category III/pollution degree 2
The unit is suitable for use on a circuit capable of delivering not more than 100000 A_{rms} symmetrical Amperes, 240/480 V maximum.	

7.4.2 Motor Output (U, V, W)

Output voltage	0–100% of supply voltage
Output frequency	0–200 Hz (VVC+), 0–400 Hz (u/f)
Switching on output	Unlimited
Ramp times	0.05–3600 s

7.4.3 Cable Length and Cross-section

Maximum motor cable length, shielded/armored (EMC-correct installation)	See *chapter 7.2 EMC Emission Test Results*
Maximum motor cable length, unshielded/unarmored	50 m (164 ft)
Maximum cross-section to motor, mains[1)]	
Cross-section DC terminals for filter feedback on enclosure sizes H1–H3, I2, I3, I4	4 mm^2/11 AWG
Cross-section DC terminals for filter feedback on enclosure sizes H4–H5	16 mm^2/6 AWG
Maximum cross-section to control terminals, rigid wire	2.5 mm^2/14 AWG
Maximum cross-section to control terminals, flexible cable	2.5 mm^2/14 AWG
Minimum cross-section to control terminals	0.05 mm^2/30 AWG

1) See *chapter 7.1.1 3x380–480 V AC* for more information.

7.4.4 Digital Inputs

Programmable digital inputs	4
Terminal number	18, 19, 27, 29
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
Input resistance, R_i	Approximately 4 kΩ
Digital input 29 as thermistor input	Fault: >2.9 kΩ and no fault: <800 Ω
Digital input 29 as pulse input	Maximum frequency 32 kHz push-pull-driven & 5 kHz (O.C.)

7.4.5 Analog Inputs

Number of analog inputs	2
Terminal number	53, 54
Terminal 53 mode	*Parameter 16-61 Terminal 53 Setting*: 1 = voltage, 0 = current
Terminal 54 mode	*Parameter 16-63 Terminal 54 Setting*: 1 = voltage, 0 = current
Voltage level	0–10 V
Input resistance, R_i	Approximately 10 kΩ
Maximum voltage	20 V
Current level	0/4–20 mA (scalable)
Input resistance, R_i	<500 Ω
Maximum current	29 mA
Resolution on analog input	10 bit

7.4.6 Analog Output

Number of programmable analog outputs	2
Terminal number	42, 45[1)]
Current range at analog output	0/4–20 mA
Maximum load to common at analog output	500 Ω
Maximum voltage at analog output	17 V
Accuracy on analog output	Maximum error: 0.4% of full scale
Resolution on analog output	10 bit

1) Terminals 42 and 45 can also be programmed as digital outputs.

7.4.7 Digital Output

Digital output	
Number of digital outputs	4
Terminals 27 and 29	
Terminal number	27, 29[1)]
Voltage level at digital output	0–24 V
Maximum output current (sink and source)	40 mA
Terminals 42 and 45	
Terminal number	42, 45[2)]
Voltage level at digital output	17 V
Maximum output current at digital output	20 mA
Maximum load at digital output	1 kΩ

1) Terminals 27 and 29 can also be programmed as input.

2) Terminals 42 and 45 can also be programmed as analog output.

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

7.4.8 Control Card, RS485 Serial Communication

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

7.4.9 Control Card, 24 V DC Output

Terminal number	12
Maximum load	80 mA

7.4.10 Relay Output

Programmable relay output	2
Relay 01 and 02	01–03 (NC), 01–02 (NO), 04–06 (NC), 04–05 (NO)
Maximum terminal load (AC-1)[1)] on 01–02/04–05 (NO) (resistive load)	250 V AC, 3 A
Maximum terminal load (AC-15)[1)] on 01–02/04–05 (NO) (inductive load @ cosφ 0.4)	250 V AC, 0.2 A
Maximum terminal load (DC-1)[1)] on 01–02/04–05 (NO) (resistive load)	30 V DC, 2 A
Maximum terminal load (DC-13)[1)] on 01–02/04–05 (NO) (inductive load)	24 V DC, 0.1 A
Maximum terminal load (AC-1)[1)] on 01–03/04–06 (NC) (resistive load)	250 V AC, 3 A
Maximum terminal load (AC-15)[1)] on 01–03/04–06 (NC) (inductive load @ cosφ 0.4)	250 V AC, 0.2 A
Maximum terminal load (DC-1)[1)] on 01–03/04–06 (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
Environment according to EN 60664-1	Overvoltage category III/pollution degree 2

1) IEC 60947 parts 4 and 5.

7.4.11 Control Card, 10 V DC Output

Terminal number	50
Output voltage	10.5 V ±0.5 V
Maximum load	25 mA

7.4.12 Ambient Conditions

Enclosure protection rating	IP20, IP54
Enclosure kit available	IP21, TYPE 1
Vibration test	1.0 g
Maximum relative humidity	5–95% (IEC 60721-3-3; Class 3K3 (non-condensing)) during operation
Aggressive environment (IEC 60721-3-3), coated (standard) enclosure sizes H1–H5	Class 3C3
Aggressive environment (IEC 60721-3-3), non-coated enclosure sizes H6–H10	Class 3C2
Aggressive environment (IEC 60721-3-3), coated (optional) enclosure sizes H6–H10	Class 3C3
Aggressive environment (IEC 60721-3-3), non-coated enclosure sizes I2–I8	Class 3C2
Test method according to IEC 60068-2-43 H2S (10 days)	
Ambient temperature[1)]	See maximum output current at 40/50 °C (104/122 °F) in *chapter 7.1 Mains Supply 3x380–480 V*.
Minimum ambient temperature during full-scale operation	0 °C (32 °F)
Minimum ambient temperature at reduced performance	-20 °C (-4 °F)
Minimum ambient temperature at reduced performance	-10 °C (14 °F)
Temperature during storage/transport	-30 to +65/70 °C (-22 to +149/158°F)
Maximum altitude above sea level without derating	1000 m (3281 ft)
Maximum altitude above sea level with derating	3000 m (9843 ft)
Derating for high altitude, see *chapter 7.3.2 Derating for Low Air Pressure and High Altitudes*.	
Safety standards	EN/IEC 61800-5-1, UL 508C
EMC standards, Emission	EN 61800-3, EN 61000-6-3/4, EN 55011, IEC 61800-3
EMC standards, Immunity	EN 61800-3, EN 61000-3-12, 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
Energy efficiency class[2)]	IE2

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

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

2) Determined according to EN 50598-2 at:

- *Rated load.*
- *90% rated frequency.*
- *Switching frequency factory setting.*
- *Switching pattern factory setting.*

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