ENGINEERING TOMORROW

Operating Guide

VLT® Flow Drive FC 111

vlt-drives.danfoss.com

Contents

1 Introduction

1.1 Purpose of this Operating Guide

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

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

Pay particular attention to the safety instructions and general warnings. Always keep this Operating Guide with the drive.

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1.2 Additional Resources

1.2.1 Other Resources

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

- The VLT® Flow Drive FC 111 Programming Guide provides information on how to program and includes complete parameter descriptions.
- The VLT® Flow Drive FC 111 Design Guide provides all technical information about the drive. It also lists options and accessories.

The technical documentation is available in electronic form online at www.danfoss.com.

1.2.2 MCT 10 Set-up Software Support

Download the software from the service and support section on www.danfoss.com.

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

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

1.3 Document and Software Version

The Operating Guide is regularly reviewed and updated. All suggestions for improvement are welcome.

The original language of this manual is English.

Table 1: Document and Software Version

Edition	Remarks	Software version
AQ304735638503, version 0301	Update the manual for 30–90 kW (40–125 hp) drives.	75.02 for 30–90 kW (40–125 hp); 65.02 for other power sizes of the drive.

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

2.1 Safety Symbols

The following symbols are used in this manual:

⚠ D A N G E R ⚠

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

⚠ W A R N I N G ⚠

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

⚠ C A U T I O N ⚠

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

N O T I C E

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

2.2 Qualified Personnel

To allow trouble-free and safe operation of the unit, only qualified personnel with proven skills are allowed to transport, store, assemble, install, program, commission, maintain, and decommission this equipment.

Persons with proven skills:

- Are qualified electrical engineers, or persons who have received training from qualified electrical engineers and are suitably experienced to operate devices, systems, plant, and machinery in accordance with pertinent laws and regulations.
- Are familiar with the basic regulations concerning health and safety/accident prevention.
- Have read and understood the safety guidelines given in all manuals provided with the unit, especially the instructions given in the Operating Guide.
- Have good knowledge of the generic and specialist standards applicable to the specific application.

2.3 Safety Precautions

⚠ W A R N I N G ⚠

HAZARDOUS VOLTAGE

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

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

⚠ W A R N I N G ⚠

UNINTENDED START

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

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

⚠ W A R N I N G ⚠

DISCHARGE TIME

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

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

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

Table 2: Discharge Time

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
3x400	110–315 (150–450)	20

⚠ W A R N I N G ⚠

LEAKAGE CURRENT HAZARD

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

- Ensure that the minimum size of the ground conductor complies with the local safety regulations for high touch current equipment.

⚠ W A R N I N G ⚠

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.

⚠ C A U T I O N ⚠

INTERNAL FAILURE HAZARD

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

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

2.4 Motor Thermal Protection

Procedure

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

3 Product Overview

3.1 Intended Use

The drive is an electronic motor controller that converts AC mains input into a variable AC waveform output. The frequency and voltage of the output are regulated to control the motor speed or torque. The drive is designed to:

- Regulate motor speed in response to system feedback or remote commands from external controllers.
- Monitor system and motor status.
- Provide motor overload protection.

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

N O T I C E

RADIO INTERFERENCE

In a residential environment, this product can cause radio interference.

– Take supplementary mitigation measures.

Foreseeable misuse

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

3.2 Power Ratings, Weights, and Dimensions

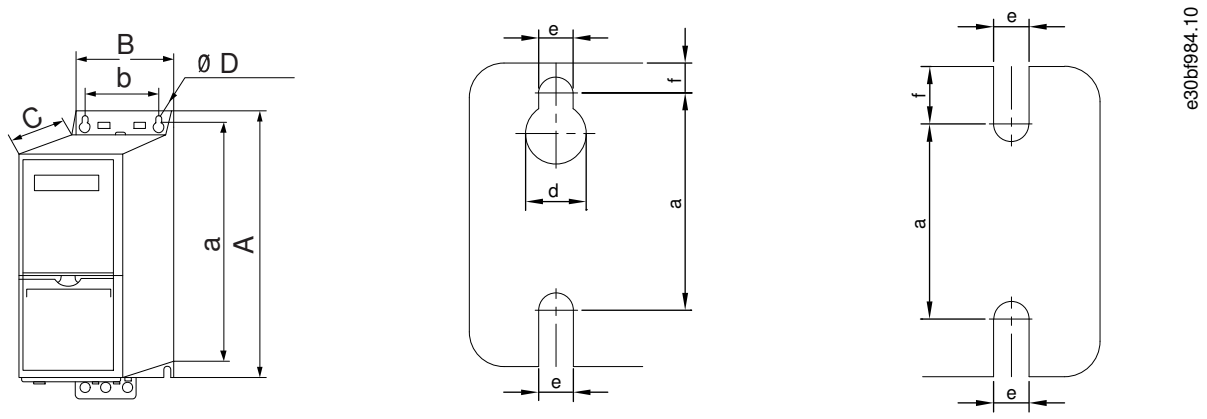


Illustration 1: Dimensions, Enclosure Sizes H1–H5 & H11–H12

Table 3: Power Ratings, Weights, and Dimensions, Enclosure Sizes H1–H5

Enclosure Size		H1	H2	H3	H4	H5
IP class		IP20	IP20	IP20	IP20	IP20
Power [kW (hp)]	**3x380–480 V**	0.37–1.5 (0.5–2.0)	2.2–4.0 (3.0–5.0)	5.5–7.5 (7.5–10)	11–15 (15–20)	18.5–22 (25–30)
Height [mm (in)]	**A**	195 (7.7)	227 (8.9)	255 (10.0)	296 (11.7)	334 (13.1)
	A[(1)]	273 (10.7)	303 (11.9)	329 (13.0)	359 (14.1)	402 (15.8)
	a	183 (7.2)	212 (8.3)	240 (9.4)	275 (10.8)	314 (12.4)
Width [mm (in)]	**B**	75 (3.0)	90 (3.5)	100 (3.9)	135 (5.3)	150 (5.9)
	b	56 (2.2)	65 (2.6)	74 (2.9)	105 (4.1)	120 (4.7)
Depth [mm (in)]	**C**	168 (6.6)	190 (7.5)	206 (8.1)	241 (9.5)	255 (10)

Enclosure Size		H1	H2	H3	H4	H5
Mounting hole [mm (in)]	d	9 (0.35)	11 (0.43)	11 (0.43)	12.6 (0.50)	12.6 (0.50)
	e	4.5 (0.18)	5.5 (0.22)	5.5 (0.22)	7 (0.28)	7 (0.28)
	f	5.3 (0.21)	7.4 (0.29)	8.1 (0.32)	8.4 (0.33)	8.5 (0.33)
Maximum weight [kg (lb)]		2.1 (4.6)	3.4 (7.5)	4.5 (9.9)	7.9 (17.4)	9.5 (20.9)

[1] Including decoupling plate.

Table 4: Power Ratings, Weights, and Dimensions H11–H12

Enclosure Size		H11	H12
IP class		IP20	IP20[1]
Power [kW (hp)]	3x380–480 V	30–45 (40–60)	55–90 (70–125)
Height [mm (in)]	A	515 (20.3)	550 (21.7)
	A[2]	545 (21.5)	610.5 (24)
	a	495 (19.5)	521 (20.5)
Width [mm (in)]	B	233 (9.2)	308 (12.1)
	b	200 (7.9)	270 (10.6)
Depth [mm (in)]	C	241 (9.5)	323 (12.7)
Mounting hole [mm (in)]	d	–	–
	e	8.5 (0.33)	8.5 (0.33)
	f	13 (0.5)	17 (0.67)
Maximum weight [kg (lb)]		22.6 (49.8)	40.7 (89.7)

[1] Install the protective cover on the mains and motor terminals after connecting the stripped wire. See Illustration 2.

[2] Including decoupling plate.

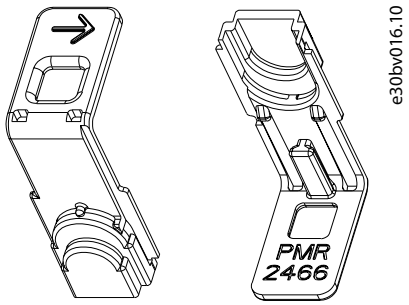


Illustration 2: Protective Cover

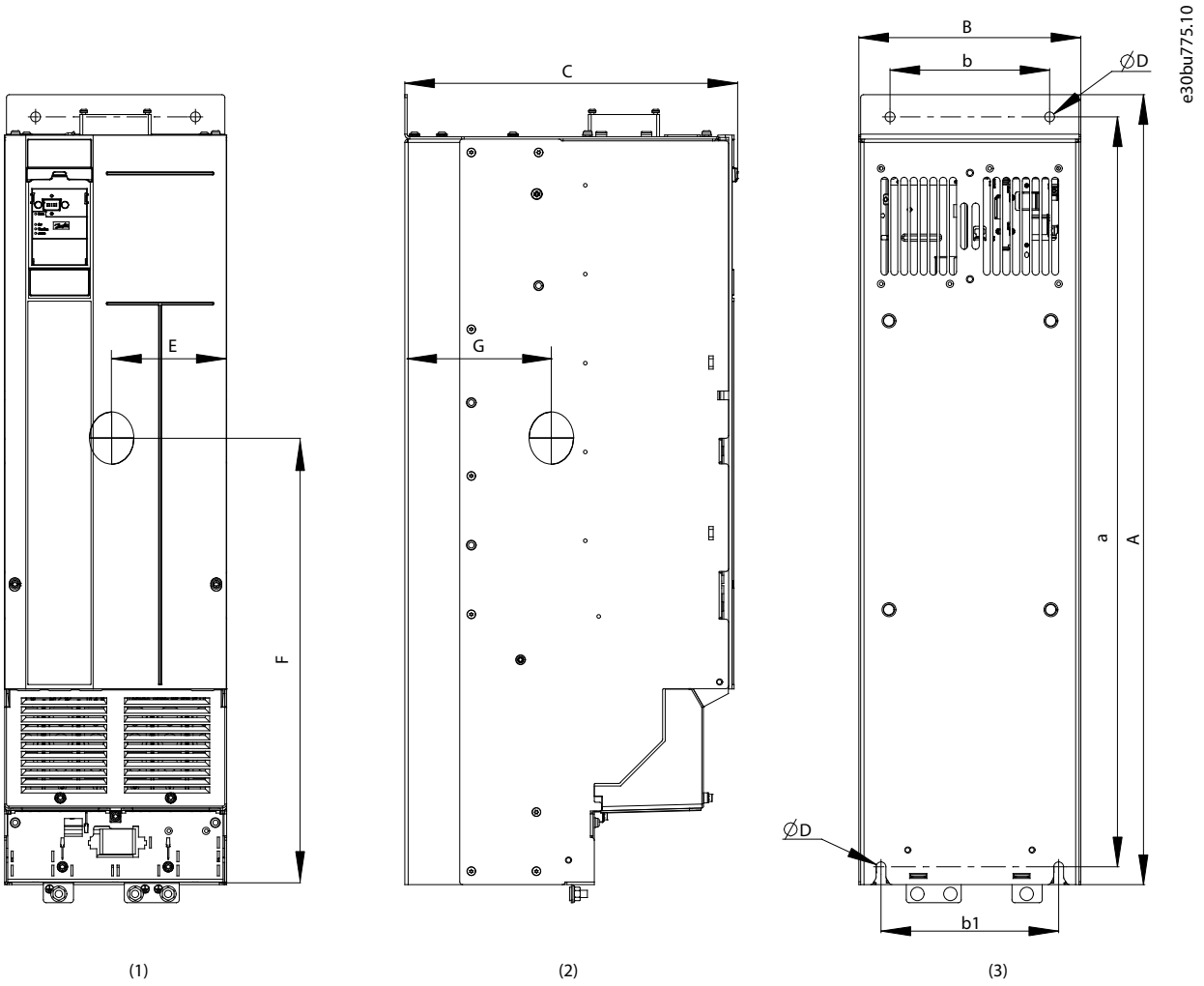


Illustration 3: Dimensions, Enclosure Sizes H13–H14

1	Front view	3	Back view
2	Side view		

Table 5: Power Ratings, Weights, and Dimensions H13–H14

Enclosure Size		**H13**	**H14**
IP class		IP20	IP20
Power [kW (hp)]	**3x380–480 V**	110–160 (150–250)	200–315 (300–450)
Height [mm (in)]	**A**	889 (35.0)	1096 (43.1)
	A(1)	909 (35.8)	1122 (44.2)
	a	844 (33.2)	1051 (41.4)
Width [mm (in)]	**B**	250 (9.8)	350 (13.8)
	b	180 (7.1)	280 (11.0)
	b1	200 (7.9)	271 (10.7)

Enclosure Size		H13	H14
Depth [mm (in)]	**C**	375 (14.8)	375 (14.8)
Mounting hole [mm (in)]	**D**	11 (0.4)	11 (0.4)
Center of gravity [mm (in)]	**E**	128 (5.0)	176 (6.9)
	F	495 (19.5)	611 (24.1)
	G	148 (5.8)	148 (5.8)
Maximum weight [kg (lb)]		98 (216)	164 (362)

[1] Including decoupling plate.

The dimensions are only for the physical units.

3.3 Check Valve Monitoring

In the pump application system, a damaged check valve is hard to detect, which therefore causes low efficiency of the whole system. VLT® Flow Drive FC 111 can monitor the status of check valves in the system. After enabling the check valve monitoring function via setting *parameter 22-04 Check Valve Monitor* to *[1] Enabled*, the drive trips *warning 159, Check Valve Failure* if a damaged check valve is detected.

3.4 Dry Pump Detection

In the pump application system, the drive monitors the operation status of the system to detect whether there is water on the pump's suction side. If the pump runs at maximum speed and consumes little power, then it can be assumed that there is no water on the pump's suction side. Via setting *parameter 22-26 Dry Pump Function* to warning or alarm, the drive trips *warning/alarm 93, dry pump* if the dry-pump condition is detected.

3.5 End of Curve Detection

In the pump application system, the drive monitors the operation status of the system to detect whether the pressure side of pump is subject to a major leakage. If the pump runs at maximum speed for a defined time period, but the pressure is below the set point, then it can be considered to reflect the end-of-curve situation. Via setting *parameter 22-50 End of Curve Function* to warning or alarm, the drive trips *warning/alarm 94, end of curve* if the end-of-curve condition is detected.

3.6 Time-based Functions

In some application scenarios, there are requirements to control the motor running for a specific time, in a specific direction and a specific speed within a specific time interval. For example, checking the motor status in fire mode or exercising pumps, fans, and compressors.

For detailed parameter settings, refer to the *parameter group 23-** Time-based Functions* in the drive's Programming Guide.

3.7 Relays and Terminals

3.7.1 Relays and Terminals on Enclosure Sizes H1–H5

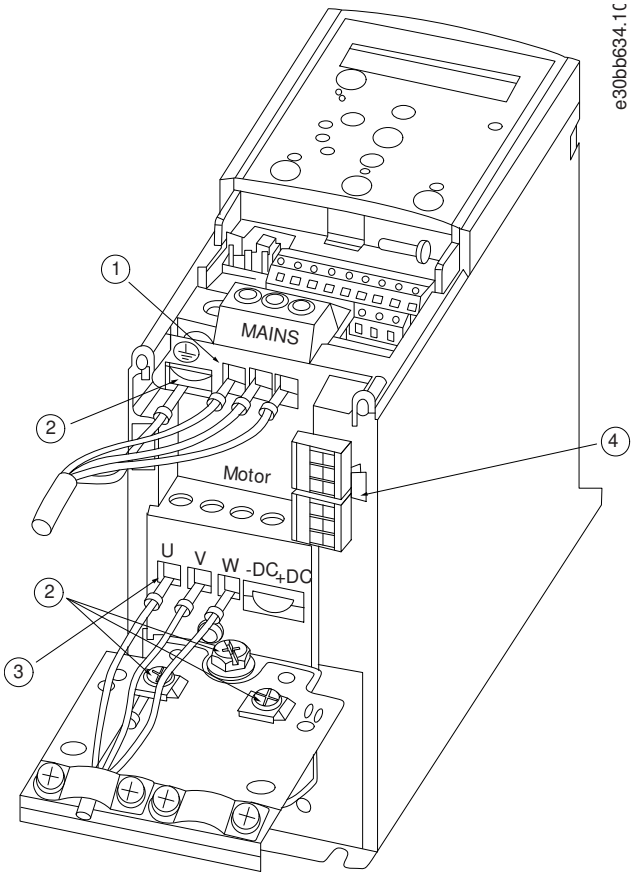


Illustration 4: Enclosure Sizes H1–H5 IP20, 380–480 V, 0.37–22 kW (0.5–30 hp)

1	Mains	3	Motor
2	Ground	4	Relays

3.7.2 Relays and Terminals on Enclosure Size H11

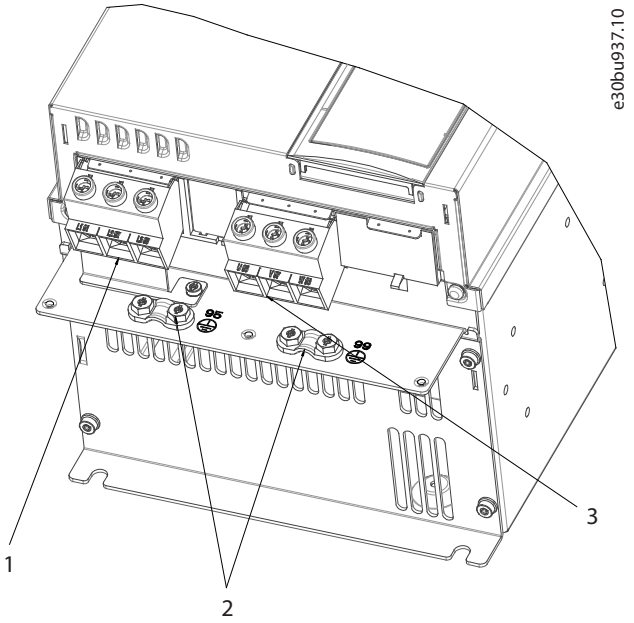


Illustration 5: Enclosure Size H11 IP20, 380–480 V, 30–45 kW (40–60 hp)

1	Mains	3	Motor
2	Ground		

See 3.8 View of Control Shelf for the relay terminals of H11 drives.

3.7.3 Relays and Terminals on Enclosure Size H12

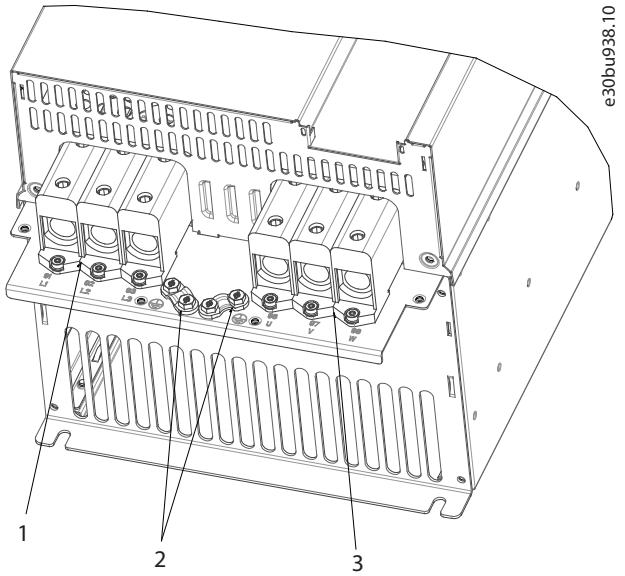


Illustration 6: Enclosure Size H12 IP20, 380–480 V, 55–90 kW (75–125 hp)

1	Mains	3	Motor
2	Ground		

See 3.8 View of Control Shelf for the relay terminals of H12 drives.

3.7.4 Relays and Terminals on Enclosure Size H13–H14

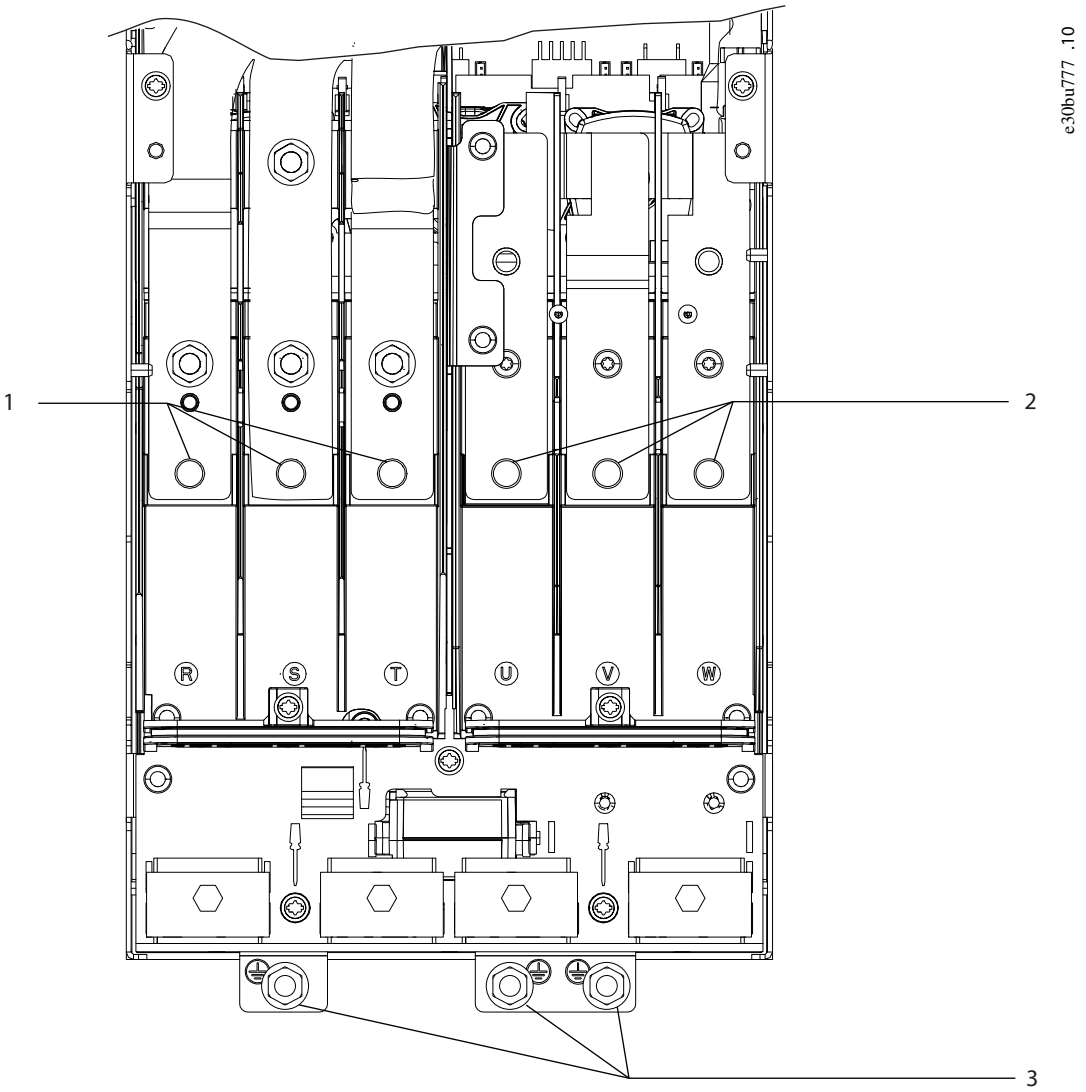


Illustration 7: Enclosure Size H13–H14 IP20, 380–480 V, 110–315 kW (150–450 hp)

1	Mains	3	Ground
2	Motor		

See 3.8 View of Control Shelf for the relay terminals of H13–H14 drives.

3.8 View of Control Shelf

The control shelf of H11-H14 drives holds the keypad, known as the local control panel or LCP. The control shelf also includes the control terminals, relays, and various connectors.

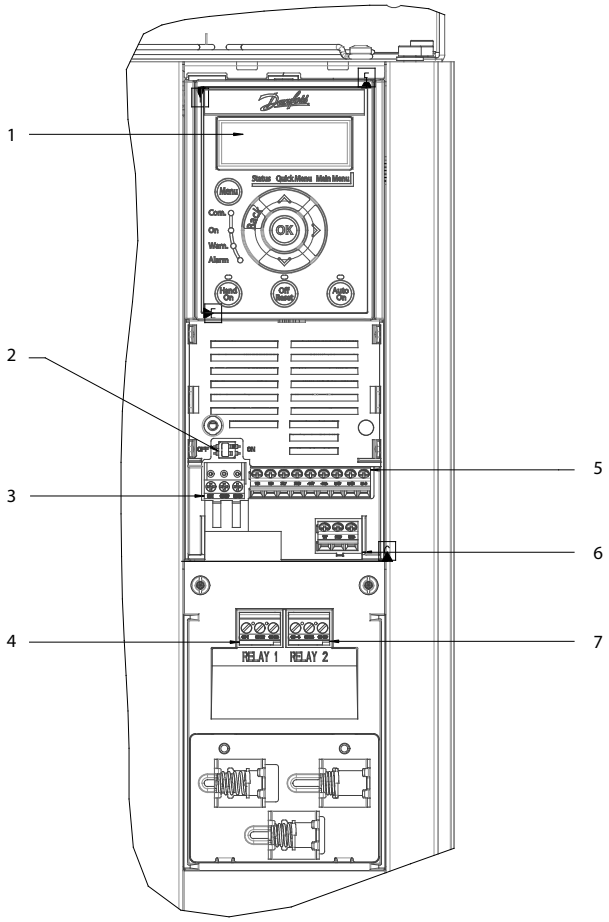


Illustration 8: View of Control Shelf in H11–H12

1	LCP	5	Digital I/O and 24 V supply
2	RS485 termination switch	6	Analog I/O connector
3	RS485 fieldbus connector	7	Relay 2 on power card
4	Relay 1 on power card		

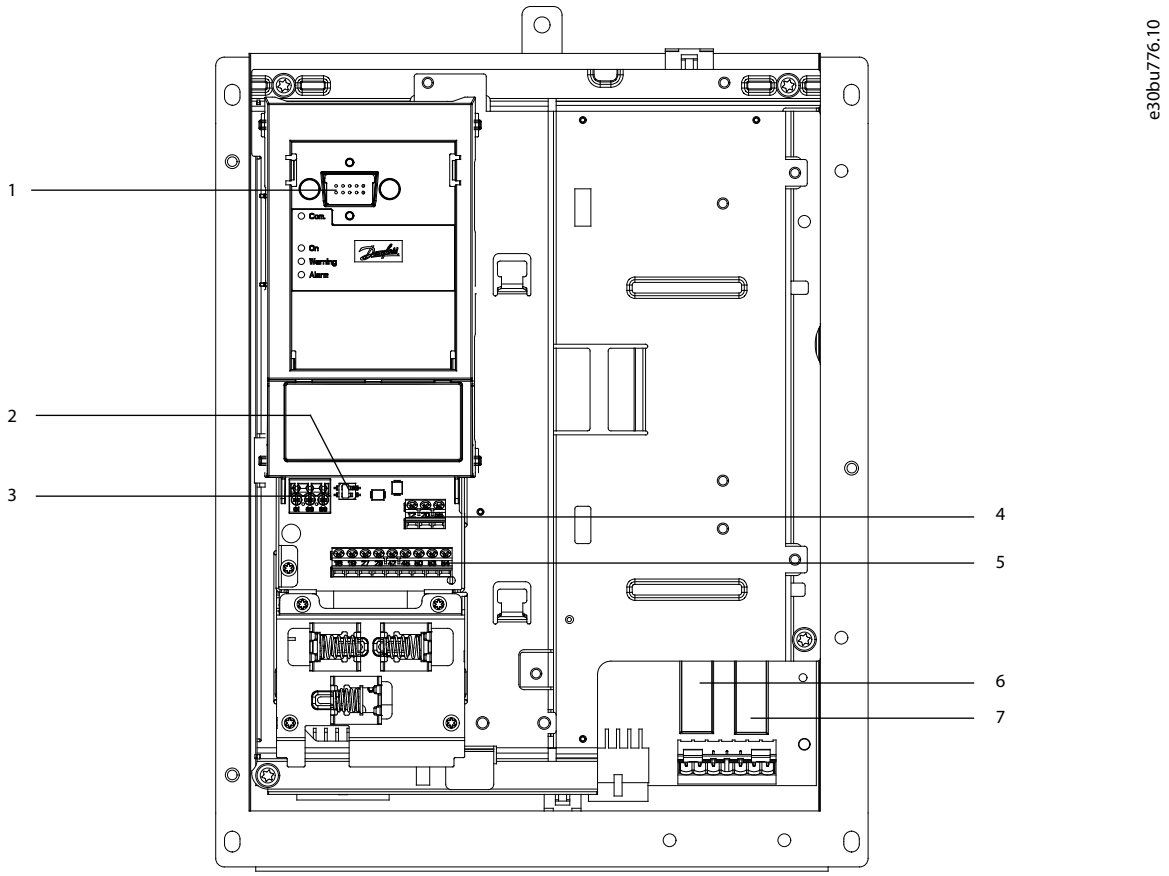


Illustration 9: View of Control Shelf in H13–H14

1	LCP connector	5	Digital I/O and 24 V supply
2	RS485 termination switch	6	Relay 1 on power card
3	RS485 fieldbus connector	7	Relay 2 on power card
4	Analog I/O connector		

4 Mechanical Installation

4.1 Storage and Operating Environment

Storage

Store the drive in a dry location. Keep the equipment sealed in its packaging until installation. Refer to the *Ambient Conditions* section for recommended ambient temperature.

Periodic forming (capacitor charging) is not necessary during storage unless storage exceeds 12 months.

Operating Environment

NOTICE

OPERATING ENVIRONMENT

In environments with airborne liquids, particles, or corrosive gases, failure to meet requirements for ambient conditions can reduce the lifetime of the drive.

- Ensure that the IP/Type rating of the equipment matches the installation environment.
- Ensure that requirements for air humidity, temperature, and altitude are met.

Table 6: Installation at High Altitudes

Voltage [V]	Altitude restrictions
380–480	At altitudes above 3000 m (9842 ft), contact Danfoss regarding PELV.

NOTICE

CONDENSATION

Moisture can condense on the electronic components and cause short circuits.

- Avoid installation in areas subject to frost.
- Install an optional space heater when the drive is colder than the ambient air.
- Operating in standby mode reduces the risk of condensation as long as the power dissipation keeps the circuitry free of moisture.

NOTICE

EXTREME AMBIENT CONDITIONS

Hot or cold temperatures compromise unit performance and longevity.

- Do not operate in environments where the ambient temperature exceeds 55 °C (131 °F).
- The drive can operate at temperatures down to -15 °C (5 °F). However, proper operation at rated load is only guaranteed at 0 °C (32 °F) or higher.
- Extra air conditioning of the cabinet or installation site is required if temperature exceeds ambient temperature limits.

⚠ WARNING ⚠

EXPLOSIVE ATMOSPHERE

Do not install the drive in a potentially explosive atmosphere.

- Install the unit in a cabinet outside of this area.
- Failure to follow this guideline increases risk of death or serious injury.

N O T I C E

GASES

Aggressive gases, such as hydrogen sulfide, chlorine, or ammonia can damage the electrical and mechanical components.

– The unit uses conformal-coated circuit boards to reduce the effects of aggressive gases.

When installing the drive in dusty environments, pay attention to the following:

Periodic maintenance

When dust accumulates on electronic components, it acts as a layer of insulation. This layer reduces the cooling capacity of the components, and the components become warmer. The hotter environment decreases the life of the electronic components. Keep the heat sink and fans free from dust build-up.

Cooling fans

Fans provide airflow to cool the drive. When fans are exposed to dusty environments, the dust can damage the fan bearings and cause premature fan failure. Also, dust can accumulate on fan blades causing an imbalance which prevents the fans from properly cooling the unit.

4.2 Side-by-side Installation

The drive can be mounted side by side but requires the clearance above and below for cooling.

Table 7: Clearance Required for Cooling

Size	IP class	Power [kW (hp)]	Clearance above/below [mm (in)]
		3x380–480 V	
H1	IP20	0.37–1.5 (0.5–2.0)	100 (4)
H2	IP20	2.2–4.0 (3.0–5.4)	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)
H11	IP20	30–45 (40–60)	200 (7.9)
H12	IP20	55–90 (70–125)	200 (7.9)
H13	IP20/Chassis	110–160 (150–250)	225 (9)
H14	IP20/Chassis	200–315 (300–450)	225 (9)

N O T I C E

With IP21 option kit mounted (available for H1–H5 & H11–H12), a distance of 50 mm (2 in) between the units is required.

4.3 Tools Needed

Table 8: Tools Needed

Tools Needed	Receiving/unloading	Installation
H1–H5	–	• 3 mm flat-edged screwdriver for terminals. • T20 torx head screwdriver for M5 grounding screw.
H11–H12	• I-beam and hooks rated to lift the weight of the drive. Refer to 3.2 Power Ratings, Weights, and Dimensions. • Crane or other lifting aid to place the unit into position.	• Allen key 6# (for M8). • T30 torx head screwdriver for terminals. • T25 torx head screwdriver for M6 grounding screw.
H13–H14		• Drill with a 12 mm (1/2 in) drill bit. • Tape measurer. • Phillips and flat bladed screwdrivers. • Wrench with 7–17 mm metric sockets. • Wrench extensions. • T25 and T50 torx drives. • Sheet metal punch and/or pliers for cable entry plate.

4.4 Installation and Cooling Requirements

NOTICE

OVERHEATING

Improper mounting can result in overheating and reduced performance.

– Install the drive according to the installation and cooling requirements.

Installation requirements

- Ensure drive stability by mounting the drive vertically to a solid flat surface.
- Ensure that the strength of the mounting location supports the drive weight. Ensure that the mounting location allows access to open the enclosure door. Refer to 3.2 Power Ratings, Weights, and Dimensions.
- Ensure that there is enough space around the drive for cooling airflow.
- Place the drive as near to the motor as possible. Keep the motor cables as short as possible. See 10.4.4 Cable Length and Cross-section.
- Ensure the location allows for cable entry at the bottom of the drive.

Cooling and airflow requirements

- Ensure that top and bottom clearance for air cooling is provided, see 4.2 Side-by-side Installation.
- Consider derating for temperatures starting between 40 °C (104 °F) and 55 °C (131 °F) and elevation 1000 m (3300 ft) above sea level. See *chapter Derating* in the Design Guide for detailed information.
- The drive's maximum heating value could be estimated via the following equation:

  Maximum heating value ≈ Power × (1 − Efficiency)

  For example, the heating value of 110 kW (150 hp) drive could be 2.2 kW. Refer to 10.1.1 3x380–480 V AC for the drive's efficiency at rated load.
- If multiple drives are installed in 1 cabinet at the same time, the heating value and ventilation volume shall be accumulated.

- If there are other heating devices, increase the ventilation according to the instructions.
- If the dust screen needs to be installed, the air volume needs to be appropriately increased according to the wind resistance coefficient of the dust screen. For the wind resistance coefficient of dust screen, contact the dust screen supplier.

Table 9: Ventilation Volume Reference Value of the Cabinet

Power [kW (hp)]	Ventilation volume reference value of the cabinet	
	CFM	m^3/hr
0.37 (0.5)	2	4
0.75 (1.0)	4	7
1.5 (2.0)	8	14
2.2 (3.0)	9	15
3 (4.0)	13	22
4 (5.0)	19	32
5.5 (7.5)	22	37
7.5 (10)	40	68
11 (15)	73	125
15 (20)	100	170
18.5 (25)	135	229
22 (30)	160	272
30 (40)	178	303
37 (50)	220	374
45 (60)	240	408
55 (70)	257	436
75 (100)	350	595
90 (125)	370	629
110 (150)	414	704
132 (175)	499	849
160 (250)	605	1029
200 (300)	757	1286
250 (350)	887	1507
315 (450)	1118	1900

4.5 Lifting the Drive

⚠ W A R N I N G ⚠

HEAVY LOAD

Unbalanced loads can fall or tip over. Failure to take proper lifting precautions increases risk of death, serious injury, or equipment damage.

- Move the unit using a hoist, crane, forklift, or other lifting device with the appropriate weight rating. See 3.2 Power Ratings, Weights, and Dimensions for the weight of the drive.
- Failure to locate the center of gravity and correctly position the load can cause unexpected shifting during lifting and transport. For measurements and center of gravity, see 3.2 Power Ratings, Weights, and Dimensions.
- The angle from the top of the drive module to the lifting cables affects the maximum load force on the cable. This angle must be 65° or greater. Refer to the following illustration. Attach and dimension the lifting cables properly.
- Never walk under suspended loads.
- To guard against injury, wear personal protective equipment such as gloves, safety glasses, and safety shoes.

Always lift the drive using the dedicated eye bolts at the top of the drive. See the following illustration.

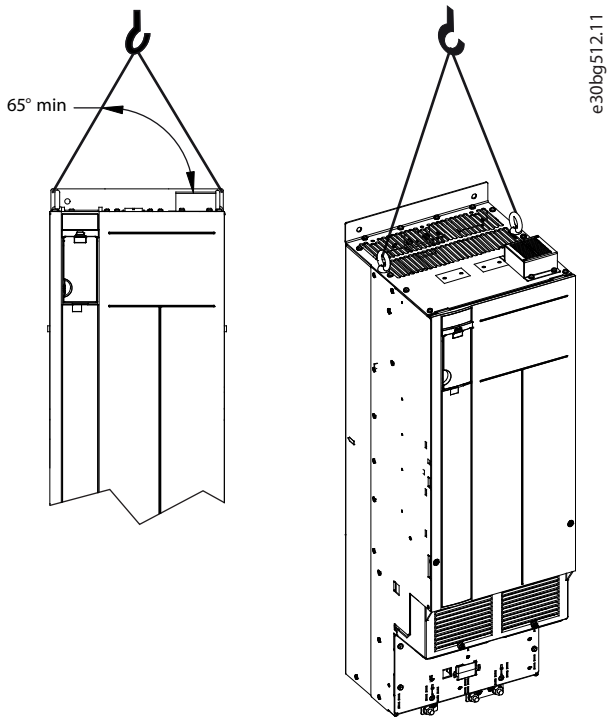


Illustration 10: Lifting the Drive

4.6 Wall Mounting the Drive

H13 and H14 are chassis drives intended to be mounted on a wall or on a mounting plate within an enclosure. To wall mount the drive, use the following steps.

Procedure

1. Fasten 2 M10 bolts in the wall to align with the fastener slots at the bottom of drive.
2. Slide the lower fastener slots in the drive over the M10 bolts.

3. Tip the drive against the wall, and secure the top with 2 M10 bolts in the mounting holes.

Example

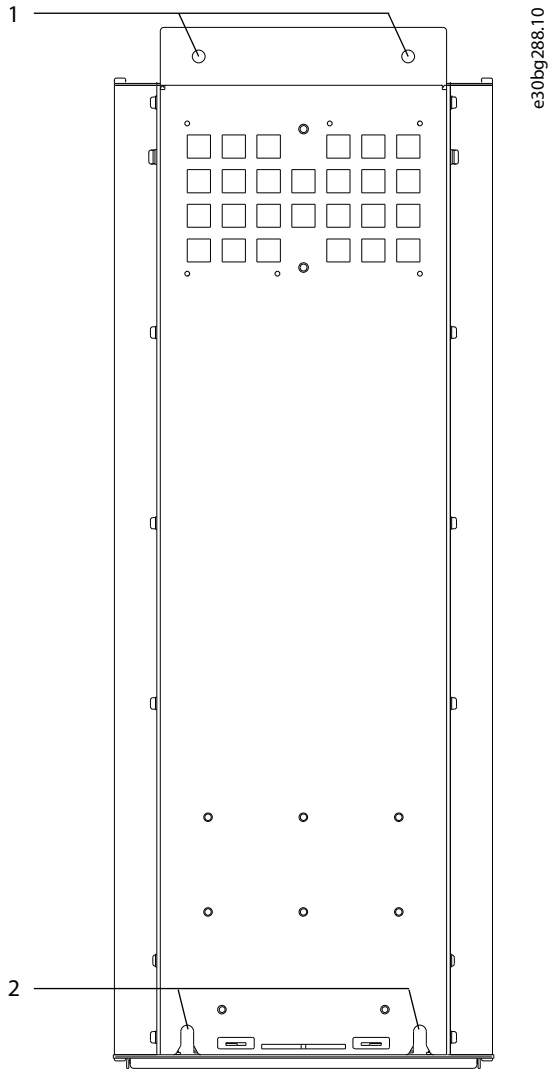


Illustration 11: Drive-to-wall Mounting Holes

1	Top mounting holes
2	Lower fastener slots

4.7 Creating Cable Openings

After installing H13-H14 drive, create cable openings in the gland plate to accommodate the mains and motor cables. The gland plate is required to maintain the drive protection rating.

Procedure

1. Punch out plastic tabs to accommodate the cables.

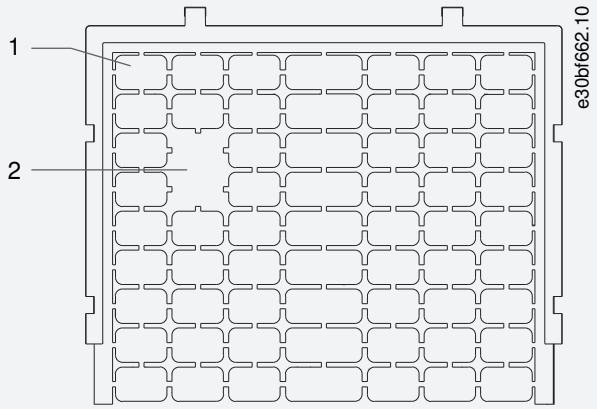


Illustration 12: Cable Openings in Plastic Gland Plate

1	Plastic tabs
2	Tabs removed for cable access

5 Electrical Installation

5.1 Safety Instructions

See *chapter Safety* for general safety instructions.

⚠ WARNING ⚠

INDUCED VOLTAGE

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

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

⚠ WARNING ⚠

SHOCK HAZARD

The drive can cause a DC current in the ground conductor and thus result in death or serious injury. Failure to follow the recommendation means that the residual current-operated protective device (RCD) cannot provide the intended protection.

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

Overcurrent protection

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

Wire type and ratings

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

See 10.4.4 Cable Length and Cross-section for recommended wire sizes and types.

5.2 EMC-compliant Electrical Installation

To ensure EMC-correct electrical installation, observe the following:

- 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 drive and the ground potential of PLC.
- Use star washers and galvanically conductive installation plates.

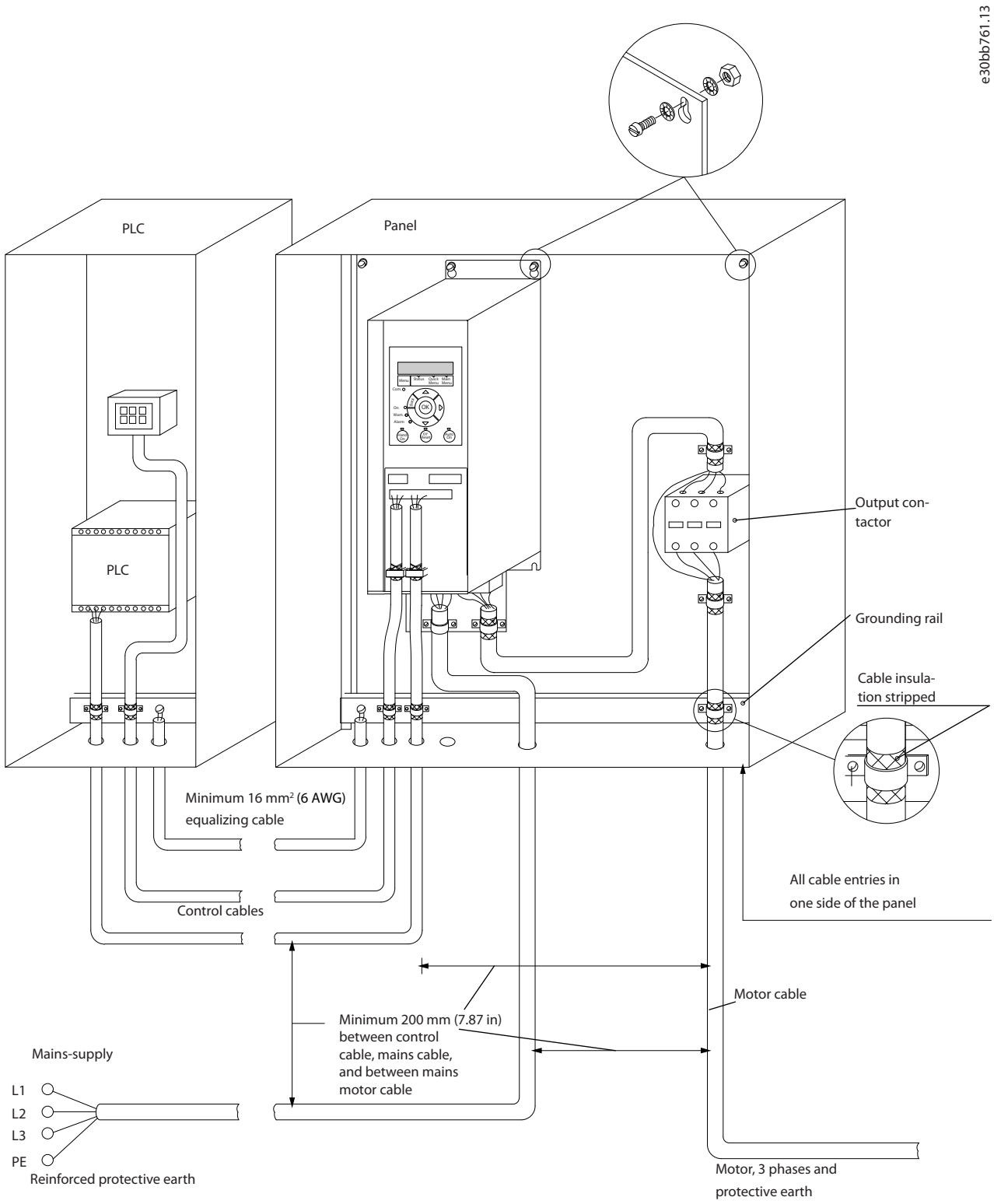


Illustration 13: EMC-compliant Installation

5.3 Electrical Wiring

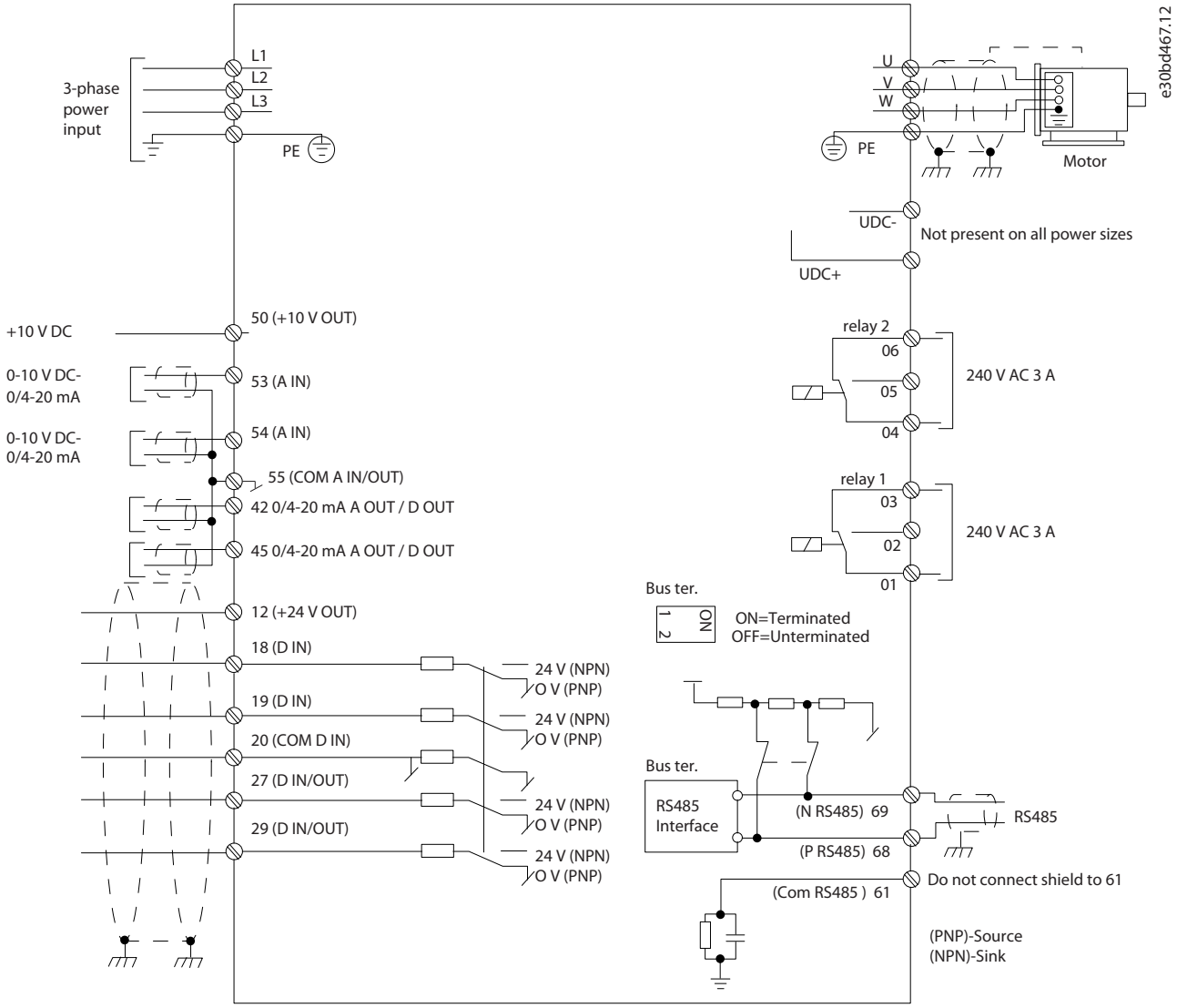


Illustration 14: Basic Wiring Schematic Drawing

N O T I C E

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

- IP20, 380–480 V, 30–315 kW (40–450 hp)

5.4 Fastener Tightening Torques

Apply the correct torque when tightening fasteners in the locations that are listed in the following tables. Too low or too high torque when fastening an electrical connection results in a bad electrical connection. To ensure correct torque, use a torque wrench.

Table 10: Tightening Torques for Enclosure Sizes H1–H5 & H11–H12, 3x380–480 V

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)	0.8 (7)	0.8 (7)	0.8 (7)	0.5 (4)	0.8 (7)	0.5 (4)
H2	IP20	2.2–4.0 (3.0–5.4)	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)

Power [kW (hp)]			Torque [Nm (in-lb)]					
Enclosure size	IP class	3x380–480 V	Mains	Motor	DC connection	Control terminals	Ground	Relay
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)
H11	IP20	30–45 (40–60)	4.5 (40)	4.5 (40)	–	0.5 (4)	3 (27)	0.5 (4)
H12	IP20	55 (70)	10 (89)	10 (89)	–	0.5 (4)	3 (27)	0.5 (4)
H12	IP20	75 (100)	14 (124)	14 (124)	–	0.5 (4)	3 (27)	0.5 (4)
H12	IP20	90 (125)	24 (212)[1]	24 (212)[1]	–	0.5 (4)	3 (27)	0.5 (4)

[1] Cable dimensions >95 mm^2.

Table 11: Tightening Torques for Enclosure Sizes H13–H14, 3x380–480 V

Location	Bolt size	Torque [Nm (in-lb)]
Mains terminals	M10/M12	19 (168)/37 (335)
Motor terminals	M10/M12	19 (168)/37 (335)
Ground terminals	M8/M10	9.6 (84)/19.1 (169)
Relay terminals	–	0.5 (4)
Door/panel cover	M5	2.3 (20)
Gland plate	M5	2.3 (20)

5.5 IT Mains

⚠ C A U T I O N ⚠

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 drive when at IT grid.

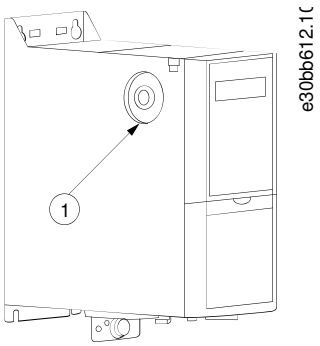


Illustration 15: IP20, 0.37–22 kW (0.5–30 hp), 380–480 V

1	EMC screw

NOTICE

If reinserted, use only M3x12 screw.

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.

For 380–480 V, 110–315 kW (150–450 hp) units, if the drive is supplied from an isolated mains source (IT mains, floating delta, or grounded delta) or TT/TN-S mains with grounded leg, the RFI switch is recommended to be turned off via *parameter 14-50 RFI Filter* on the drive and *parameter 14-50 RFI Filter* on the filter. For more details, see IEC 364-3. In the *[Off]* position, the filter capacitors between the chassis and the DC link are cut off to avoid damage to the DC link and to reduce the ground capacity currents, according to IEC 61800-3.

If optimum EMC performance is needed, or parallel motors are connected, or the motor cable length is above 25 m (82 ft), Danfoss recommends setting *parameter 14-50 RFI Filter* to *[On]*. It is important to use isolation monitors that are rated for use together with power electronics (IEC 61557-8).

5.6 Mains and Motor Connection

5.6.1 Introduction

The drive is designed to operate all standard 3-phase asynchronous motors.

- 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 the relevant Decoupling Plate Installation Guide.
- Also see EMC-Correct Installation in the 5.2 EMC-compliant Electrical Installation.

5.6.2 Connecting to the Ground

⚠ WARNING ⚠

LEAKAGE CURRENT HAZARD

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

– Ensure that the minimum size of the ground conductor complies with the local safety regulations for high touch current equipment.

For electrical safety:

- Ground the drive in accordance with applicable standards and directives.
- Use a dedicated ground wire for input power, motor power, and control wiring.
- Do not ground 1 drive to another in a daisy chain fashion.
- Keep the ground wire connections as short as possible.
- Follow motor manufacturer wiring requirements.
- Minimum cable cross-section: 10 mm^2 (8 AWG) Cu or 16 mm^2 (6 AWG) Al (or 2 rated ground wires terminated separately).
- Tighten the terminals in accordance with the information provided in 5.4 Fastener Tightening Torques.

For EMC-compliant installation

- Establish electrical contact between the cable shield and the drive enclosure by using metal cable glands or by using the clamps provided on the equipment.
- Reduce burst transient by using high-strand wire.
- Do not use twisted shield ends (pigtails).

N O T I C E

POTENTIAL EQUALIZATION

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

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

5.6.3 Connecting the Motor

⚠ W A R N I N G ⚠

INDUCED VOLTAGE

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

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

- Comply with local and national electrical codes for cable sizes. For maximum wire sizes, see 10.4.4 Cable Length and Cross-section.
- Follow motor manufacturer wiring requirements.
- Motor wiring knockouts or access panels are provided at the base of IP21 and higher units.
- Do not wire a starting or pole-changing device (for example, Dahlander motor or slip ring asynchronous motor) between the drive and the motor.

Procedure

1. For H12 drives, remove the protective covers using a screwdriver before connecting the stripped wire.
2. For H1–H5 and H13–H14 drives, strip a section of the outer cable insulation.
3. For H11-H12 drives:
   a. If ferrule without plastic sleeve is used, strip 16–17 mm (0.63–0.67 in) section of the outer cable insulation.
   b. If ferrule with plastic sleeve is used, strip a section of the outer cable insulation.

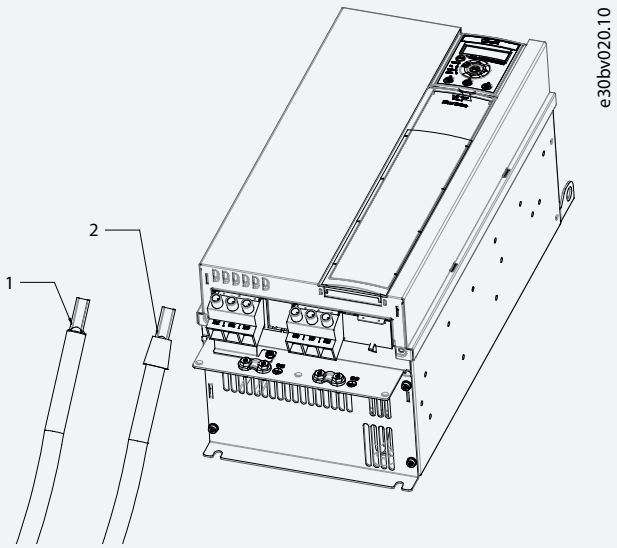


Illustration 16: Ferrule with/without Plastic Sleeve

1	Ferrule without plastic sleeve
2	Ferrule with plastic sleeve

4. Position the stripped wire under the cable clamp, establishing mechanical fixation and electrical contact between the cable shield and ground.
5. Connect the ground wire to the nearest grounding terminal in accordance with the grounding instructions provided in 5.6.2 Connecting to the Ground.
6. Connect the 3-phase motor wiring to terminals U, V, and W.
7. Tighten the terminals in accordance with the information provided in 5.4 Fastener Tightening Torques.
8. For H12 drives, install the protective cover on the terminals.
    a. Cut the cable block slice according to the wire size.
    b. Put the positioning pin to the terminal locating slot.

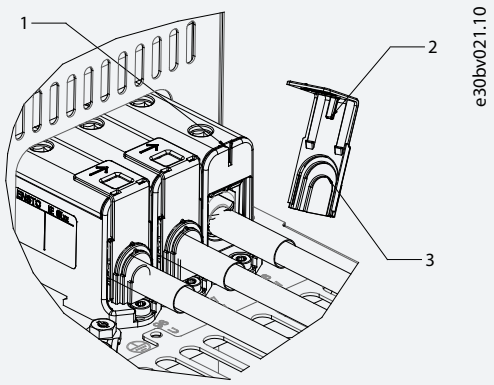


Illustration 17: Installing Protective Covers, H12

1	Terminal locating slot	3	Cable block slice
2	Cover positioning pins		

5.6.4 Connecting the AC Mains

- Size the wiring according to the input current of the drive. For maximum wire sizes, see 10.1.1 3x380–480 V AC.
- Comply with local and national electrical codes for cable sizes.

Procedure

1. For H12 drives, remove the protective covers using a screwdriver before connecting the stripped wire.
2. For H1–H5 and H13–H14 drives, strip a section of the outer cable insulation.
3. For H11-H12 drives, see the *Illustration Ferrule with/without Plastic Sleeve* in 5.6.3 Connecting the Motor.
    a. If ferrule without plastic sleeve is used, strip 16–17 mm (0.63–0.67 in) section of the outer cable insulation.
    b. If ferrule with plastic sleeve is used, strip a section of the outer cable insulation.
4. Position the stripped wire under the cable clamp, establishing mechanical fixation and electrical contact between the cable shield and ground.
5. Connect the ground wire to the nearest grounding terminal in accordance with the grounding instructions provided in 5.6.2 Connecting to the Ground.
6. For H1-H5 & H11-H12 drives, connect the 3-phase AC input power wiring to terminals L1, L2, and L3.
7. For H13-H14 drives, connect the 3-phase AC input power wiring to terminals R, S, and T.
8. When supplied from an isolated mains source (IT mains or floating delta) or TT/TN-S mains with a grounded leg (grounded delta), ensure that *parameter 14-50 RFI Filter* is set to *[0] Off* to avoid damage to the DC link and to reduce ground capacity currents.
9. Tighten the terminals in accordance with the information provided in 5.4 Fastener Tightening Torques.
10. For H12 drives, install the protective cover on the terminals, see the *Illustration Installing Protective Covers, H12* in 5.6.3 Connecting the Motor.
    a. Cut the cable block slice according to the wire size.
    b. Put the positioning pin to the terminal locating slot.

5.7 Fuses and Circuit Breakers

5.7.1 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.

5.7.2 Short-circuit Protection

Danfoss recommends using the fuses and circuit breakers listed in this chapter to protect service personnel or other equipment in case of an internal failure in the unit or a short circuit on the DC link. The drive provides full short-circuit protection in case of a short circuit on the motor.

5.7.3 Overcurrent Protection

Provide overload protection to avoid overheating of the cables in the installation. Overcurrent protection must always be carried out 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.

5.7.4 CE Compliance

To ensure compliance with IEC 61800-5-1, use the circuit breakers or fuses listed in this chapter. Circuit breakers must be designed for protection in a circuit capable of supplying a maximum of 10000 A_{rms} (symmetrical), 480 V maximum.

5.7.5 Recommendation of Fuses

N O T I C E

In the event of malfunction, failure to follow the protection recommendation may result in damage to the drive.

Table 12: Recommendation of Fuses

3x380–480 V IP20 [kW (hp)]	Maximum fuse
0.37 (0.5)	gG-10
0.75 (1.0)	gG-10
1.5 (2.0)	gG-10
2.2 (3.0)	gG-16
3.0 (4.0)	gG-16
4.0 (5.4)	gG-16
5.5 (7.5)	gG-25
7.5 (10)	gG-25
11 (15)	gG-50
15 (20)	gG-50
18.5 (25)	gG-63
22 (30)	gG-63
30 (40)	gG-125
37 (50)	gG-125
45 (60)	gG-125
55 (70)	aR-250

75 (100)	aR-250
90 (125)	aR-250
110 (150)	aR-315
132 (175)	aR-350
160 (250)	aR-400
200 (300)	aR-500
250 (350)	aR-630
315 (450)	aR-800

Table 13: H13–H14 Power/semiconductor Fuse Options, 380–480 V

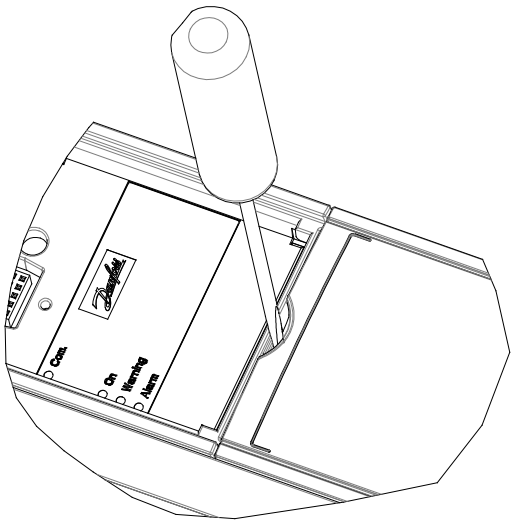
Model	Fuse Options						
	Bussman	Littelfuse	Littelfuse	Bussman	Siba	Ferraz-Shawmut	Ferraz-Shawmut(Europe)
P110	170M2619	LA50QS300-4	L50S-300	FWH-300A	20 189 20.315	A50QS300-4	6,9URD31D08A0315
P132	170M2620	LA50QS350-4	L50S-350	FWH-350A	20 189 20.350	A50QS350-4	6,9URD31D08A0350
P160	170M2621	LA50QS400-4	L50S-400	FWH-400A	20 189 20.400	A50QS400-4	6,9URD31D08A0400
P200	170M4015	LA50QS500-4	L50S-500	FWH-500A	20 189 20.550	A50QS500-4	6,9URD31D08A0550
P250	170M4016	LA50QS600-4	L50S-600	FWH-600A	20 189 20.630	A50QS600-4	6,9URD31D08A0630
P315	170M4017	LA50QS800-4	L50S-800	FWH-800A	20 189 20.800	A50QS800-4	6,9URD32D08A0800

5.8 Control Terminals

Remove the terminal cover (H1-H5 & H11-H12) or the cradle cover (H13-H14) to access the control terminals.

H1-H5 & H11-H12

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 18.



e30bd331.11

Illustration 18: Removing the Terminal Cover

H13-H14

Press the tips of the cradle cover inwards as shown in Illustration 19, and then lift the cradle cover up.

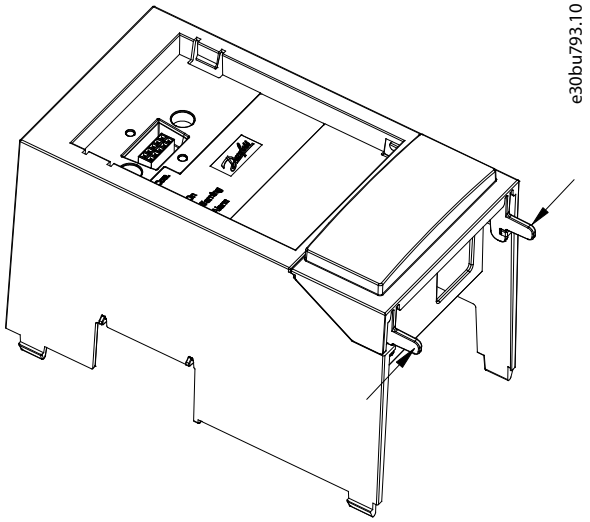


Illustration 19: Removing the Cradle Cover

All the drive control terminals are shown in Illustration 20. Applying start (terminal 18), connection between terminals 12-27, and an analog reference (terminal 53 or 54, and 55) make the drive run.

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

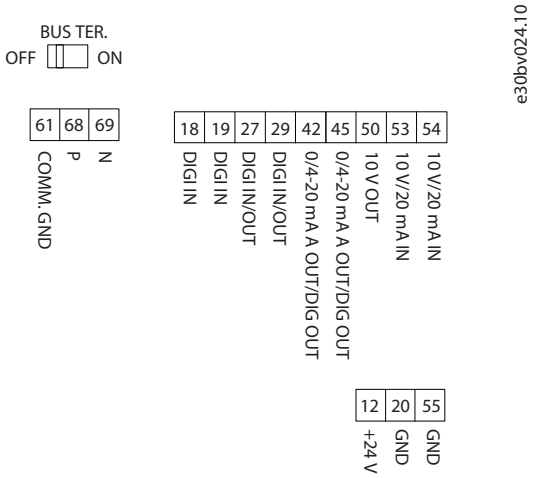


Illustration 20: Control Terminals

5.9 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*.

6 Programming

6.1 Local Control Panel (LCP)

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

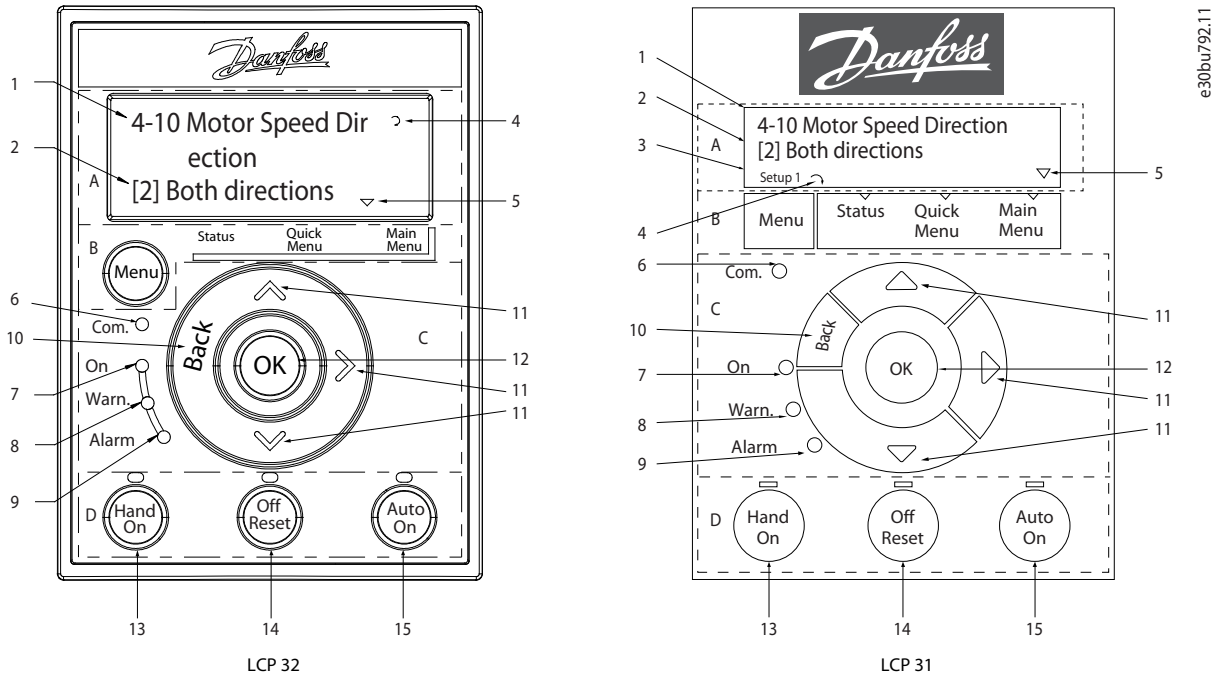


Illustration 21: Local Control Panel (LCP)

A. Display

The LCD-display of LCP 32 is illuminated with 3 alphanumeric lines, while the LCD-display of LCP 31 is illuminated with 2 alphanumeric lines. All data is shown on the LCP. The Table 14 describes the information that can be read from the display.

Table 14: Legend to Section A, Illustration 3

1	Parameter number and name.
2	Parameter value.
3	The setup number shows the active setup and the edit setup. For LCP 32, the setup number only shows in Status menu, the number outside the brackets is active setup, and the number inside the brackets is edit setup. For example, 1(2) means 1 is the active setup, and 2 is the edit setup. For LCP 31, if the same setup acts as both active and edit setup, only that setup number is shown (factory setting). When the active and the edit setup differ, both numbers are shown in the display (setup 12). The number flashing indicates the edit setup.
4	Motor direction is shown to the bottom left of the display – indicated by a small arrow pointing either clockwise or counter-clockwise.
5	The triangle indicates if the LCP is in Status, Quick Menu, or Main Menu.

B. Menu key

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

C. Navigation keys and indicator lights

Table 15: Legend to Section C, Illustration 3

6	Com. (yellow indicator): Flashes during bus communication.
7	On (green indicator): Shows the power-on status.
8	Warn. (yellow indicator): Indicates a warning.
9	Alarm (red indicator): Indicates an alarm.
10	[Back]: For moving to the previous step or layer in the navigation structure.
11	[▵], [▿], and [▹]: 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.

D. Operation keys and indicator lights

Table 16: Legend to Section D, Illustration 3

13	[Hand On]: Starts the motor and enables control of the drive via the LCP. **N O T I C E** *[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 compressor (Off). If in alarm mode, the alarm is reset.
15	[Auto On]: The drive is controlled either via control terminals or serial communication.

6.2 Set-up Wizard

6.2.1 Setup Wizard Introduction

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

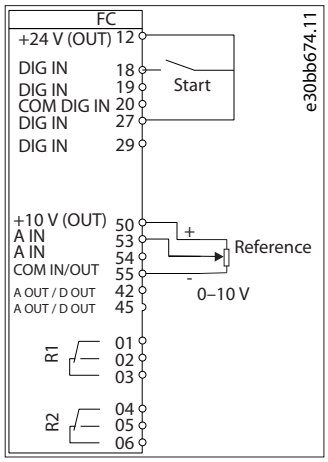


Illustration 22: Drive Wiring

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.

6.2.2 Setup Wizard for Open-loop Applications

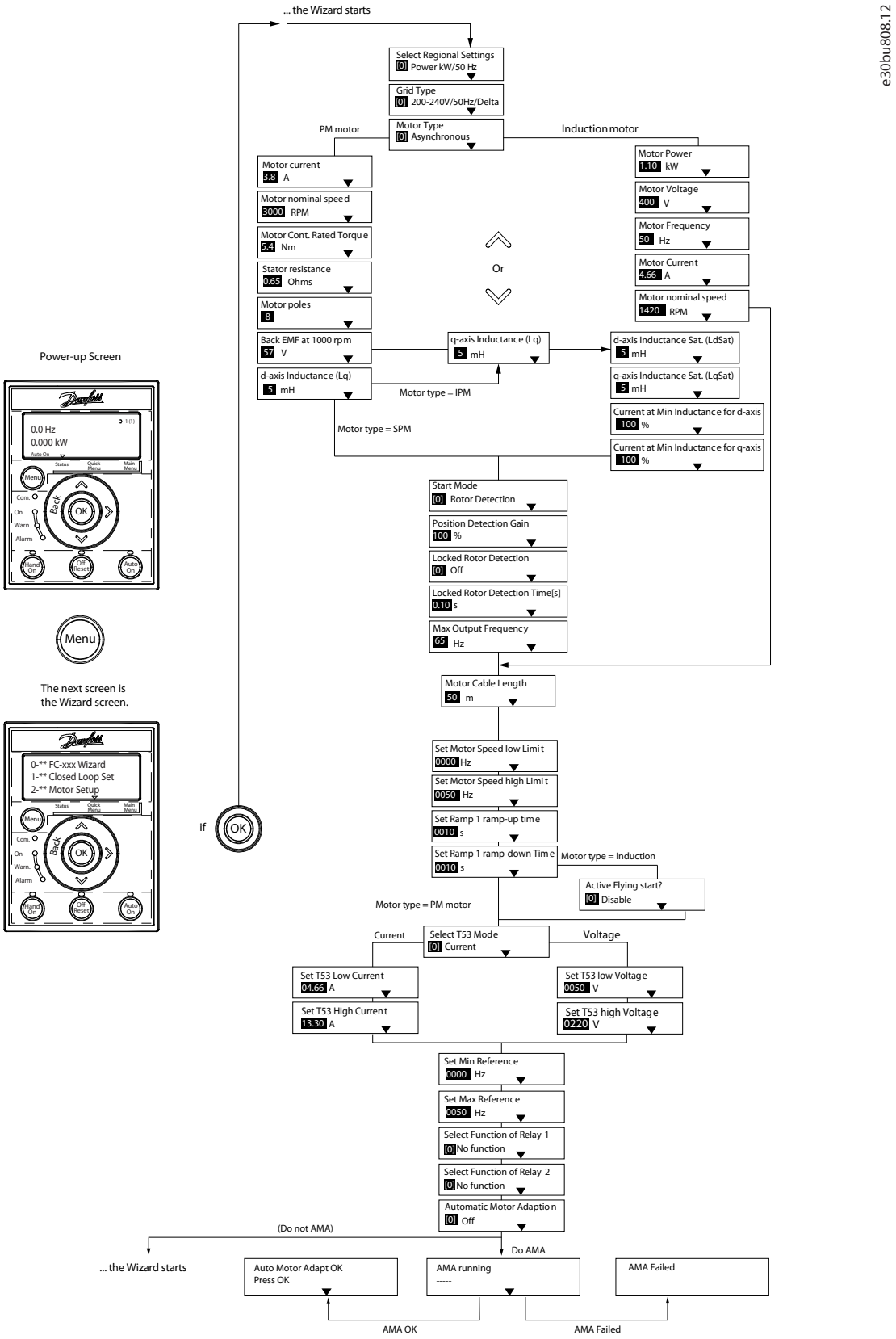


Illustration 23: Setup Wizard for Open-loop Applications

Table 17: Setup Wizard for Open-loop Applications

Parameter	Option	Default	Usage
Parameter 0-03 Regional Settings	[0] International [1] US	*[0] International*	–
Parameter 0-06 GridType	[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 [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	Size related	Select the operating mode for restart after reconnection of the drive to mains voltage after power down. **NOTICE** Compared to 380–440 V groups, when selecting 440–480 V groups, the rated current decreases accordingly.
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	Option	Default	Usage
			• *Parameter 1-70 PM 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 1-20 Motor Power	0.18–110 kW/0.25–150 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	0.01–1000.00 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 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.

Parameter	Option	Default	Usage
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 PM Start Mode	[0] Rotor Detection [1] Parking [3] Rotor Last Position	*[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 drive 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	Option	Default	Usage
Parameter 3-41 Ramp 1 Ramp Up Time	0.01–3600.00 s	Size related	If induction 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	0.01–3600.00 s	Size related	For induction 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 Detection	[0] Off [1] On	*[0] Off*	–
Parameter 30-23 Locked Rotor Detection Time [s]	0.05–1 s	*0.10 s*	–

6.2.3 Setup Wizard for Closed-loop Applications

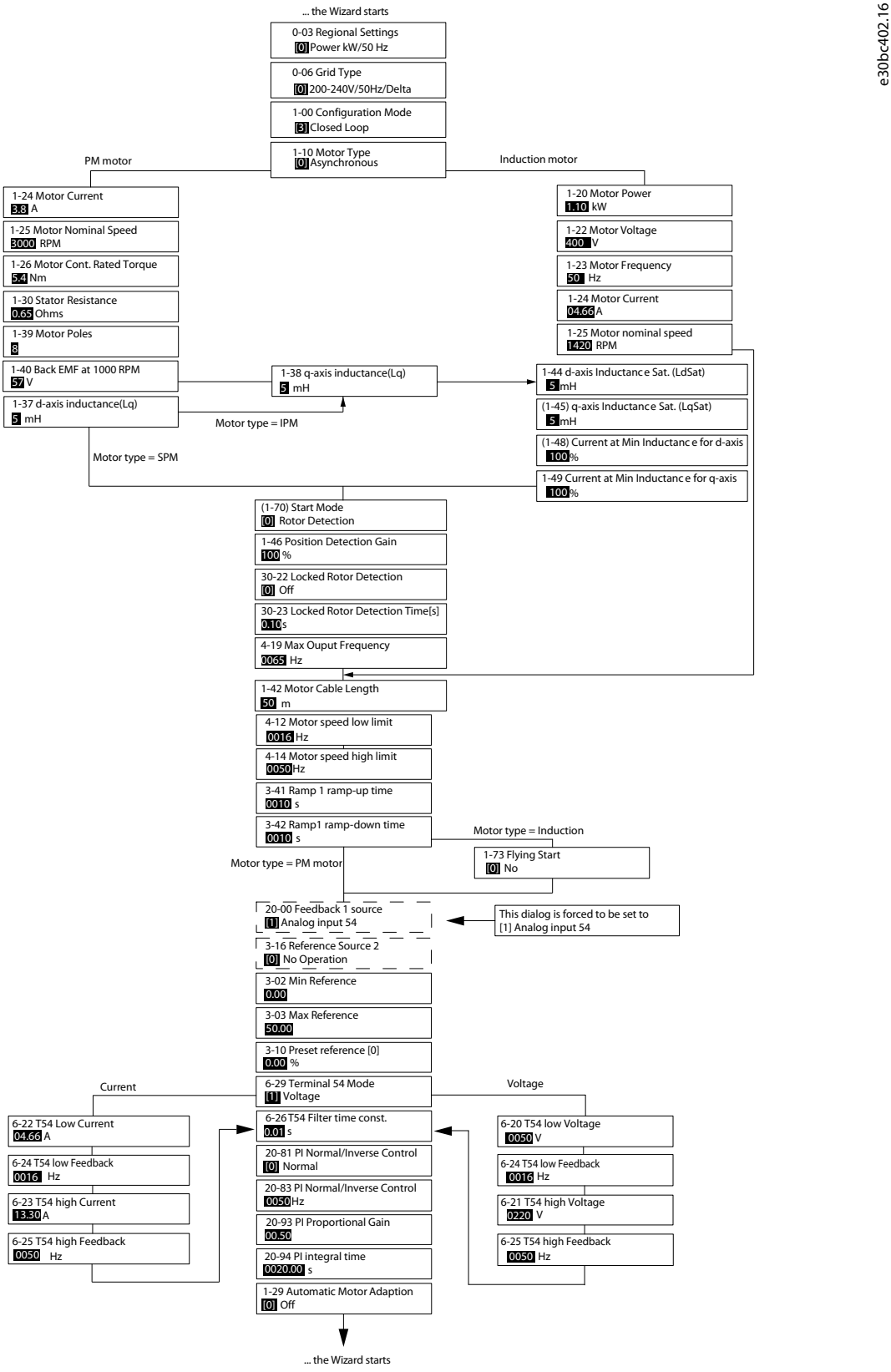


Illustration 24: Setup Wizard for Closed-loop Applications

Table 18: Setup Wizard for Closed-loop Applications

Parameter	Range	Default	Usage
Parameter 0-03 Regional Settings	[0] International [1] US	*[0] International*	–
Parameter 0-06 GridType	[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 [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	Size selected	Select the operating mode for restart after reconnection of the drive to mains voltage after power down.
Parameter 1-00 Configuration Mode	[0] Open loop [3] Closed loop	*[0] Open loop*	Select *[3] Closed loop*.
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	Range	Default	Usage
			• *Parameter 1-49 Current at Min Inductance for q-axis.* • *Parameter 1-66 Min. Current at Low Speed.* • *Parameter 1-70 PM 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 1-20 Motor Power	0.18–110 kW/0.25–150 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	0.01–1000.00 A	Size related	Enter the motor current from the nameplate data.
Parameter 1-25 Motor Nominal Speed	50–60000 RPM	Size related	Enter the motor nominal speed from the nameplate data.
Parameter 1-26 Motor Cont. Rated Torque	0.1–10000.0 Nm	Size related	This parameter is available when *parameter 1-10 Motor Construction* is set to options that enable permanent motor mode. **NOTICE** Changing this parameter affects the settings of other parameters.
Parameter 1-29 Automatic Motor Adaption (AMA)	–	*Off*	Performing an AMA optimizes motor performance.
Parameter 1-30 Stator Resistance (Rs)	0.000–9999.000 Ω	Size related	Set the stator resistance value.

Parameter	Range	Default	Usage
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.
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 PM Start Mode	[0] Rotor Detection [1] Parking [3] Rotor Last Position	*[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 drive to catch a spinning motor in, for example, fan applications. When PM is selected, this parameter is enabled.
Parameter 3-02 Minimum Reference	-4999.000–4999.000	*0*	The minimum reference is the lowest value obtainable by summing all references.

Parameter	Range	Default	Usage
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 induction 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 induction 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	Range	Default	Usage
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 Detection	[0] Off [1] On	*[0] Off*	–
Parameter 30-23 Locked Rotor Detection Time [s]	0.05–1.00 s	*0.10 s*	–

6.2.4 Motor Setup

The motor setup wizard guides users through the needed motor parameters.

Table 19: Motor Setup Wizard Settings

Parameter	Range	Default	Usage
Parameter 0-03 Regional Settings	[0] International [1] US	*[0] International*	–
Parameter 0-06 GridType	[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 [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	Size selected	Select the operating mode for restart after reconnection of the drive to mains voltage after power down.
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	Range	Default	Usage
			• *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 PM 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	0.18–110 kW/0.25–150 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 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.
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	Range	Default	Usage
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 PM Start Mode	[0] Rotor Detection [1] Parking [3] Rotor Last Position	*[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 drive 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 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 Detection	[0] Off [1] On	*[0] Off*	–
Parameter 30-23 Locked Rotor Detection Time [s]	0.05–1.00 s	*0.10 s*	–

6.2.5 Changes Made Function

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

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

6.2.6 Changing Parameter Settings

Procedure

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 setup, motor setup, 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.

6.2.7 Accessing All Parameters via the Main Menu

Procedure

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.
7. Press [OK] to accept the change.

7 Applications

7.1 Application Selections

Use the 4 selections for quick application setup of the most common applications via changing the setting of *parameter 0-16 Application Selection*.

- Open loop control.
- Process closed loop control.
- Constant pressure water supply.
- Multiple pump control.

7.1.1 Open Loop

Table 20: Parameter settings

Parameter	Option/value
Parameter 1-10 Motor Construction	*[0] Asynchron*
Parameter 1-20 Motor Power	Configuration dependent
Parameter 1-22 Motor Voltage	Configuration dependent
Parameter 1-23 Motor Frequency	Configuration dependent
Parameter 1-24 Motor Current	Configuration dependent
Parameter 1-25 Motor Nominal Speed	Configuration dependent
Parameter 1-29 Automatic Motor Adaption (AMA)	*[0] Off*
Parameter 1-39 Motor Poles	–
Parameter 1-40 Back EMF at 1000 RPM	–
Parameter 1-73 Flying start	*[0] Disabled*
Parameter 3-02 Minimum Reference	*0*
Parameter 3-03 Maximum Reference	*50*
Parameter 3-10 [0] Preset Reference	–
Parameter 3-15 Reference 1 Source	*[1] Analog Input 53*
Parameter 3-16 Reference 2 Source	*[0] No function*
Parameter 3-17 Reference 3 Source	*[11] Local bus reference*
Parameter 3-41 Ramp 1 Ramp Up Time	*10.00 s*
Parameter 3-42 Ramp 1 Ramp Down Time	*10.00 s*
Parameter 4-12 Motor Speed Low Limit [Hz]	*0 Hz*
Parameter 4-14 Motor Speed High Limit [Hz]	*100 Hz*
Parameter 5-10 Terminal 18 Digital Input	*[8] Start*
Parameter 5-11 Terminal 19 Digital Input	*[0] No operation*
Parameter 5-40 [1] Function Relay	*[9] Alarm*
Parameter 5-40 [2] Function Relay	*[5] Drive running*

Parameter	Option/value
Parameter 6-10 Terminal 53 Low Voltage	*0.07 V*
Parameter 6-11 Terminal 53 High Voltage	*10 V*
Parameter 6-12 Terminal 53 Low Current	*4 mA*
Parameter 6-13 Terminal 53 High Current	*20 mA*
Parameter 6-14 Terminal 53 Low Ref./Feedb. Value	*0*
Parameter 6-15 Terminal 53 High Ref./Feedb. Value	*50.0*
Parameter 6-19 Terminal 53 mode	*[1] Voltage mode*
Parameter 8-01 Control Site	–
Parameter 8-02 Control Source	–
Parameter 8-03 Control Timeout Time	–
Parameter 8-04 Control Timeout Function	–

7.1.2 Process Closed Loop

Table 21: Parameter settings

Parameter	Option/value
Parameter 1-00 Configuration Mode	*[3] Process Closed Loop*
Parameter 1-10 Motor Construction	*[0] Asynchron*
Parameter 1-20 Motor Power	Configuration dependent
Parameter 1-22 Motor Voltage	Configuration dependent
Parameter 1-23 Motor Frequency	Configuration dependent
Parameter 1-24 Motor Current	Configuration dependent
Parameter 1-25 Motor Nominal Speed	Configuration dependent
Parameter 1-29 Automatic Motor Adaption (AMA)	*[0] Off*
Parameter 1-39 Motor Poles	–
Parameter 1-40 Back EMF at 1000 RPM	–
Parameter 1-73 Flying start	*[0] Disabled*
Parameter 3-02 Minimum Reference	*0*
Parameter 3-03 Maximum Reference	*50*
Parameter 3-15 Reference 1 Source	*[1] Analog Input 53*
Parameter 3-16 Reference 2 Source	*[0] No function*
Parameter 3-17 Reference 3 Source	*[11] Local bus reference*
Parameter 3-41 Ramp 1 Ramp Up Time	*10.00 s*
Parameter 3-42 Ramp 1 Ramp Down Time	*10.00 s*

Parameter	Option/value
Parameter 4-12 Motor Speed Low Limit [Hz]	*0 Hz*
Parameter 4-14 Motor Speed High Limit [Hz]	*50 Hz*
Parameter 5-10 Terminal 18 Digital Input	*[8] Start*
Parameter 5-11 Terminal 19 Digital Input	*[0] No operation*
Parameter 5-40 [1] Function Relay	*[9] Alarm*
Parameter 5-40 [2] Function Relay	*[5] Drive running*
Parameter 6-10 Terminal 53 Low Voltage	*0.07 V*
Parameter 6-11 Terminal 53 High Voltage	*10 V*
Parameter 6-12 Terminal 53 Low Current	*4 mA*
Parameter 6-13 Terminal 53 High Current	*20 mA*
Parameter 6-14 Terminal 53 Low Ref./Feedb. Value	*0*
Parameter 6-15 Terminal 53 High Ref./Feedb. Value	*50.0*
Parameter 6-19 Terminal 53 mode	*[1] Voltage mode*
Parameter 6-20 Terminal 54 Low Voltage	*0.07 V*
Parameter 6-21 Terminal 54 High Voltage	*10 V*
Parameter 6-22 Terminal 54 Low Current	*4 mA*
Parameter 6-23 Terminal 54 High Current	*20 mA*
Parameter 6-24 Terminal 54 Low Ref./Feedb. Value	*0*
Parameter 6-25 Terminal 54 High Ref./Feedb. Value	*50*
Parameter 6-26 Terminal 54 Filter Time Constant	*0.01 s*
Parameter 6-29 Terminal 54 mode	*[1] Voltage mode*
Parameter 8-01 Control Site	*–*
Parameter 8-02 Control Source	*–*
Parameter 8-03 Control Timeout Time	*–*
Parameter 8-04 Control Timeout Function	*–*
Parameter 20-00 Feedback 1 Source	*[2] Analog Input 54*
Parameter 20-01 Feedback 1 Conversion	*–*
Parameter 20-12 Reference/Feedback Unit	*–*
Parameter 20-21 Setpoint 1	*–*
Parameter 20-81 PI Normal/ Inverse Control	*[0] Normal*

Parameter	Option/value
Parameter 20-83 PI Start Speed [Hz]	*0 Hz*
Parameter 20-93 PI Proportional Gain	*0.50*
Parameter 20-94 PI Integral Time	*20 s*

7.1.3 Constant Pressure Water Supply

Table 22: Parameter settings

Parameter	Option/value
Parameter 1-00 Configuration Mode	*[3] Process Closed Loop*
Parameter 1-01 Motor Control Principle	*[0] U/f*
Parameter 1-10 Motor Construction	–
Parameter 1-20 Motor Power	Configuration dependent
Parameter 1-22 Motor Voltage	Configuration dependent
Parameter 1-23 Motor Frequency	Configuration dependent
Parameter 1-24 Motor Current	Configuration dependent
Parameter 1-26 Motor Cont. Rated Torque	Configuration dependent
Parameter 1-39 Motor Poles	–
Parameter 1-40 Back EMF at 1000 RPM	–
Parameter 3-03 Maximum Reference	*11*
Parameter 3-15 Reference 1 Source	*[0] No function*
Parameter 3-16 Reference 2 Source	*[0] No function*
Parameter 3-17 Reference 3 Source	*[11] Local bus reference*
Parameter 3-41 Ramp 1 Ramp Up Time	*10.00 s*
Parameter 3-42 Ramp 1 Ramp Down Time	*10.00 s*
Parameter 4-12 Motor Speed Low Limit [Hz]	*25 Hz*
Parameter 4-14 Motor Speed High Limit [Hz]	*100 Hz*
Parameter 4-19 Max Output Frequency	*100.0 Hz*
Parameter 4-40 Warning Freq. Low	*0 Hz*
Parameter 4-41 Warning Freq. High	*100 Hz*
Parameter 4-57 Warning Feedback High	*4999 ProcessCtrlUnit*
Parameter 5-12 Terminal 27 Digital Input	*[2] Coast inverse*
Parameter 5-40 [1] Function Relay	–
Parameter 5-40 [2] Function Relay	–
Parameter 6-10 Terminal 53 Low Voltage	*0.07 V*

Parameter	Option/value
Parameter 6-11 Terminal 53 High Voltage	*10 V*
Parameter 6-12 Terminal 53 Low Current	*4 mA*
Parameter 6-13 Terminal 53 High Current	*20 mA*
Parameter 6-14 Terminal 53 Low Ref./Feedb. Value	*0*
Parameter 6-15 Terminal 53 High Ref./Feedb. Value	*–*
Parameter 6-19 Terminal 53 mode	*[0] Current mode*
Parameter 6-20 Terminal 54 Low Voltage	*0.07 V*
Parameter 6-21 Terminal 54 High Voltage	*10 V*
Parameter 6-22 Terminal 54 Low Current	*4 mA*
Parameter 6-23 Terminal 54 High Current	*20 mA*
Parameter 6-24 Terminal 54 Low Ref./Feedb. Value	*0*
Parameter 6-25 Terminal 54 High Ref./Feedb. Value	*–*
Parameter 6-29 Terminal 54 mode	*[0] Current mode*
Parameter 6-70 Terminal 45 Mode	*[0] 0-20 mA*
Parameter 6-71 Terminal 45 Analog Output	*[100] Output frequency*
Parameter 6-73 Terminal 45 Output Min Scale	*0%*
Parameter 6-74 Terminal 45 Output Max Scale	*50%*
Parameter 6-90 Terminal 42 Mode	*[1] 4-20 mA*
Parameter 6-91 Terminal 42 Analog Output	*[102] Feedback*
Parameter 6-93 Terminal 42 Output Min Scale	*50%*
Parameter 6-94 Terminal 42 Output Max Scale	*75%*
Parameter 8-31 Address	*2*
Parameter 8-32 Baud Rate	*[2] 9600 Baud*
Parameter 8-33 Parity / Stop Bits	*[2] No Parity, 1 Stop Bit*
Parameter 8-43 [0] PCD Read Configuration	*[7] [1603] Status Word*
Parameter 8-43 [1] PCD Read Configuration	*[8] [1605] Main Actual Value [%]*
Parameter 8-43 [2] PCD Read Configuration	*[13] [1613] Frequency*
Parameter 8-43 [3] PCD Read Configuration	*[13] [1613] Frequency*
Parameter 8-43 [4] PCD Read Configuration	*[15] [1615] Frequency [%]*
Parameter 8-80 Bus Message Count	*–*
Parameter 14-20 Reset Mode	*[3] Automatic reset x 3*
Parameter 15-43 Software Version	*63*

Parameter	Option/value
Parameter 20-00 Feedback 1 Source	*[1] Analog Input 53*
Parameter 20-21 Setpoint 1	*40*
Parameter 20-81 PI Normal/ Inverse Control	*[0] Normal*
Parameter 20-93 PI Proportional Gain	*2*
Parameter 20-94 PI Integral Time	*1 s*
Parameter 22-40 Minimum Run Time	*60 s*
Parameter 22-41 Minimum Sleep Time	*5 s*
Parameter 22-43 Wake-Up Speed [Hz]	*49 Hz*
Parameter 22-44 Wake-Up Ref./FB Diff	*5%*
Parameter 22-45 Setpoint Boost	*2%*
Parameter 22-46 Maximum Boost Time	*30 s*
Parameter 22-47 Sleep Speed [Hz]	*37 Hz*
Parameter 22-48 Sleep Delay Time	*10 s*
Parameter 22-49 Wake-Up Delay Time	*0 s*

7.1.4 Multiple Pump Control

Table 23: Parameter settings

Parameter	Option/value
Parameter 1-00 Configuration Mode	*[3] Process Closed Loop*
Parameter 1-01 Motor Control Principle	*[0] U/f*
Parameter 1-20 Motor Power	Configuration dependent
Parameter 1-22 Motor Voltage	Configuration dependent
Parameter 1-23 Motor Frequency	Configuration dependent
Parameter 1-24 Motor Current	Configuration dependent
Parameter 1-26 Motor Cont. Rated Torque	Configuration dependent
Parameter 1-39 Motor Poles	–
Parameter 3-03 Maximum Reference	*50.0*
Parameter 3-15 Reference 1 Source	*[1] Analog Input 53*
Parameter 3-16 Reference 2 Source	*[0] No function*
Parameter 3-41 Ramp 1 Ramp Up Time	*10.00 s*
Parameter 3-42 Ramp 1 Ramp Down Time	*10.00 s*
Parameter 4-12 Motor Speed Low Limit [Hz]	*25 Hz*
Parameter 4-14 Motor Speed High Limit [Hz]	*50 Hz*

Parameter	Option/value
Parameter 5-11 Terminal 19 Digital Input	*[130] Pump 1 Interlock*
Parameter 5-13 Terminal 29 Digital Input	*[131] Pump 2 Interlock*
Parameter 5-40 [1] Function Relay	–
Parameter 5-40 [2] Function Relay	–
Parameter 5-41 On Delay, Relay	*0.01 s*
Parameter 5-42 Off Delay, Relay	*0.01 s*
Parameter 6-10 Terminal 53 Low Voltage	*0.07 V*
Parameter 6-11 Terminal 53 High Voltage	*10 V*
Parameter 6-12 Terminal 53 Low Current	–
Parameter 6-13 Terminal 53 High Current	–
Parameter 6-14 Terminal 53 Low Ref./Feedb. Value	*0*
Parameter 6-15 Terminal 53 High Ref./Feedb. Value	–
Parameter 6-19 Terminal 53 mode	*[1] Voltage mode*
Parameter 6-20 Terminal 54 Low Voltage	*0.07 V*
Parameter 6-21 Terminal 54 High Voltage	*10 V*
Parameter 6-22 Terminal 54 Low Current	–
Parameter 6-23 Terminal 54 High Current	–
Parameter 6-24 Terminal 54 Low Ref./Feedb. Value	*0*
Parameter 6-25 Terminal 54 High Ref./Feedb. Value	–
Parameter 6-29 Terminal 54 mode	*[1] Voltage mode*
Parameter 20-00 Feedback 1 Source	*[2] Analog Input 54*
Parameter 20-21 Setpoint 1	*0*
Parameter 20-81 PI Normal/ Inverse Control	*[0] Normal*
Parameter 20-93 PI Proportional Gain	*3*
Parameter 20-94 PI Integral Time	*1 s*
Parameter 22-40 Minimum Run Time	*60 s*
Parameter 22-41 Minimum Sleep Time	*5 s*
Parameter 22-43 Wake-Up Speed [Hz]	*49 Hz*
Parameter 22-44 Wake-Up Ref./FB Diff	*5%*
Parameter 22-45 Setpoint Boost	*2%*
Parameter 22-46 Maximum Boost Time	*30 s*
Parameter 22-47 Sleep Speed [Hz]	*37 Hz*

Parameter	Option/value
Parameter 22-48 Sleep Delay Time	*10 s*
Parameter 22-49 Wake-Up Delay Time	*0 s*
Parameter 25-00 Cascade Controller	*[1] Enabled*
Parameter 25-04 Pump Cycling	*[1] Enabled*
Parameter 25-05 Fixed Lead Pump	*[0] No*
Parameter 25-06 Number of Pumps	*2*
Parameter 25-20 Staging Bandwidth	*–*
Parameter 25-21 Override Bandwidth	*–*
Parameter 25-22 Fixed Speed Bandwidth	*–*
Parameter 25-23 SBW Staging Delay	*25 s*
Parameter 25-24 SBW Destaging Delay	*15 s*
Parameter 25-25 OBW Time	*10 s*
Parameter 25-27 Stage Function	*[1] Enabled*
Parameter 25-28 Stage Function Time	*15 s*
Parameter 25-29 Destage Function	*[1] Enabled*
Parameter 25-30 Destage Function Time	*15 s*
Parameter 25-42 Staging Threshold	*96%*
Parameter 25-43 Destaging Threshold	*50%*
Parameter 25-50 Lead Pump Alternation	*[3] At staging or command*
Parameter 25-51 Alternation Event	*[1] Alternation Time Interval*
Parameter 25-52 Alternation Time Interval	*8 h*
Parameter 25-56 Staging Mode at Alternation	*[1] Quick*
Parameter 25-57 Relays per Pump	*1*
Parameter 25-58 Run Next Pump Delay	*1.1 s*
Parameter 25-59 Run on Mains Delay	*2.1 s*

8 Cascade Controller

8.1 Introduction

8.1.1 Cascade Controller

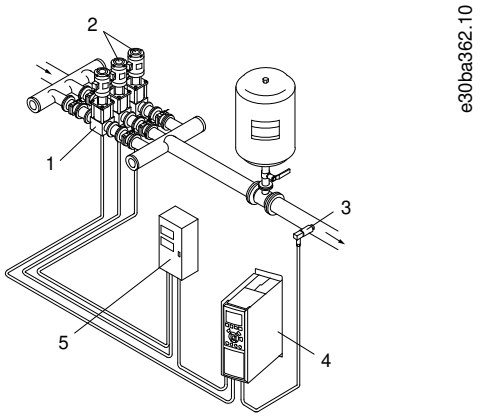


Illustration 25: Cascade Controller

1	Variable speed pumps (1)	4	Drive with cascade controller
2	Constant speed pumps (2)	5	Motor starter
3	Pressure sensor		

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 drive 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.

8.1.2 Fixed Lead Pump

The motors must be of equal size. The cascade controller allows the drive to control up to 5 equal size pumps using the 2 built-in relays of the drive and terminals 27, 29 (digital input/digital output). When the variable pump (lead) is connected directly to the drive, 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.

8.1.3 Lead Pump Alternation

The motors must be of equal size. This function makes it possible to cycle the drive 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.

8.1.4 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 drive 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.

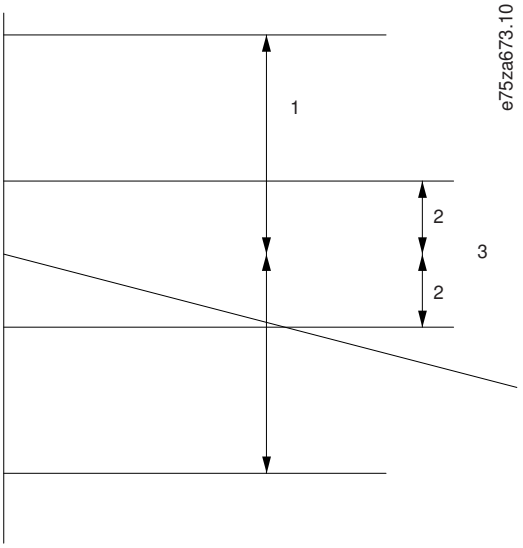


Illustration 26: Bandwidth

1	Override bandwidth	3	Setpoint
2	SBW		

8.2 System Status and Operation

Only when lead pump is working, the drive 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 drive, 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.

8.3 Start/Stop Conditions

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

Table 24: Commands Assigned to 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 pump start	Ramps up if system start is active	Not affected
Coast (emergency stop)	Coast to stop	Cut out (corresponding relays, terminal 27/29 and 42/45)
External interlock	Coast to stop	Cut out (built-in relays are deenergized)

Table 25: LCP Key Functions

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 drive is in auto-on mode.	Staging/destaging

8.4 Cascade Controller Wizard

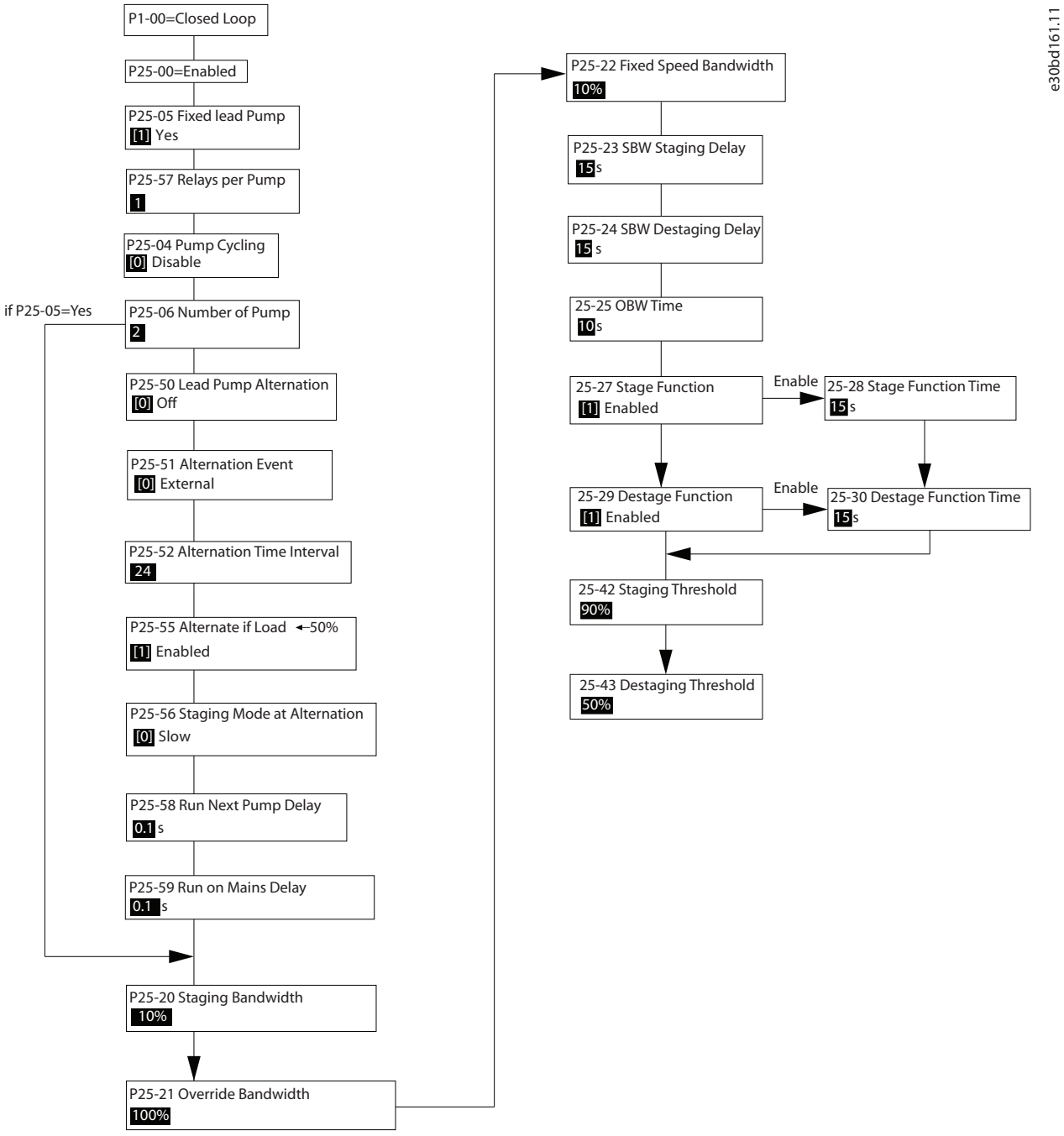


Illustration 27: Cascade Controller Wizard (Recommended Logistic)

8.5 Cascade Controller Connection

8.5.1 1 Pump, 1 Relay Mode

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

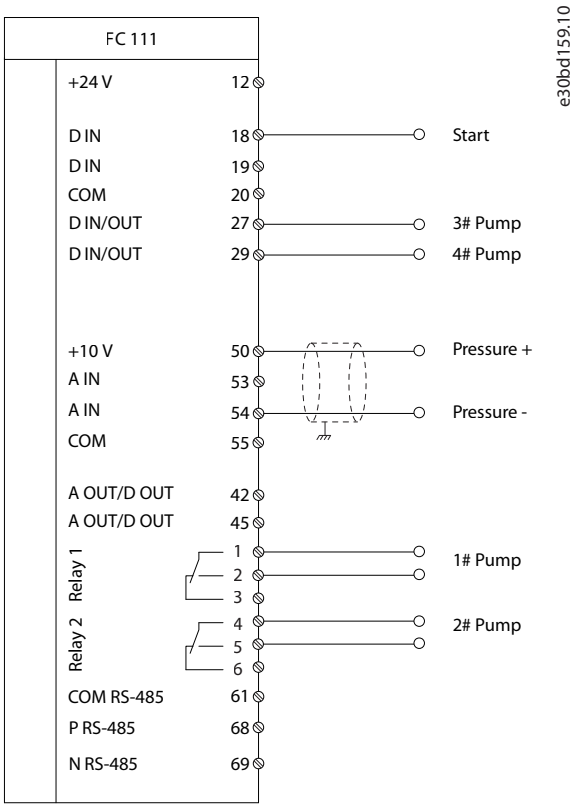


Illustration 28: 1 Pump, 1 Relay Mode

Every pump operation is controlled by 1 output.

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

8.5.2 1 Pump, 2 Relay Mode

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

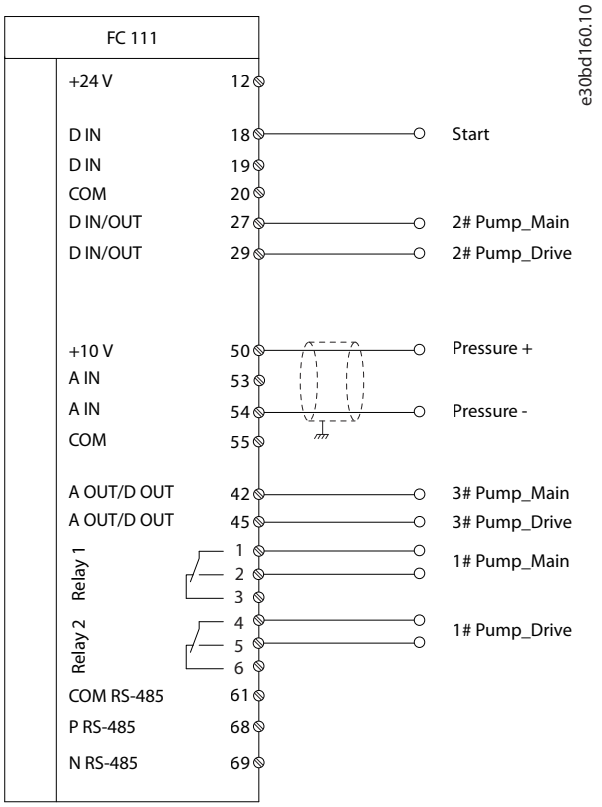


Illustration 29: 1 Pump, 2 Relay Mode

Every pump operation is controlled by 2 outputs.

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

9 Warnings and Alarms

9.1 List of Warnings and Alarms

Table 26: 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*.
3	–	No motor	X	–	–	No motor is connected to the output of the drive.
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 Function at 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	–	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	–	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 drive. 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, 30–315 kW (40–450 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.

Fault number	Alarm/ warning bit number	Fault text	Warning	Alarm	Trip locked	Cause of problem
47	23	24 V supply low	X	X	X	24 V DC supply may be overloaded.
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 I_{nom}	–	X	–	The motor current is too low. Check the settings.
53	–	AMA big motor	–	X	–	The motor is too big to perform AMA.
54	–	AMA small motor	–	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 has been interrupted by the user.
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, however, this 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 drive (via serial communication, digital I/O, or by pressing [Reset] key on the 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 initialised	–	X	–	All parameter settings are initialized to default settings.
92	–	No-Flow	X	X	–	A no-flow condition has been detected in the system. *Parameter 22-23 No-Flow Function* is set for alarm.

Fault number	Alarm/ warning bit number	Fault text	Warning	Alarm	Trip locked	Cause of problem
93	38	Dry pump	X	X	–	A dry-pump condition has been detected in the system. *Parameter 22-26 Dry Pump Function* is set for alarm.
94	39	End of curve	X	X	–	An end-of-curve condition has been detected in the system. *Parameter 22-50 End of Curve Function* is set for alarm.
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*.
99	–	Locked rotor	–	X	X	The rotor is blocked.
101	–	Flow/pressure Info Missing	–	–	–	Sensorless-pump table is missing or wrong. Download sensorless-pump table again.
126	–	Motor Rotating	–	X	–	High back EMF voltage. Stop the rotor of the PM motor.
127	–	Back EMF too high	X	–	–	This warning applies to PM motors only. When the back EMF exceeds 90% x U_{invmax} (overvoltage threshold) and does not drop to normal level within 5 s, this warning is reported. The warning remains until the back EMF returns to a normal level.
159	36	Check valve failure	X	–	–	When the drive is not in operation, a broken check valve leads to the motor runs in reverse.
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 drive has a new type code (on 400 V, 30– 90 kW (40–125 hp) units). Contact the local Danfoss supplier.

9.2 LCP Errors Messages

LCP errors are not warnings or alarms. They do not affect the operation of the drive. An LCP error example on the LCP is shown in the following illustration.

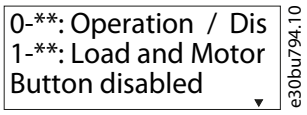


Illustration 30: LCP Error Example

Table 27: LCP Error List

LCP error code	Error message	Description
Err 84	LCP comm. lost	Communication between the LCP and the drive 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 drive to LCP, or from LCP to drive (*parameter 0-50 LCP Copy*).
Err 88	Data not compatible	LCP data incompatible. This error occurs when data is being copied from LCP to drive (*parameter 0-50 LCP Copy*). The typical reason is that data is moved between drive 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 drive 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 drive is running.
Err 95	Not while running	The parameter cannot be changed while the drive is running.
Err 96	Password rejected	The password that is input via the LCP is incorrect.

10 Specifications

10.1 Mains Supply

10.1.1 3x380–480 V AC

Table 28: 3x380–480 V AC, 0.37–15 kW (0.5–20 hp), Enclosure Sizes H1–H4

Drive	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) [mm^2 (AWG)]	4 (10)	4 (10)	4 (10)	4 (10)	4 (10)	4 (10)	4 (10)	4 (10)	16 (6)	16 (6)
Output current at 40°C (104°F) ambient temperature[1]										
Continuous [A]	1.2	2.2	3.7	5.3	7.2	9.0	12.0	15.5	23.0	31.0
Intermittent (110% overload 60 s) [A][2]	1.3	2.4	4.1	5.8	7.9	9.9	13.2	17.1	25.3	34.0
Maximum input current										
Continuous [A]	1.2	2.1	3.5	4.7	6.3	8.3	11.2	15.1	22.1	29.9
Intermittent [A]	1.3	2.3	3.9	5.2	6.9	9.1	12.3	16.6	24.3	32.9
Maximum external mains fuses [A]	See 5.7.5 Recommendation of Fuses.									
Estimated power loss [W][3]	15	21	57	58	83	118	131	198	274	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 [%][4]	97.3	97.6	97.2	97.9	97.8	97.6	98.0	97.8	97.9	97.8

[1] Refer to the *chapter Derating* in the Design Guide for the derating curves at 50°C (122°F) ambient temperature.

[2] The drive also supports 150% overload for 60 s when selecting 1 level higher power size.

[3] Applies for dimensioning of drive 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 Danfoss MyDrive® ecoSmart website.

[4] Efficiency measured at nominal current. For energy efficiency class, see 10.4.13 Ambient Conditions. For part load losses, see Danfoss MyDrive® ecoSmart website.

Table 29: 3x380–480 V AC, 18.5–90 kW (25–125 hp), Enclosure Sizes H5, H11–H12

Drive	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	H11	H11	H11	H12	H12	H12
Maximum cable size in terminals (mains, motor) [mm^2 (AWG)]	16 (6)	16 (6)	50 (1)	50 (1)	50 (1)	50 (1)	95 (0)	120 (250 MCM)

Drive	P18K	P22K	P30K	P37K	P45K	P55K	P75K	P90K
Output current at 40°C/45°C (104°F/113°F) ambient temperature[1]								
Continuous [A]	37.0	42.5	61.0	73.0	90.0	106.0	147.0	177.0
Intermittent (110% overload 60 s) [A][2]	40.7	46.8	67.1	80.3	99.0	116.6	161.7	194.7
Maximum input current								
Continuous [A]	35.2	41.5	57.0	70.3	84.2	102.9	140.3	165.6
Intermittent [A]	38.7	45.7	62.7	77.3	92.6	113.2	154.3	182.2
Maximum external mains fuses [A]	See 5.7.5 Recommendation of Fuses.							
Estimated power loss [W][3]	403	468	630	848	1175	1250	1507	1781
Weight enclosure protection rating IP20 [kg (lb)]	9.5 (20.9)	9.5 (20.9)	22.4 (49.4)	22.5 (49.6)	22.6 (49.8)	37.3 (82.2)	38.7 (85.3)	40.7 (89.7)
Efficiency [%][4]	98.1	97.9	98.1	98	97.7	98	98.2	98.3

[1] P18K, P22K, and P90K operates at 40°C (104°F). P30K, P37K, P45K, P55K, and P75K operates at 45°C (113°F). Refer to the *chapter Derating* in the Design Guide for the derating curves at 50°C (122°F) ambient temperature.

[2] The drive also supports 150% overload for 60 s when selecting 1 level higher power size.

[3] Applies for dimensioning of drive 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 Danfoss MyDrive® ecoSmart website.

[4] Efficiency measured at nominal current. For energy efficiency class, see 10.4.13 Ambient Conditions. For part load losses, see Danfoss MyDrive® ecoSmart website.

Table 30: 3x380–480 V AC, 110–315 kW (150–450 hp), Enclosure Sizes H13–H14

Drive	P110	P132	P160	P200	P250	P315
Typical shaft output [kW]	110	132	160	200	250	315
Typical shaft output [hp]	150	175	250	300	350	450
Protection rating IP20	H13	H13	H13	H14	H14	H14
Maximum cable size in terminals (mains, motor) [mm^2 (AWG)]	2x95 (2x3/0)			2x185 (2x350 mcm)		
Output current at 40°C/45°C (104°F/113°F) ambient temperature[1]						
Continuous [A]	212	260	315	395	480	588
Intermittent (110% overload 60 s) [A][2]	233	286	347	435	528	647
Maximum input current						
Continuous [A]	204	251	304	381	463	567
Intermittent [A]	224	276	334	419	509	623
Maximum external mains fuses [A]	See 5.7.5 Recommendation of Fuses.					
Estimated power loss [W][3][4]	2559	2954	3770	4116	5137	6674

Drive	P110	P132	P160	P200	P250	P315
Efficiency[4]	0.98					
Output frequency [Hz]	0–500					
Heat sink overtemperature trip [°C (°F)]	110 (230)					
Weight, enclosure protection rating IP20 kg (lbs)	98 (216)			164 (362)		
Control card overtemperature trip [°C (°F)]	75 (167)			80 (176)		

[1] Refer to the *chapter Derating* in the Design Guide for the derating curves at 50°C (122°F) ambient temperature.

[2] The drive also supports 150% overload for 60 s when selecting 1 level higher power size.

[3] Typical power loss is at normal conditions and expected to be within ±15% (tolerance relates to variety in voltage and cable conditions). These values are based on a typical motor efficiency (IE/IE3 border line). Lower efficiency motors add to the power loss in the drive. Applies for dimensioning of drive cooling. If the switching frequency is higher than the default setting, the power losses can increase. LCP and typical control card power consumptions are included. For power loss data according to EN 50598-2, refer to Danfoss MyDrive® ecoSmart website. Options and customer load can add up to 30 W to the losses, though usually a fully loaded control card and options for slots A and B each add only 4 W.

[4] Measured using 5 m (16.4 ft) shielded motor cables at rated load and rated frequency. Efficiency measured at nominal current. For energy efficiency class, see 10.4.13 Ambient Conditions. For part load losses, see Danfoss MyDrive® ecoSmart website.

10.2 EMC Emission Test Results

The following test results have been obtained using a system with a drive, a shielded control cable, a control box with potentiometer, and a shielded motor cable.

Table 31: EMC Emission Test Results, H1–H5 & H11–H12

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
H2 RFI filter (EN55011 A2, EN/IEC61800-3 C3)										
0.37–22 kW (0.5–30 hp) 3x380–480 V IP20	25 (82)	–	–	–	–	–	–	–	–	–
H2 RFI filter (EN 55011 A2, EN/IEC 61800-3 C3)										
30–90 kW (40–125 hp) 3x380–480 V IP20	25 (82)	–	–	–	–	–	No	–	No	–

Table 32: EMC Emission Test Results, H13–H14

RFI filter type	Conduct emission. Maximum shielded cable length [m (ft)]			Radiated emission		
EN 55011	**Class B Housing, trades and light industries**	**Class A Group 1 Industrial environment**	**Class A Group 2 Industrial environment**	**Class B Housing, trades and light industries**	**Class A Group 1 Industrial environment**	**Class A Group 2 Industrial environment**
EN/IEC 61800-3	**Category C1** First environment home and office	**Category C2** First environment home and office	**Category C3** Second environment industrial	**Category C1** First environment home and office	**Category C2** First environment home and office	**Category C3** First environment home and office
H2 RFI filter (EN 55011 A2, EN/IEC 61800-3 C3)						
110–315 kW (150– 450 hp) 3x380–480 V IP20	No	No	150 m (492 ft)	No	No	Yes

10.3 Special Conditions

10.3.1 Dusty or Humid Environment

N O T I C E

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

10.3.2 Derating for Ambient Temperature and Switching Frequency

Ensure that the ambient temperature measured over 24 hours is at least 5 °C (9 °F) lower than the maximum ambient temperature that is specified for the drive. If the drive is operated at a high ambient temperature, decrease the constant output current. For derating specifications, see the VLT® Flow Drive FC 111 Design Guide.

10.3.3 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 cooling air temperature by 1 °C (1.8 °F) per 200 m (656 ft).

10.4 General Technical Data

10.4.1 Protection and Features

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

10.4.2 Mains Supply

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	Maximum 1 time/30 s
Switching on the input supply L1, L2, L3 (power-ups) enclosure sizes H11–H12	Maximum 1 time/minute
Switching on the input supply R, S, T (power-ups) enclosure sizes H13–H14	Maximum 1 time/2 minutes
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.

10.4.3 Motor Output (U, V, W)

Output voltage	0–100% of supply voltage
Output frequency in U/f mode (for AM motor)	0–500 Hz
Output frequency in VVC+ mode (for AM motor)	0–200 Hz
Output frequency in VVC+ mode (for PM motor)	0–400 Hz
Switching on output	Unlimited
Ramp time	0.01–3600 s

10.4.4 Cable Length and Cross-section

Maximum motor cable length, shielded/armored (EMC-correct installation)	See 10.2 EMC Emission Test Results.
Maximum motor cable length, unshielded/unarmored, H1–H5	50 m (164 ft)
Maximum motor cable length, shielded, H11–H12	50 m (164 ft)
Maximum motor cable length, unshielded/unarmored, H11–H12	100 m (328 ft)
Maximum motor cable length, shielded, H13–H14	150 m (492 ft)
Maximum motor cable length, unshielded, H13–H14	300 m (984 ft)
Maximum cross-section to motor, mains	See 10.1.1 3x380–480 V AC for more information
Cross-section DC terminals for filter feedback on enclosure sizes H1–H3	4 mm^2/12 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, H1–H5 & H11–H12	2.5 mm^2/14 AWG
Maximum cross-section to control terminals, rigid wire, H13–H14	1.5 mm^2/16 AWG (2x0.75 mm^2)
Maximum cross-section to control terminals, flexible cable, H1–H5 & H11–H12	2.5 mm^2/14 AWG
Maximum cross-section to control terminals, flexible cable, H13–H14	1 mm^2/18 AWG
Maximum cross-section to control terminals, cable with enclosed core, H13–H14	0.05 mm^2/20 AWG
Minimum cross-section to control terminals, H1–H5 & H11–H12	0.05 mm^2/30 AWG
Minimum cross-section to control terminals, H13–H14	0.25 mm^2/23 AWG

10.4.5 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.)

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

10.4.6 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

10.4.7 Analog Outputs

Number of programmable analog outputs	2
Terminal number	42, 45[1]
Current range at analog output	0/4–20 mA
The load resistor to common at analog out	≤ 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.

10.4.8 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

The load resistor 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.

10.4.9 RS485 Serial Communication

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

The RS485 serial communication outputs are galvanically isolated from the supply voltage (PELV) and other high-voltage terminals.

10.4.10 24 V DC Output

Terminal number	12
Maximum load	80 mA

The 24 V DC output is galvanically isolated from the supply voltage (PELV) and other high-voltage terminals.

10.4.11 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. Endurance of the relay varies with different load type, switching current, ambient temperature, driving configuration, working profile, and so forth. It is recommended to mount a snubber circuit when connecting inductive loads to the relays.

10.4.12 10 V DC Output

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

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

10.4.13 Ambient Conditions

Enclosure protection rating (H1–H5 & H11–H14)	IP20/Chassis
Vibration test (H1–H5 & H11–H14)	1.0 g
Maximum relative humidity (H1–H5 & H11–H14)	5–95% (non-condensing) during operation

Aggressive environment (IEC 60721-3-3), coated enclosure sizes (H1–H5 & H11–H14)	Class 3C3
Aggressive gases (IEC 60721-3-3), enclosure sizes (H13–H14)	Class 3C3
Aggressive environment (IEC 60068-2-43) H_2S test enclosure sizes H13–H14	Class Kd
Test method according to IEC 60068-2-43	H_2S (10 days)
Ambient temperature-full output current (H1–H5 & H11–H14)[1]	See maximum output current at 45 °C (113 °F) in 10.1.1 3x380–480 V AC[2].
Ambient temperature with derating (H1–H5 & H11–H14)	Maximum 55° C (131° F)[1]
Minimum ambient temperature during full-scale operation (H1–H5 & H11–H14)	-15 °C (5 °F)[3]
Minimum ambient temperature at reduced performance (H1–H5 & H11–H14)	-20 °C (-4 °F)[4]
Temperature during storage/transport (H1–H5 & H11–H12)	-30 to +65/70 °C (-22 to +149/158°F)
Temperature during storage/transport (H13–H14)	-25 to +65/70 °C (-13 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)[1]
Derating for high altitude	See 10.3.3 Derating for Low Air Pressure and High Altitudes.
Safety standards (H1–H5 & H11–H12)	EN/IEC 61800-5-1
EMC standards, Emission (H1–H5 & H11–H14)	EN/IEC 61800-3, IEC 61000-6-2/3/12, EN55011
EMC standards, Immunity (H1–H5 & H11–H14)	EN/IEC 61800-3, IEC 61000-6-2, IEC 61000-4-2/3/4/5/6, IEC 61000-4-11/13/27/28/34
Energy efficiency class	IE2[5]

[1] For more information on derating, see *chapter Derating* in the Design Guide.

[2] Apply for enclosure sizes H1, H2, H4, H11, H12, H13, and H14. For enclosure sizes H3, H5, and 90 kW (125 hp) drives, the maximum ambient temperature is 40 °C (104 °F).

[3] Apply for enclosure sizes H13–H14. For enclosure sizes H1–H5 and H11–H12 drives, the minimum ambient temperature during full-scale operation is -10 °C (14 °F).

[4] Apply for enclosure sizes H13–H14. For enclosure sizes H1–H5 and H11–H12 drives, the minimum ambient temperature at reduced performance is -15 °C (5 °F).

[5] Determined according to EN 50598-2 at:

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

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