

PowerXL™

DC1 Variable Frequency Drive



Powering Business Worldwide

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Original operating manual

The German-language edition of this document is the original operating manual.

Translation of the original operating manual

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Subject to alteration.



Danger! **Dangerous electrical voltage!**

Before commencing the installation

- Disconnect the power supply of the device.
- Ensure that devices cannot be accidentally retriggered.
- Verify isolation from the supply.
- Ground and short-circuit.
- Cover or enclose neighbouring units that are live.
- Follow the engineering instructions (IL) of the device concerned.
- Only suitably qualified personnel in accordance with EN 50110-1/-2 (VDE 0105 Part 100) may work on this device/system.
- Before installation and before touching the device ensure that you are free of electrostatic charge.
- The functional earth (FE) must be connected to the protective earth (PE) or to the potential equalizing. The system installer is responsible for implementing this connection.
- Connecting cables and signal lines should be installed so that inductive or capacitive interference do not impair the automation functions.
- Install automation devices and related operating elements in such a way that they are well protected against unintentional operation.
- Suitable safety hardware and software measures should be implemented for the I/O connection so that a cable or wire breakage on the signal side does not result in undefined states in the automation device.
- Ensure a reliable electrical isolation of the low voltage for the 24 V supply. Only use power supply units complying with IEC 60364-4-41 or HD 384.4.41 S2 (VDE 0100 part 410).
- Deviations of the mains voltage from the nominal value must not exceed the tolerance limits given in the technical data, otherwise this may cause malfunction and dangerous operation.
- Emergency-Stop devices complying with IEC/EN 60204-1 must be effective in all operating modes of the automation devices. Unlatching the emergency switching off devices must not cause restart.
- Built-in devices for enclosures or cabinets must only be run and operated in an installed state, desk-top devices or portable devices only when the housing is closed.
- Measures should be taken to ensure the proper restart of programs interrupted after a voltage dip or failure. This should not cause dangerous operating states even for a short time. If necessary, emergency switching off devices should be implemented.
- Wherever faults in the automation system may cause damage to persons or property, external measures must be implemented to ensure a safe operating state in the event of a fault or malfunction (for example, by means of separate limit switches, mechanical interlocks, etc.).
- During operation, and depending on their degree of protection, variable frequency drives may have live, uninsulated, moving, and/or rotating parts, as well as hot surfaces.
- The impermissible removal of the required cover, improper installation or incorrect operation of the motor or variable frequency drive can cause the failure of the device and serious injury and/or material damage.
- Comply with all applicable national accident prevention regulations (e.g. BGV A3) when working with energized variable frequency drives.
- The electrical installation must be carried out in accordance with the relevant regulations (e.g. with regard to cable cross sections, fuses, PE).
- All transport, installation, commissioning and maintenance work must only be carried out by trained personnel (observe IEC 60364, HD 384 or DIN VDE 0100 and national accident prevention regulations).
- If applicable, systems in which variable frequency drives are installed must be equipped with additional monitoring and protective devices in accordance with the applicable safety regulations, e.g., the German Equipment and Product Safety Act, accident prevention regulations, etc. Making changes to the variable frequency drives by using the operating software is allowed.
- Keep all covers and doors closed during operation.
- When designing the machine, the user must incorporate mechanisms and measures that limit the consequences of a drive controller malfunction or failure (an increase in motor speed or the motor's sudden stop) so as to prevent hazards to people and property, e.g.:
 - Additional stand-alone devices for monitoring parameters that are relevant to safety (speed, travel, end positions, etc.)
 - Electrical and non-electrical safety devices (interlocks or mechanical locks) for mechanisms that protect the entire system
 - Due to the possibility of there being capacitors that are still holding a charge, do not touch live device parts or terminals immediately after disconnecting the variable frequency drives from the supply voltage. Heed the corresponding labels on the variable frequency drives

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0 About this manual

This manual contains specific information designed to enable you to select a DC1 variable frequency drive, connect it, and use its parameters to configure it as required for your specific needs. The manual applies to all DC1 variable frequency drive sizes. Any differences between and special characteristics of the various rating levels and sizes will be noted accordingly.

0.1 List of revisions

The following significant amendments have been introduced since previous issues:

Publication date	Page	Subject	New	Modification	Deleted
12/13		Completely revised	✓	✓	
10/12		Initial issue			

0.2 Target group

The content of MN04020003Z-EN manual is written for engineers and electricians. A specialist knowledge of electrical engineering and fundamental technical principles is needed for commissioning. We assume that you have a good knowledge of engineering fundamentals and that you are familiar with handling electrical systems and machines, as well as with reading technical drawings.

0.3 Writing conventions

Symbols with the following meaning are used in this manual:

- ▶ Indicates instructions to be followed.

0.3.1 Hazard warnings of material damages

NOTICE

Warns about the possibility of material damage.

0.3.2 Hazard warnings of personal injury



CAUTION

Warns of the possibility of hazardous situations that may possibly cause slight injury.



WARNING

Warns of the possibility of hazardous situations that could result in serious injury or even death.



DANGER

Warns of hazardous situations that result in serious injury or death.

0.3.3 Tips



Indicates useful tips.



In order to make it easier to understand some of the figures included in this manual, the variable frequency drive housing, as well as other safety-relevant parts, has been left out. However, it is important to note that the variable frequency drive must always be operated with its housing in its proper place, as well as with all required safety-relevant parts.



All the specifications in this manual refer to the hardware and software versions documented in it.



More information on the devices described here can be found on the Internet under: www.eaton.eu/powerxl

0.4 Abbreviations

The following abbreviations are used in this manual:

dec	Decimal (base-10 numeral system)
EMC	Electromagnetic compatibility
FE	Functional earth
FS	Frame Size
FWD	Forward run (clockwise rotating field)
GND	Ground (0-V-potential)
hex	Hexadecimal (base-16 numeral system)
ID	Identifier (unique ID)
IGBT	Insulated gate bipolar transistor
LED	Light Emitting Diode (LED)
LSB	Least significant bit
MSB	Most significant bit
OLED	Organic Light Emitting Diode
PC	Personal Computer
PDS	Power Drive System (magnet system)
PE	Protective earth \oplus
PES	EMC connection to PE for screened lines
PNU	Parameter number
REV	Reverse run (anticlockwise rotation field active)
ro	Read Only (read access only)
rw	Read/Write (read/write access)
SCCR	Short Circuit Current Rating
UL	Underwriters Laboratories
DS	Default settings

0.5 Mains supply voltages

The rated operating voltages stated in the following table are based on the standard values for networks with a grounded star point.

In ring networks (as found in Europe) the rated operating voltage at the transfer point of the power supply companies is the same as the value in the consumer networks (e.g. 230 V, 400 V).

In star networks (as found in North America), the rated operating voltage at the transfer point of the utility companies is higher than in the consumer network.

Example: 120 V → 115 V, 240 V → 230 V, 480 V → 460 V.

The DC1 variable frequency drive's wide tolerance range takes into account a permissible voltage drop of 10% (i.e. $U_{LN} - 10\%$) while, in the 400-V category, it takes into account the North American mains voltage of 480 V + 10% (60 Hz).

The permissible power supply for the DC1 series is listed in the Technical Specifications section in the annex.

The rated mains voltage operational data is always based on mains frequencies of 50/60 Hz within a range of 48 to 62 Hz.

0.6 Units of measurement

Every physical dimension included in this manual uses international metric system units, otherwise known as SI (Système International d'Unités) units. For the purpose of the equipment's UL certification, some of these dimensions are accompanied by their equivalents in imperial units.

Table 1: Unit conversion examples

Designation	US-American value	SI value	Conversion value	US-American Designation
Length	1 in (")	25.4 mm	0.0394	inch
Power	1 HP = 1.014 PS	0.7457 kW	1.341	horsepower
Torque	1 lbf in	0.113 Nm	8.851	pound-force inches
Temperature	1 °F (T _F)	-17.222 °C (T _C)	$T_F = T_C \times 9/5 + 32$	Fahrenheit
Speed	1 rpm	1 min ⁻¹	1	Revolutions per minute
Weight	1 lb	0.4536 kg	2.205	pound
Flow rate	1 cfm	1.698 m ³ /min	0.5889	cubic feet per minute

1 DC1 device series

1.1 Introduction

Due to their ease of use and high reliability, DC1 PowerXL™ variable frequency drives are ideal for general applications involving three-phase motors. In addition, an integrated radio interference suppression filter and a flexible interface ensure that the inverters meet a number of important needs in the machine building industry when it comes to the optimization of production and manufacturing processes.

For installations in control panels, devices with a performance range of 0.37 (for 230 V) to 11 kW (for 400 V) are available in a compact and sturdy design featuring three available sizes (FS1, FS2, FS3) and a degree of protection of IP20.

For distributed local installations, there are three sizes covering a performance range of 0.37 (for 230 V) to 7.5 kW (for 400 V) and featuring a degree of protection of IP66. These models come in two versions: with and without local controls. These local controls include a setpoint potentiometer, a selector switch for switching operating directions, and a lockable main switch on the mains side.

The computer-based drivesConnect parameter configuration program ensures data integrity and reduces the time required for commissioning and maintenance.

In addition, the comprehensive accessories available increase the inverters' flexibility in all areas of application.

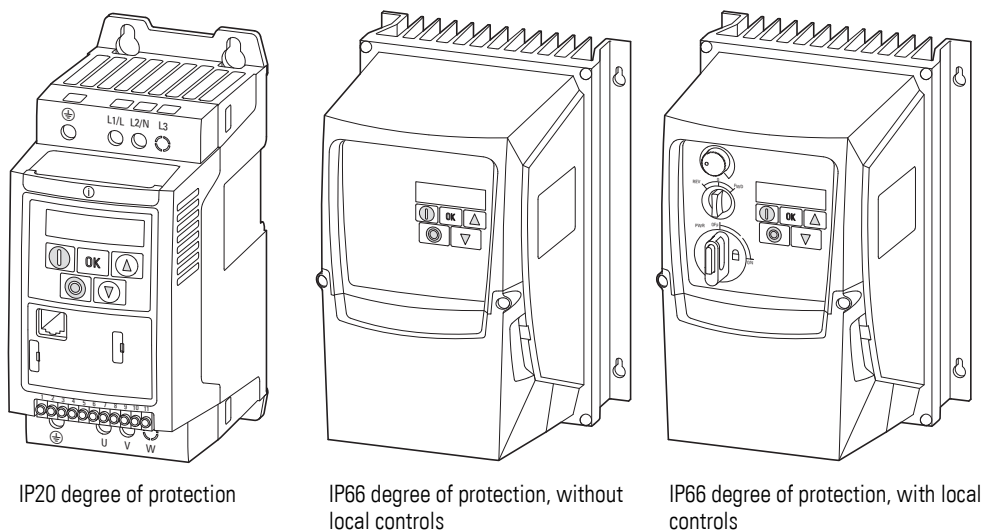


Figure 1: Designs, enclosure versions

1.2 System overview

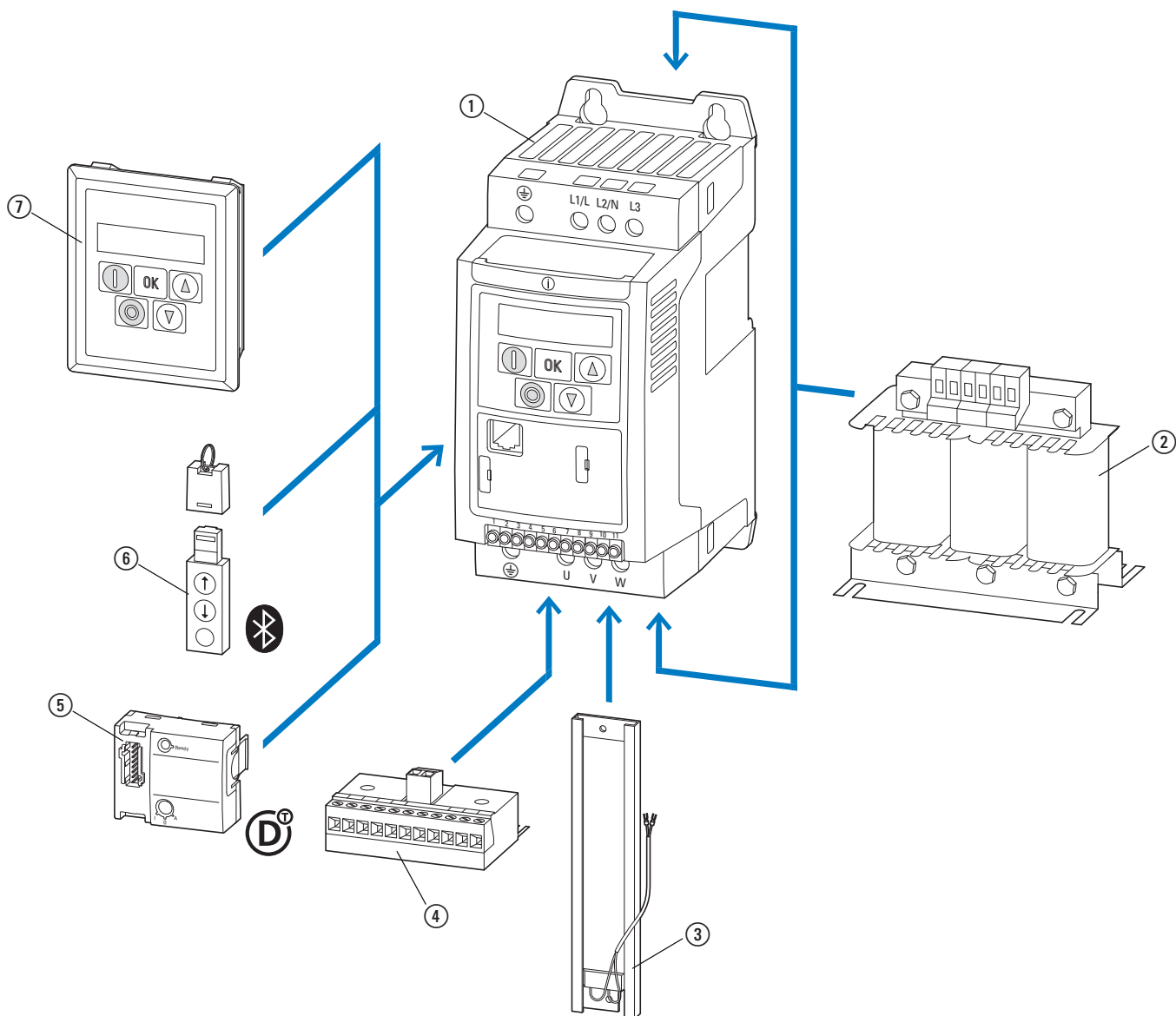


Figure 2: System overview (example)

- ① DC1-... variable frequency drives
- ② DX-LN... mains choke, DX-LM3-... motor choke, DX-SIN3-... sine filter
- ③ Integrable DX-BR... braking resistance (only for IP20, FS2 and FS3)
- ④ DXC-EXT-... expansion module
- ⑤ DX-NET-SWD3 SmartWire-DT interface (only in IP20)
- ⑥ DX-COM-STICK communication module and accessories (e. g. DX-CBL-... connection cable)
- ⑦ DE-KEY-... keypad (external)

1.3 Checking the Delivery

➔ Before opening the package, please check the nameplate on it to make sure that you received the correct variable frequency drive.

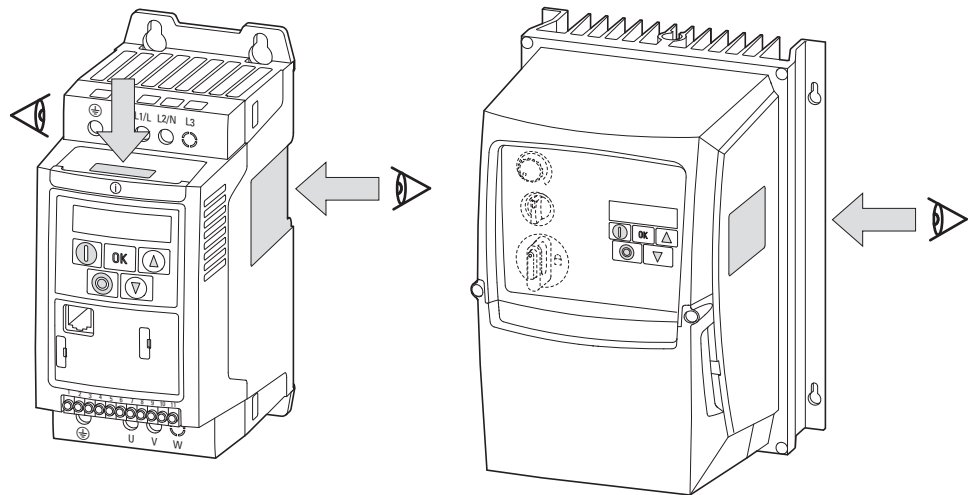


Figure 3: Nameplate location

The DC1 series variable frequency drives are carefully packaged and prepared for delivery. The devices should be shipped only in their original packaging with suitable transportation materials. Please take note of the labels and instructions on the packaging, as well as of those meant for the unpacked device.

Open the packaging with adequate tools and inspect the contents immediately after receipt in order to ensure that they are complete and undamaged.

1 DC1 device series

1.3 Checking the Delivery

The packaging must contain the following parts:

- DC1 series variable frequency drive,
- an instructional leaflet
 - IL04020009Z for devices with an IP20 degree of protection
 - IL04020013Z for devices with an IP66 degree of protection
- A data carrier (CD-ROM) containing documentation for the variable frequency drives

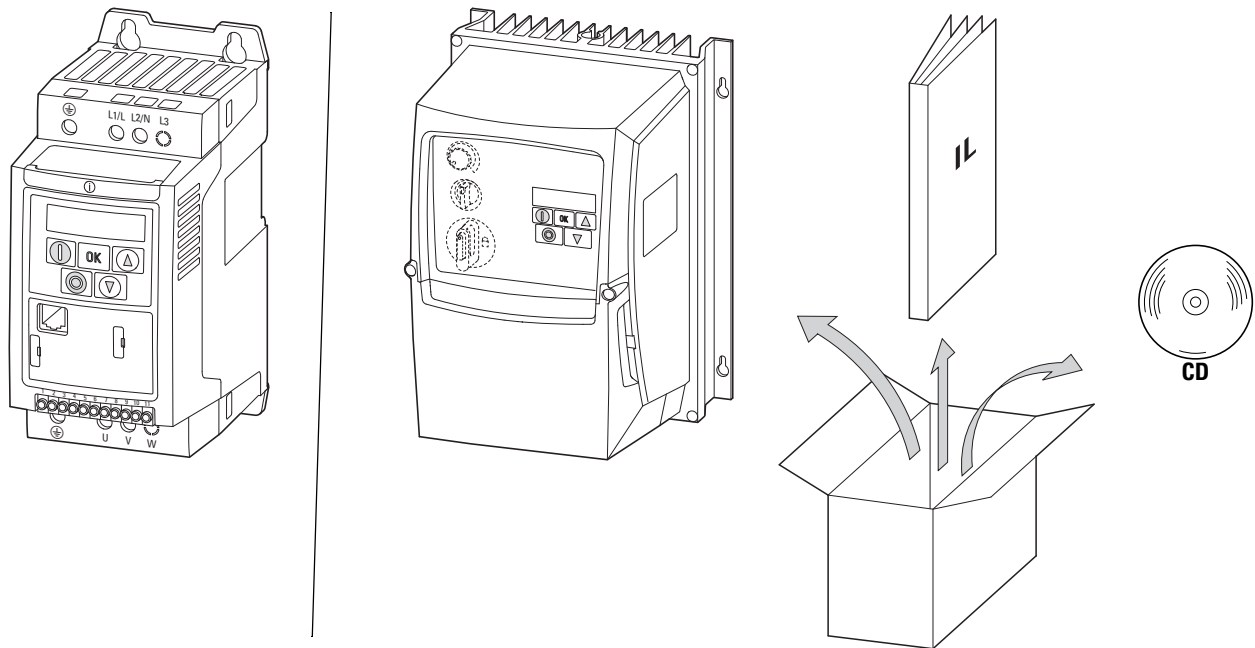


Figure 4: Equipment supplied

1.4 Rated operational data

Voltage categories


DC1 variable frequency drives are subdivided into the following mains voltage categories:

- 115 V: DC1-1**D**...
- 230 V: DC1-1**2**..., DC1-3**2**...
- 400 V: DC1-3**4**...

1.4.1 Rated operational data on the nameplate

The device-specific rated operational data for the DC1 variable frequency drive is listed on the nameplate on the right side of the device.

The inscription of the nameplate has the following meaning (example):

Inscription	Meaning
DC1-344D1FB-A20N	Part no.: DC1 = DC1 series variable frequency drive 3 = Three-phase mains connection / three-phase motor connection 4 = 400 V mains voltage category 4D1 = 4.1 A rated operational current (4-decimal-1, output current) F = integrated RFI filter B = integrated Brake Chopper A = LED display (7-segment text display) 20 = IP20 degree of protection N = basic device
Input	Rated operational data of mains connection Three-phase AC voltage (U_e 3~ AC), 380 - 480 V voltage, 50/60 Hz frequency, input phase current (4.3 A).
Output	Load side (motor) rated operational data: Three-phase AC voltage (0 - U_e), output phase current (4.1 A), output frequency (0 - 500 Hz)
Power	Assigned motor output: 1.5 kW at 400 V/2 HP at 460 V for a four-pole, internally cooled or surface-cooled three-phase asynchronous motor (1500 min ⁻¹ at 50 Hz/1800 rpm at 60 Hz)
S/N	Serial number
	variable frequency drive is an electrical apparatus. Read the manual (in this case MN04020003Z-EN) before making any electrical connections and commissioning.
IP20/Open type	Degree of protection of the housing: IP 20, UL (cUL) Open Type
25072012	Manufacturing date: 25.07.2012

1 DC1 device series
 1.4 Rated operational data

1.4.2 Key to part numbers

The catalog no. or part no. for the DC1 series of variable frequency drives is made up of four sections.

Series – Power section – Model – Version

The following figure shows it in greater detail:

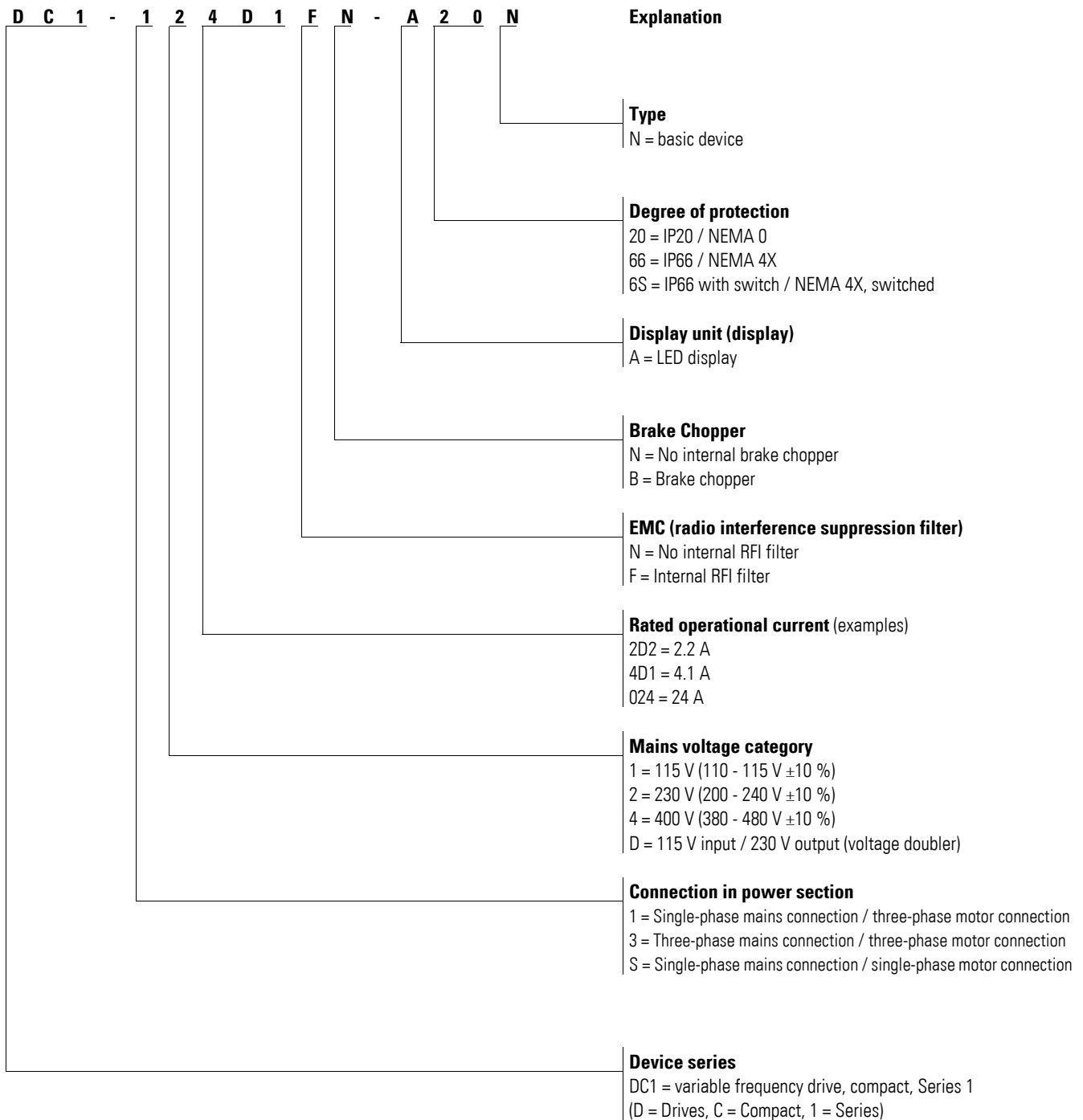


Figure 5: Key to part numbers

1) Please refer to manual MN04020004Z-EN

Catalog number examples

Inscription	Meaning
DC1-124D1FN-A20N	<p>DC1 = DC1 series variable frequency drive 1 = Single-phase mains connection / three-phase motor connection 2 = 230 V mains voltage category (200 - 240 V \pm10%) 4D1 = 4.1 A rated operational current (output current) F = Integrated radio interference suppression filter (RFI, EMC measure) N = No integrated braking chopper A = LED display (7-segment) on operating unit 20 = Degree of protection IP20 / NEMA 0 N = basic device</p>
DC1-327D0FB-A66N	<p>DC1 = DC1 series variable frequency drive 3 = Three-phase mains connection / three-phase motor connection 2 = 230 V mains voltage category (200 - 240 V \pm10%) 7D0 = 7 A rated operational current (output current) F = Integrated radio interference suppression filter (RFI, EMC measure) B = Integrated Brake Chopper. An external braking resistance (optional) is required for this function. A = LED display (7-segment) on operating unit 66 = degree of protection IP66 / NEMA 4X N = basic device</p>
DC1-34024NB-A20N	<p>DC1 = DC1 series variable frequency drive 3 = Three-phase mains connection / three-phase motor connection 4 = 400 V mains voltage category (380 - 480 V \pm10%) 024 = 24 A rated operational current (output current) N = No integrated radio interference suppression filter (RFI)¹⁾ B = Integrated Brake Chopper. An external braking resistance (optional) is required for this function. A = LED display (7-segment) on operating unit 20 = Degree of protection IP20 / NEMA 0 N = basic device</p>
DC1-342D2FN-A6SN	<p>DC1 = DC1 series variable frequency drive 3 = Three-phase mains connection / three-phase motor connection 4 = 400 V mains voltage category (380 - 480 V \pm10%) 2D2 = 2.2 A rated operational current (output current) F = Integrated radio interference suppression filter (RFI, EMC measure) N = No integrated braking chopper A = LED display (7-segment) on operating unit 6S = Degree of protection IP66 / NEMA 4X with switches (mains switch, enable/phase sequence, potentiometer) for local control N = basic device</p>

1) In the case of variable frequency drives without an integrated EMC filter, external measures (e.g., external radio interference suppression filters) must be used for operation in accordance with IEC/EN 61800-3 in order to comply with the relevant limits concerning electromagnetic compatibility (EMC).



In accordance with IEC/EN 61800-3, an external radio interference suppression filter is required for DC1-...Nx-... models.

1 DC1 device series

1.5 Designations for the elements in variable frequency drives with an IP20 degree of protection

1.5 Designations for the elements in variable frequency drives with an IP20 degree of protection

The following drawing serves as an example showing the designations used for the elements in DC1 variable frequency drives with a size of FS1 and an IP20 degree of protection.

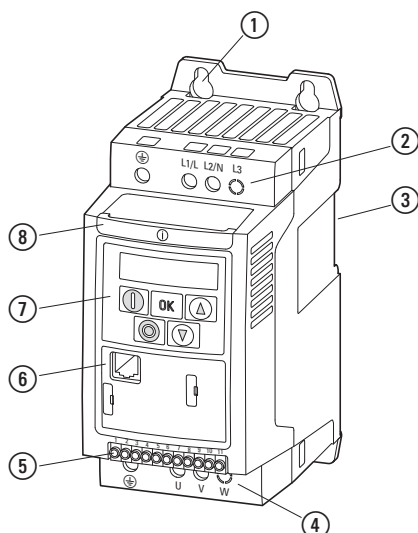


Figure 6: Designations (IP20)

- ① Fixing holes (screw fastening)
- ② Connection terminals in power section (mains side)
- ③ Cutout for mounting on mounting rail
- ④ Connection terminals in power section (motor feeder)
- ⑤ Control signal terminals (plug-in)
- ⑥ Communication interface (RJ45)
- ⑦ Operating unit with 5 control buttons and LED display
- ⑧ Info card

1.6 Designations for the elements in variable frequency drives with an IP66 degree of protection

1.6 Designations for the elements in variable frequency drives with an IP66 degree of protection

The following drawing serves as an example showing the designations used for the elements in DC1 variable frequency drives with a size of FS1 and an IP66 degree of protection.

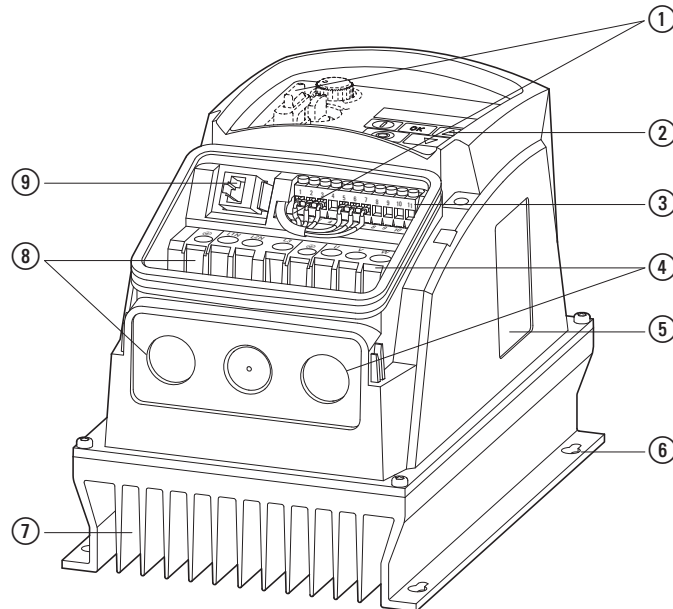


Figure 7: Designations (IP66)

- ① Local controls with connection (in DC1-...-A6SN only)
 - Setpoint potentiometer
 - Selector switch for switching operating directions
 - Mains transfer switch (lockable)
- ② Operating unit with 5 control buttons and LED display
- ③ Control signal terminal strip (plug-in)
- ④ Connection terminals in power section (motor feeder) and cableway for EMC cable gland
- ⑤ Nameplate
- ⑥ Fixing holes (screw fastening)
- ⑦ Heat sink
- ⑧ Connection terminals in power section (mains side) and cableway for cable gland
- ⑨ Communication interface (RJ45)

The info card and three additional knockouts for cable glands are found under the lower terminal cover.

1 DC1 device series

1.7 Features

1.7 Features

DC1 series variable frequency drives convert the voltage and frequency of an existing AC supply system into a DC voltage.

This DC voltage is then used to generate a single-phase or three-phase AC voltage with an adjustable frequency and assigned amplitude values for the variable speed control of AC motors and three-phase asynchronous motors.

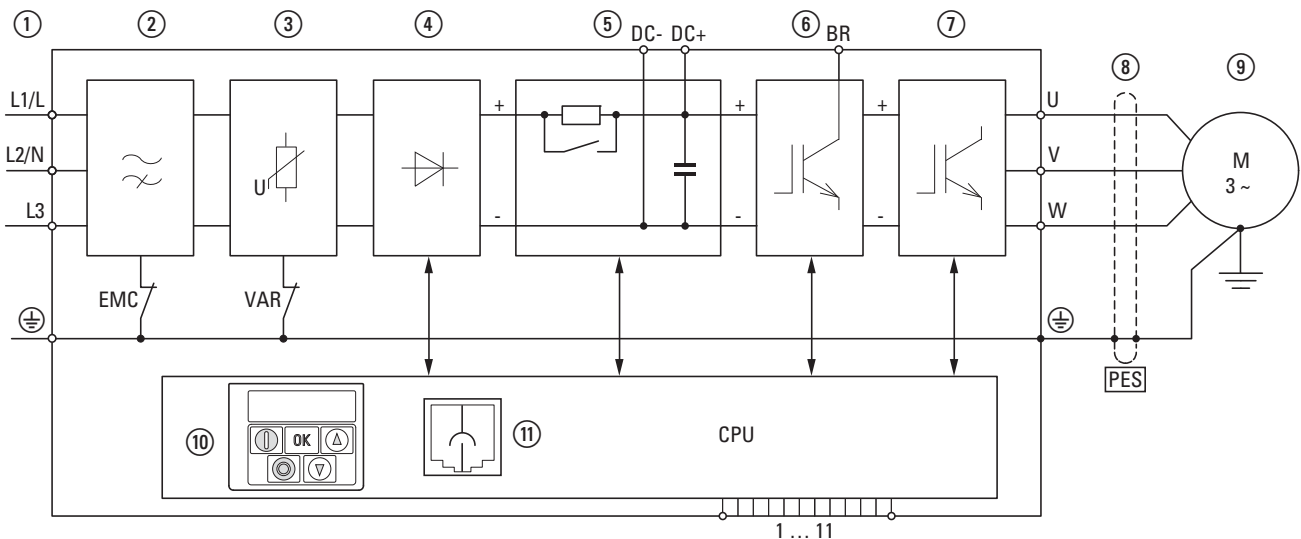


Figure 8: Block diagram; components in a DC1 variable frequency drive

- ① L1/L, L2/N, L3, PE supply, mains supply voltage $U_{LN} = U_e$ at 50/60 Hz:
 DC1-1D...: single-phase mains connection (1 AC 115 V), with voltage doubler, motor feeder (3 AC 230 V)
 DC1-12...: single-phase mains connection (1 AC/2 AC 230 V/240 V), motor feeder (3 AC 230 V)
 DC1-32...: three-phase mains connection (3 AC 230 V/240 V), motor feeder (3 AC 230 V)
 DC1-34...: three-phase mains connection (3 AC 400 V/480 V), motor feeder (3 AC 400 V)
- ② Internal radio interference suppression filter (not in DC1-1D...), EMC connection to PE
- ③ Internal voltage filter, VAR connection to PE
- ④ Rectifier bridge: it converts the AC voltage of the electrical supply to a DC voltage.
- ⑤ Internal DC link with charging resistor, capacitor, and switched-mode power supply unit and DC link (DC- and DC+ connection only in FS2 and FS3 sizes with IP20 degree of protection)
- ⑥ Braking chopper for external braking resistance (DC+ and BR connection only in FS2 and FS3 sizes)
- ⑦ Inverter. The IGBT based inverter converts the DC voltage of the DC link (U_{DC}) into a three-phase AC voltage (U_2) with variable amplitude and frequency (f_2).

- ⑧ Motor connection with output voltage U_2 (0 to 100% U_e) and output frequency f_2 (0 to 500 Hz)
The connection in the motor feeder is implemented with a screened cable that is earthed on both sides across a large area (PES).
Rated operational current (I_e , output current):
DC1-1D...: 2.3 - 5.8 A
DC1-12...: 2.3 - 15 A
DC1-32...: 2.3 - 18 A
DC1-34...: 2.2 - 24 A
100% at an ambient temperature of +50 °C with an overload capability of 150% for 60 s and a starting current of 175% for 2 s.
- ⑨ Three-phase asynchronous motor
Continuously variable speed control for motors with the rated motor shaft outputs (P_2):
DC1-1D...: 0.37 - 1.1 kW (230 V, 50 Hz) or 0.5 - 1.5 HP (230 V, 60 Hz)
DC1-12...: 0.37 - 4 kW (230 V, 50 Hz) or 0.5 - 5 HP (230 V, 60 Hz)
DC1-32...: 0.37 - 4 kW (230 V, 50 Hz) or 0.5 - 5 HP (230 V, 60 Hz)
DC1-34...: 0.75 - 11 kW (400 V, 50 Hz) or 1 - 15 HP (460 V, 60 Hz)
- ⑩ Control section with operating unit and control buttons, seven-segment display, control voltage, plug-in control signal terminals
- ⑪ RJ45 interface for the computer and fieldbus connection (OP bus, Modbus RTU, CANopen)

1.8 Selection criteria

Select the variable frequency drive according to the supply voltage U_{LN} of the supply system and the rated operational current of the assigned motor. The circuit type (Δ / Y) of the motor must be selected according to the supply voltage.

The rated output current I_e of the variable frequency drive must be greater than or equal to the rated motor current.

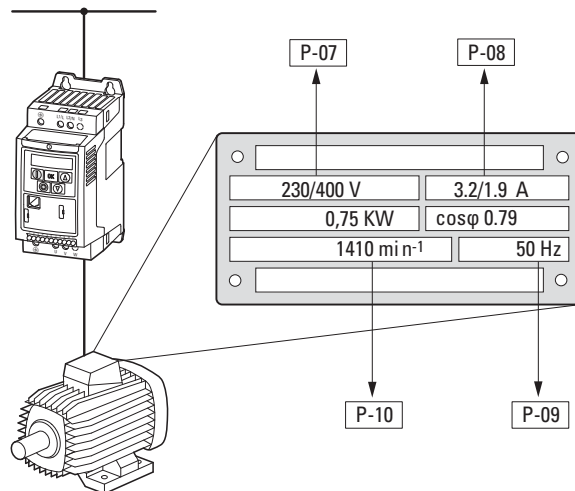


Figure 9: Selection criteria

When selecting the drive, the following criteria must be known:

- Type of motor
- Mains voltage = rated operating voltage of the motor (e. g. 3~ 400 V),
- Rated motor current (recommended value, dependent on the circuit type and the power supply)
- Load torque (quadratic, constant),
- Starting torque,
- Ambient air temperature (rated value e. g. +40 °C).
- Ambient conditions (control cabinet installation for IP20 degree of protection and direct local installation for IP66 degree of protection)



When connecting multiple motors in parallel to the output of a variable frequency drive, the motor currents are added geometrically – separated by effective and idle current components.

When you select a variable frequency drive, make sure that it can supply the total resulting current. If necessary, for dampening and compensating the deviating current values, motor reactors or sine filters must be installed between the variable frequency drive and the motor.

1.9 Proper use

The DC1 variable frequency drives are not domestic appliances. They are designed only for industrial use as system components.

The DC1 variable frequency drives are electrical devices for controlling variable speed drives with three-phase motors. They are designed for installation in machines or for use in combination with other components within a machine or system

If installed in a machine, the variable frequency drives must not be placed into operation until it is confirmed that the relevant machine complies with the safety requirements set forth in the 2006/22/EC Machinery Directive (meets the requirements set forth in EN 60204). The user of the equipment is responsible for ensuring that the machine use complies with the relevant EU Directives.

The CE markings on DC1 variable frequency drives confirm that the devices meet the requirements set forth in the European Union's Low Voltage and EMC Directives (Directives 2006/95/EC and 2006/42/EC) when used in their typical drive configuration.

In the described system configurations, DC1 variable frequency drives are suitable for use in public and non-public networks.

A connection of a DC1 variable frequency drive to IT networks (networks without reference to earth potential) is permissible only to a limited extent, since the device's built-in filter capacitors connect the network with the earth potential (enclosure).

On earth free networks, this can lead to dangerous situations or damage to the device (isolation monitoring required).



To the output (terminals U, V, W) of the DC1 variable frequency drive you must not:

- connect a voltage or capacitive loads (e.g. phase compensation capacitors),
- connect multiple variable frequency drives in parallel,
- make a direct connection to the input (bypass).

Observe the technical data and connection requirements.

For additional information, refer to the equipment rating plate or label of the variable frequency drive and the documentation. Any other usage constitutes improper use.

1 DC1 device series

1.10 Maintenance and inspection

1.10 Maintenance and inspection

DC1 series variable frequency drives will be maintenance-free as long as the general rated operational data (→ Section 1.5, „Designations for the elements in variable frequency drives with an IP20 degree of protection“, page 18) is adhered to and the specific technical data (see annex) for the corresponding ratings is taken into account. Please note, however, that external influences may affect the operation and lifespan of a DC1 variable frequency drive.

We therefore recommend that the devices are checked regularly and the following maintenance measures are carried out at the specified intervals.

Table 2: Recommended maintenance for DC1 variable frequency drives

Maintenance measures	Maintenance interval
Clean cooling vents (cooling slits)	please enquire
Check to make sure that the fan and the 7-segment display are working properly (press all five buttons simultaneously, starting with the Stop button)	6 - 24 months (depending on the environment)
Check the filter in the control panel doors (see the manufacturer's specifications)	6 - 24 months (depending on the environment)
Check all earth connections to make sure they are intact	On a regular basis, at periodic intervals
Check the tightening torques of the terminals (control signal terminals, power terminals)	On a regular basis, at periodic intervals
Check connection terminals and all metallic surfaces for corrosion	6 - 24 months; when stored, no more than 12 months later (depending on the environment)
Motor cables and shield connection (EMC)	According to manufacturer specifications, no later than 5 years
Charge capacitors	12 months (→ Section 1.12, „Charging the internal DC link capacitors“)

There are no plans for replacing or repairing individual components of DC1 variable frequency drives!

If the DC1 variable frequency drive is damaged by external influences, repair is not possible.

Dispose of the device according to the applicable environmental laws and provisions for the disposal of electrical or electronic devices.

1.11 Storage

If the DC1 variable frequency drive is stored before use, suitable ambient conditions must be ensured at the site of storage:

- Storage temperature: -40 - +60 °C,
- Relative average air humidity: < 95 %, non condensing (EN 50178),
- To prevent damage to the RASP DC link capacitors, storage times longer than 12 months are not recommended
(→ Section 1.12, „Charging the internal DC link capacitors“).

1.12 Charging the internal DC link capacitors

After extended storage times or extended downtimes during which no power is supplied (> 12 months), the capacitors in the internal DC link must be recharged in a controlled manner in order to prevent damage. To do this, the DC1 variable frequency drive must be supplied with power, with a controlled DC power supply unit, via two mains connection terminals (e.g. L1 and L2).

In order to prevent the capacitors from having excessively high leakage currents, the inrush current should be limited to approximately 300 to 800 mA (depending on the relevant rating). The variable frequency drive must not be enabled during this time (i.e. no start signal). After this, the DC voltage must be set to the magnitudes for the corresponding DC link voltage ($U_{DC} \sim 1.41 \times U_e$) and applied for one hour at least (regeneration time).

- DC1-12..., DC1-32...: about 324 V DC at $U_e = 230$ V AC
- DC1-34...: about 560 V DC at $U_e = 400$ V AC



Due to the internal voltage doubler circuit, the capacitors in DC1-1D... variable frequency drives cannot be reformed using the connection terminals!

Please contact your local sales office.

1.13 Service and warranty

In the unlikely event that you have a problem with your DC1 variable frequency drive, please contact your local sales office.

When you call, have the following data ready:

- The exact variable frequency drive part number (see nameplate),
- the date of purchase,
- a detailed description of the problem which has occurred with the variable frequency drive.

If some of the information printed on the rating plate is not legible, please state only the data which are clearly legible.

Information concerning the guarantee can be found in the Terms and Conditions Eaton Industries GmbH.

24-hour hotline: +49 (0)1805 223 822

E-Mail: AfterSalesEGBonn@eaton.com

1 DC1 device series
1.13 Service and warranty

2.2 Electrical power network

2.2.1 Mains connection and configuration

DC1 variable frequency drives can be connected to and run on all neutral point-grounded AC supply systems (TN-S, TN-C, TT grounding systems; please refer to IEC 60364) without any limitations.

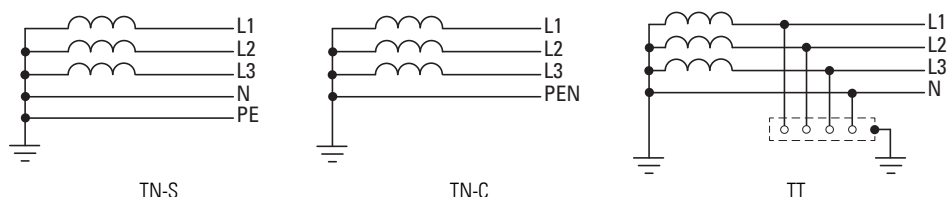


Figure 11: AC supply systems with earthed center point

➔ While planning the project, consider a symmetrical distribution to the three main phase conductors, if multiple variable frequency drives with single-phase supplies are to be connected. The total current of all single phase consumers is not to cause an overload of the neutral conductor (N-conductor).

The connection and operation of variable frequency drives to asymmetrically grounded TN networks (phase-grounded Delta network "Grounded Delta", USA) or non-grounded or high-resistance grounded (over 30 Ω) IT networks is only conditionally permissible.

➔ Operation on non-earthed networks (IT) requires the use of suitable insulation monitors (e.g. pulse-code measurement method)

➔ In networks with an earthed phase conductor, the maximum phase-earth voltage must not exceed 300 VAC.

If a DC1 variable frequency drive is connected to a corner-grounded system or to an IT system (ungrounded, insulated), the internal radio interference suppression filter must be disconnected (by unscrewing the screw marked EMC – in DC1-...-A20N only).

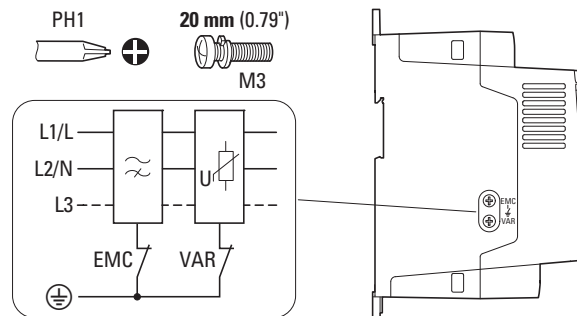


Figure 12: EMC and VAR screw locations

The required filter winding for electromagnetic compatibility (EMC) no longer exists in this case.



Measures for electromagnetic compatibility are mandatory in a magnet system, to meet the legal standards for EMC- and Low Voltage Directive.

Good earthing measures are a prerequisite for the effective insert of further measures such as screen earth kit or filters here. Without respective grounding measures, further steps are superfluous.

2.2.2 Mains voltage and frequency

DC1 variable frequency drives feature a wide tolerance range that incorporates the rated values for European ($U_{LN} = 230 \text{ V}/400 \text{ V}$, 50 Hz) and American ($U_{LN} = 240 \text{ V}/480 \text{ V}$, 60 Hz) standard voltages:

- 115 V, 50/60 Hz at DC1-1D...
110 V - 10 % - 115 V + 10 % (99 V - 0 % - 126.5 V + 0 %)
- 230 V, 50 Hz; 240 V, 60 Hz bei DC1-12..., DC1-32...
200 V - 10 % - 240 V + 10 % (180 V - 0 % - 264 V + 0 %)
- 400 V, 50 Hz; 480 V, 60 Hz bei DC1-34...
380 V - 10 % - 480 V + 10 % (342 V - 0 % - 528 V + 0 %)

The permissible frequency range for all voltage categories is 50/60 Hz (48 Hz - 0% - 62 Hz + 0%).

2.2.3 Voltage balance

Unbalanced voltages and deviations from the ideal voltage shape may occur in three-phase AC supply systems if the phase conductors are loaded unevenly and if large output loads are connected directly. In variable frequency drives powered with a three-phase power supply, these unbalances may cause the diodes in the mains rectifier to be loaded unevenly, resulting in premature diode failure.



In the project planning for the connection of three-phase supplied variable frequency drives (DC1-3...), consider only AC supply systems that handle permitted asymmetric divergences in the mains voltage $\leq +3\%$.

If this condition is not met or if the unbalance at the connection location is not known, it is recommended to use a recommended mains choke (please refer to the annex, "Mains chokes" section, page 214).

2.2.4 Total Harmonic Distortion (THD)

Non-linear consumers (loads) in an AC supply system produce harmonic voltages that again result in harmonic currents. These harmonic currents at the inductive and capacitive reactances of a mains supply system produce additional voltage drops with different values which are then overlaid on the sinusoidal mains voltage and result in distortions. In supply systems, this form of "noise" can give rise to problems in an installation if the sum of the harmonics exceeds certain limit values.

The THD value (THD = Total Harmonic Distortion) is defined in standard IEC/EN 61800-3 as the ratio of the rms value of all harmonic components to the rms value of the fundamental frequency.



In order to reduce THD values (up to 30%), it is recommended to use a recommended mains choke (please refer to the annex, "Mains chokes" section, page 214).

2.2.5 Idle power compensation devices

Compensation on the power supply side is not required for the variable frequency drives of the DC1 series. From the AC power supply network they only take on very little reactive power of the fundamental harmonics ($\cos \varphi \sim 0.98$).



In the AC supply systems with non-choked reactive current compensation devices, current deviations can enable parallel resonance and undefinable circumstances.

In the project planning for the connection of variable frequency drives to AC supply systems with undefined circumstances, consider using main chokes.

2.2.6 Mains chokes

Main chokes (also known as commutating chokes) increase the inductance of the mains supply cable. This extends the current flow period and dampens mains voltage drops.

Towards the variable frequency drive, the main chokes dampen the interference from the supply network. This increases the electric strength of the variable frequency drive and lengthens the lifespan (diodes of the mains power rectifier, internal DC link capacitors).



For the operation of the DC1 variable frequency drive, the application of main chokes is not necessary. We do recommend however that an upstream mains choke is used since the network quality is not known in most cases.

While planning the project, consider that a main choke is only assigned to a single variable frequency drive for decoupling.

When using an adapting transformer (assigned to a single variable frequency drive), a main choke is not necessary.

Main chokes are designed based on the mains-side input current (I_{LN}) of the variable frequency drive.

The mains chokes recommended for DC1 variable frequency drives are listed in the annex (→ Table 32 and → Table 33) (→ Section 11.16, „Mains chokes“, page 215).

2.2.7 Sine filter

Sine filters are connected in the output of a variable frequency drive.

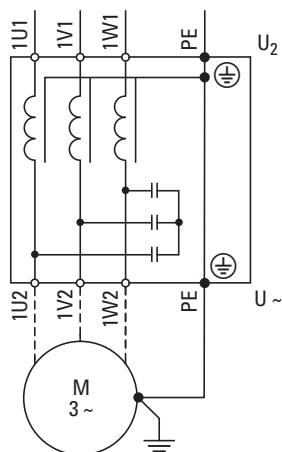


Figure 13: Circuit Diagram of a sine filter

The sine filter removes high-frequency components above the set resonance frequency from the variable frequency drive output voltage (U_2). This reduces the conducted and radiated emission.

Advantages of sine filters:

- Long motor cable lengths with reduced conducted and radiated interference
- Reduced motor losses and noise
- Longer motor lifespan

Disadvantages of sine filters:

- Voltage drop of up to 9% caused by system (approx. 36 V if $U_2 = 400$ V)
- higher heat dissipation,
- A fixed pulse frequency is required
- Require more space inside the control panel

NOTICE

sine filters must only be used with permanently set pulse frequencies.



For more information on sine filters, please refer to
→ Section 11.18, „Sine filter“, page 219.

2.3 Safety and switching

2.3.1 Fuses and cable cross-sections

The fuses and wire cross-sections allocated for power-side connections depend on the rated mains current I_{LN} of the variable frequency drive (without main choke).

NOTICE

When selecting the cable cross-section, take the voltage drop under load conditions into account.

The consideration of other standards (e.g. VDE 0113 or VDE 0289) is the responsibility of the user.

The recommended fuses and their assignment to the variable frequency drives are listed in Page 206 the annex.

The national and regional standards (for example VDE 0113, EN 60204) must be observed and the necessary approvals (for example UL) at the site of installation must be fulfilled.

When the device is operated in a UL-approved system, use only UL-approved fuses, fuse bases and cables. The permissible cables must have a heat resistance of 75 °C.

The connection terminals marked with \oplus and the metallic enclosure (IP66) must be connected to the earth-current circuit.

The leakage currents to earth (as defined in EN 50178) are higher than 3.5 mA.

They are listed for the individual ratings in the annex, under the specific technical data, starting on Page 173.



As per the requirements in standard EN 50178, a protective earth (PE) must be connected. The cable cross-section must be at least 10 mm² or consist of two separately connected earthing cables.

NOTICE

The specified minimum PE conductor cross-sections (EN 50178, VDE 0160) must be maintained.

A completely (360°) screened low impedance cable on the motor side is required. The length of the motor cable depends on the RFI class and the environment.



Choose the cross-section of the PE conductor in the motor lines at least as large as the cross-section of the phase conductors (U, V, W).

2.3.2 Residual current circuit-breaker (RCD)

Residual current circuit-breakers (RCDs = residual current devices) protect people and farm animals from the presence (not the production of!) impermissibly high touch voltages. They prevent dangerous (including fatal) injuries caused by electrical accidents and also serve to prevent fires.



CAUTION

Only AC/DC sensitive residual current circuit-breakers (RCD, type B) should be used with three-phase variable frequency drives (EN 50178, IEC 755).



In the case of variable frequency drives powered with a three-phase power supply, certain faults may produce DC currents that will prevent type A RCD protective devices from tripping, thus rendering the protection they provide ineffective.



RCD protective devices must be used exclusively for variable frequency drives powered with a single-phase (L, N) power supply.

NOTICE

Residual current devices (RCD) are only to be installed between the AC supply system and the variable frequency drive.

NOTICE

Safety-relevant leakage currents can occur while handling and when operating the variable frequency drive, if the variable frequency drive is not grounded.

Leakage currents to earth are mainly caused by foreign capacities with variable frequency drives: between the motor phases and the shielding of the motor cable and via the star capacitor of the radio interference suppression filter.

The size of the leakage currents is mainly dependent upon the:

- length of the motor cable,
- shielding of the motor cable,
- height of the pulse frequency (switching frequency of the inverter),
- design of the radio interference suppression filter
- grounding measures at the site of the motor.

2.3.3 Mains contactors

The mains contactor enables an operational switching on and off of the supply voltage for the variable frequency drive and switching off in case of a fault.

The mains contactor is designed based on the mains-side input current I_{LN} of the variable frequency drive for utilization category AC-1 (IEC 60947) and the ambient air temperature at the location of use. Mains contactors and their assignment to the variable frequency drives belonging to the DC1 series are listed in the annex (→ Table 26, page 208).



While planning the project, make sure that inching operation is not done via the mains contactor of the variable frequency drive on frequency-controlled drives, but through a controller input of the variable frequency drive.

The maximum permissible mains voltage switch-on frequency for the DC1 variable frequency drive is once every 30 seconds (normal operation).

2.4 EMC compliance

Electrical components in a system (machine) have a reciprocal effect on each other. Each device not only emits interference but is also affected by it. This occurs as a result of galvanic, capacitive and/or inductive coupling or through electromagnetic radiation. In practice, the limit between line-conducted interference and emitted interference is around 30 MHz. At values above 30 MHz the lines and cables act like antennas and radiate the electromagnetic waves.

Electromagnetic compatibility (EMC) for frequency controlled drives (variable speed drives) is implemented in accordance with product standard IEC/EN 61800-3. This includes the complete power magnet system (PDS = Power Drive System), from the mains supply to the motor, including all components, as well as cables (→ Figure 10, page 27). This type of magnet system can consist of several individual drives.

The generic standards of the individual components in a magnet system compliant with IEC/EN 61800-3 do not apply. These component manufacturers, however, must offer solutions that ensure standards-compliant use.

In Europe, maintaining the EMC Directive is mandatory.

A declaration of conformity (CE) refers always to a "typical" power magnet system (PDS). The responsibility to comply with the legally stipulated limit values and thus the provision of electromagnetic compatibility is ultimately the responsibility of the end user or system operator.

Measures must be taken to remove or minimize emission in the associated environment. He must also utilize means to increase the interference immunity of the devices of the system.

2 Engineering

2.4 EMC compliance

With their high interference immunity up to category C3, DC1 variable frequency drives are ideal for use in harsh industrial networks (2nd environment).

The DC1...-F... version (with integrated RFI filter) makes it possible to comply with the stringent limit values for conducted emission for category C1 in the 1st environment. This requires a correct EMC installation (→ Page 51) and the observance of the permissible motor cable lengths and the maximum switching frequency (f_{PWM}) of the inverter.

In the case of variable frequency drives without an internal radio interference suppression filter, longer motor cable lengths and lower leakage currents can sometimes be achieved for the individual categories by using a dedicated external radio interference suppression filter.

The required EMC measures should be taken into account in the engineering phase. Improvements and modifications during mounting and installation or even at the installation site involve additional and even considerably higher costs.

2.5 Motor

2.5.1 Motor Selection

General recommendations for motor selection:

- For a frequency-controlled magnet system (PDS), use three-phase AC motors with squirrel-cage rotors and surface cooling, also known as three-phase asynchronous motors or standard motors. Other types of motors, such as external rotor motors, wound-rotor motors, reluctance motors, permanent-magnet motors, synchronous motors, and servomotors can also be operated with a variable frequency drive, but normally require additional engineering in consultation with the motor's manufacturer.
- Only use motors that have insulation class F (maximum steady state temperature of 155 °C) at least.
- Choose 4 pole motors preferably (synchronous speed: 1500 min⁻¹ at 50 Hz and 1800 min⁻¹ at 60 Hz).
- Take the operating conditions into account for S1 operation (IEC 60034-1).
- When operating multiple motors in parallel on one variable frequency drive, the motor output should not be more than three power classes apart.
- Ensure that the motor is not overdimensioned. If it is underdimensioned in the "speed control" (slip compensation) operating mode, the motor output may only be one single assigned output level lower.

2.5.2 Parallel connection of motors

DC1 variable frequency drives make it possible to run several motors in parallel in "V/Hz control" mode (P-10 = 0).



If several motors are connected, the total of the motor currents, taking the inrush currents into account (only when the motor is connected during ongoing operation), must be less than the variable frequency drive's rated operational current.

Parallel operation at different motor speeds can be implemented only by changing the number of pole pairs and/or changing the motor's transmission ratio.

Connecting motors in parallel reduces the load resistance at the variable frequency drive output. The total stator inductance is lower and the leakage capacity of the lines greater. As a result, the current distortion is greater than in a single-motor circuit.

In order to reduce the amount of current distortion, a motor choke should be used at the variable frequency drive's output (→ Table 34, page 218 and → Table 35, page 218).

NOTICE

If multiple motors are connected in parallel to a single variable frequency drive, make sure to dimension the individual motors' contactors as required for utilization category AC-3. The motor contactors must be selected according to the rated operational currents of the motors that will be connected.



If several motors are being run in parallel, you will not be able to use the variable frequency drive's electronic motor protection. Each motor will have to be protected individually with thermistors and/or an overload relay.



Within a frequency range of 20 to 120 Hz, the PKE electronic motor-protective circuit-breaker can be used for motor protection at the variable frequency drive's output as well.



For more information, please refer to application note AP040048.

2.5.3 Circuit types with three-phase motors

The three-phase motor's stator winding can be connected in a star or delta circuit as per the rated operational data on the rating plate.

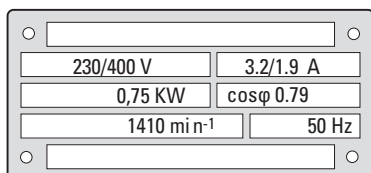


Figure 14: Example of a motor rating plate

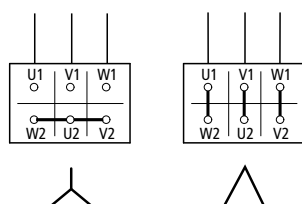


Figure 15: Configuration types:
Star-connected circuit (left), Delta circuit (right)

2.5.4 87-Hz Characteristic curve

The three-phase motor with the rating plate in Figure 14 can be operated with either a star or delta circuit. The operational characteristic curve is determined by the ratio of motor voltage to motor frequency in this case.

The 87-Hz characteristic curve is used to operate the three-phase standard motor with the rating plate in Figure 14 with a delta circuit on a 400-V network at 87 Hz. To enable this, the variable frequency drive must deliver the higher current for delta circuits (3.2 A) and the motor frequency (V/Hz key point) must be set to 87 Hz on the variable frequency drive.

This results in the following advantages:

- The motor's speed adjustment range is increased by a factor of $\sqrt{3}$ (from 50 Hz to 87 Hz)
- The motor's efficiency is improved, since the motor speed increases while the (absolute) slip remains the same and therefore is smaller, percentage-wise, relative to the new (higher) speed
- Greater power can be taken from the motor ($P \sim M \times n$), making it possible in some cases to use a motor that is one size smaller (and therefore less expensive) for the application (e.g., travel motor in crane drives)
- The machine speed of existing machines can be increased without having to change the motor and/or transmission. In other words, operation does not take place within the field-weakening range



Due to the higher thermal load, it is recommended to only use the next higher listed motor output.



If using 2 pole motors ($p = 1$), the high speed of approximately 5,000 rpm must be taken into account (consult the manufacturer's specifications).

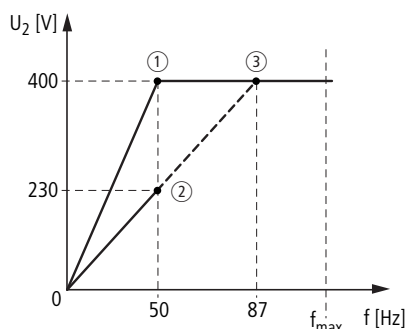


Figure 16: V/Hz characteristic curve for the rating plate of the motor from → Figure 14

- ① Star connection: 400 V, 50 Hz
- ② Delta circuit: 230 V, 50 Hz
- ③ Delta connection: 400 V, 87 Hz

2 Engineering

2.5 Motor

The following Table 3 shows the allocation of possible variable frequency drives depending on the mains voltage and the type of circuit.

Table 3: Assignments between variable frequency drives and V/Hz characteristic curve (→ Figure 16)

Physical parameters	DC1-124D3...	DC1-324D3...	DC1-342D2...	DC1-344D1...
Rated operational current	4.3A	4.3A	2.2A	4.1A
Mains voltage	1 AC 230 V	3 AC 230 V	3 AC 400 V	3 AC 400 V
U/f-characteristic curve	②	②	①	③
Motor circuit	Delta circuit (230 V)	Delta circuit (230 V)	Star-connected circuit (400 V)	Delta circuit (230 V)
Rated motor current	3.5A	3.5A	2.0A	3.5A
Motor rating	0.75 kW	0.75 kW	0.75 kW	1.1 kW ²⁾
Rated motor operating voltage	3 AC 0 - 230 V	3 AC 0 - 230 V	3 AC 0 - 400 V	3 AC 0 - 400 V
Rated motor operating speed	1430 min ⁻¹	1430 min ⁻¹	1430 min ⁻¹	2474 min ⁻¹ 1)
Rated motor operating frequency	50 Hz	50 Hz	50 Hz	87 Hz ¹⁾

1) Note the permitted limit values of the motor!

2) Mathematically $\sqrt{3} \times 0.75 \text{ kW} \approx 1.3 \text{ kW}$

2.5.5 Connecting EX motors

The following aspects must be taken into account when connecting hazardous location motors:

- A variable frequency drive can be installed in an explosion-proof enclosure within the hazardous location or in a control panel outside the hazardous location.
- All applicable industry-specific and country-specific regulations for hazardous locations (ATEX 100a) must be complied with.
- The specifications and instructions provided by the motor's manufacturer with regard to operation with a variable frequency drive – e.g., whether motor reactors (dV/dt limiting) or sine filters are required – must be taken into account.
- Temperature monitors in the motor windings (thermistor, Thermo-Click) must not be connected directly to the variable frequency drive, but instead must be connected through a relay approved for the hazardous location (e.g. EMT6).

3 Installation

3.1 Introduction

This chapter provides a description of the installation and the electrical connections for the variable frequency drive DC 1 series.



While mounting and/or assembling the variable frequency drive, cover all ventilation slots in order to ensure that no foreign bodies can enter the device.



Perform all installation work with the specified tools and without the use of excessive force.

3.2 Mounting

The instructional leaflets in this section are meant to show how to install the device in a suitable enclosure for devices with degree of protection IP20 in compliance with standard EN 60529 and/or any other applicable local regulations.

- The enclosures must be made of a material with high thermal conductivity.
- If a control panel with ventilation openings is used, the openings must be located above and below the variable frequency drive in order to allow for proper air circulation. The air should come in from below the variable frequency drive and leave above it.
- If the environment outside the control panel contains dirt particles (e.g., dust), a suitable particulate filter must be placed on the ventilation openings and forced ventilation must be used. The filters must be maintained and cleaned if necessary.
- An appropriate enclosed control panel (without ventilation openings) must be used in environments containing large percentages or amounts of humidity, salt, or chemicals.

3 Installation

3.2 Mounting

3.2.1 Mounting position

DC1 series variable frequency drives are designed to be mounted vertically. The maximum permissible inclination is 30°.

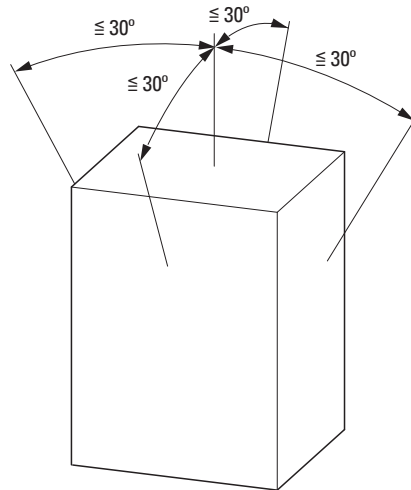


Figure 17: Mounting position

3.2.2 Free space

To ensure that there is sufficient air circulation, appropriate thermal clearances must be maintained, with these clearances depending on the size of the specific variable frequency drive.

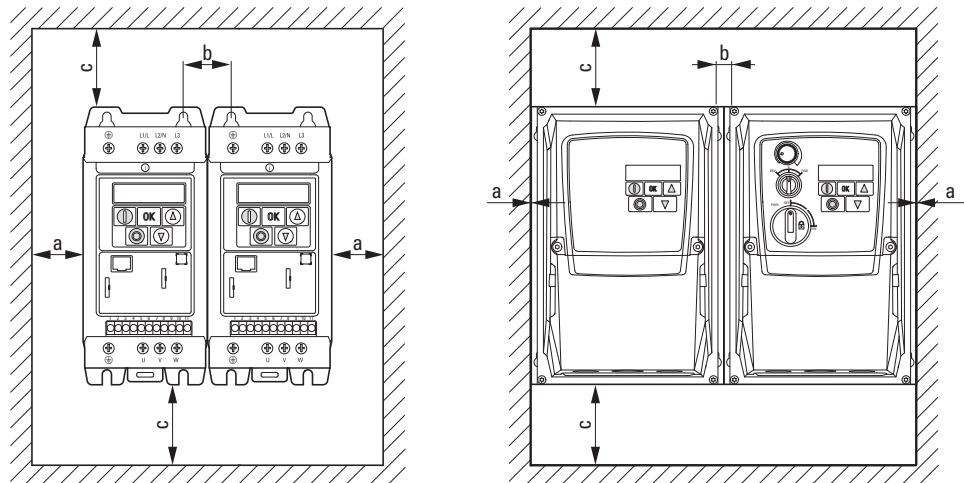


Figure 18: Clearances for air cooling (left: IP20; right: IP66)



The variable frequency drives can be mounted side by side without any lateral clearance between them.

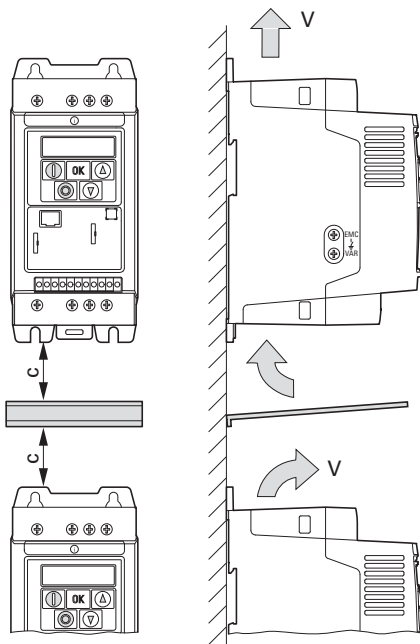


Figure 19: Baffle



Devices with high magnetic fields (e. g. reactors or transformers) should not be installed close to the variable frequency drive.

Table 4: Minimum clearance and required cooling air

Size	a		b		c		Air through-put	
	[mm]	[in]	[mm]	[in]	[mm]	[in]	[m ³ /h]	[ft ³ /min]
For degree of protection IP20								
FS1	50	1.97	31	1.22	50	1.97	18.69	11
FS2	50	1.97	32	1.26	75	2.95	18.69	11
FS3 ¹⁾	50	1.97	31	1.22	100	3.94	44.1	26
For degree of protection IP66								
FS1	0	0	12.5	0.49	150	5.91	–	–
FS2	0	0	12.0	0.47	150	5.91	–	–
FS3 ¹⁾	0	0	13.0	0.51	150	5.91	–	–

1) For UL conformity, the maximum permissible ambient air temperature over a period of 24 hours is limited to +45 °C for the DC1-127D0..., DC1-32011..., and DC1-32018... variable frequency drives.

The values in 4 are recommended values for an ambient air temperature of up to +50 °C, an installation altitude of up to 1,000 m, and a pulse frequency of up to 8 kHz.



Typical heat loss makes up about 3% of the operational load conditions.

3 Installation

3.2 Mounting

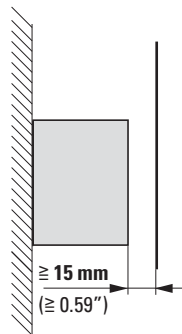
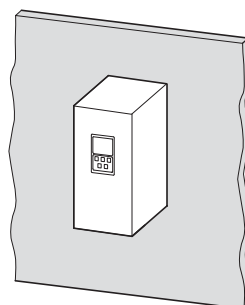


Figure 20: Front clearance

When variable frequency drives with internal fans are installed vertically over each other, an air baffle must be placed between the devices. Failure to do so may expose the device on top to a thermal overload caused by the guided air flow (device fan).

3.2.3 Fixing

FS1 and FS2 variable frequency drives can be mounted with screws or on a mounting rail. FS3 devices can only be mounted with screws.



Make sure to mount the variable frequency drive on a nonflammable mounting base (e.g., on a metal panel) only.



For dimension and weight specifications, please refer to the annex (→ Page 167ff.).

3.2.3.1 Fixing with screws



The number and the arrangement of the required fixing dimensions are found in → Section 11.4, „Dimensions and frame size“, page 183.



Use screws with a washer and split washer with the permissible tightening torque of 1 Nm in order to protect the enclosure while safely and reliably mounting the device.

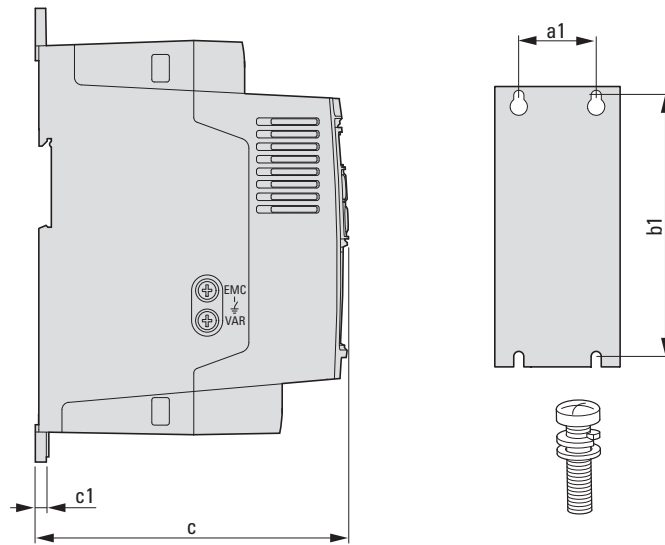


Figure 21: Mounting dimensions

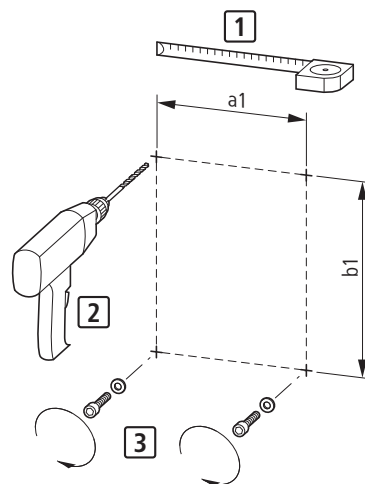


Figure 22: Mounting preparation

- ▶ First fit the screws at the specified positions, mount the variable frequency drive and then fully tighten all screws.

3 Installation

3.2 Mounting

3.2.3.2 Fixing on mounting rails

As an alternative to screw fixing, DC1 variable frequency drives with sizes FS1 and FS2 and a degree of protection of IP20 can also be mounted on a mounting rail as per IEC/EN 60715.

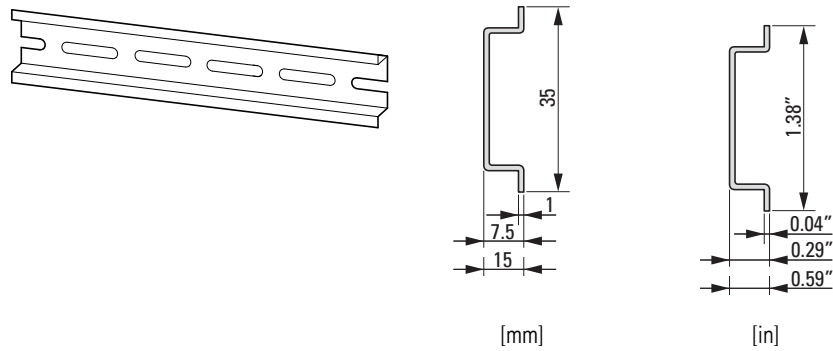


Figure 23: Mounting rail conforming with IEC/EN 60715



If you use EMC mounting adapters (DX-EMC-MNT-...), use a tall mounting rail (15 mm) preferably.

- ▶ To do this, place the variable frequency drive on the mounting rail from above [1] and press it down until it snaps into place [2].

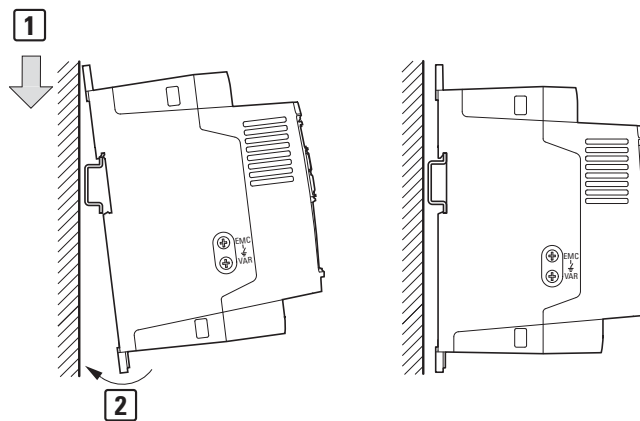


Figure 24: Fixing on mounting rails

Dismantling from mounting rails

- ▶ To remove the device, push down the spring-loaded clip. A cutout marked on the lower edge of the device is provided for this purpose. A flat-bladed screwdriver (blade width 5 mm) is recommended for pushing down the clip.

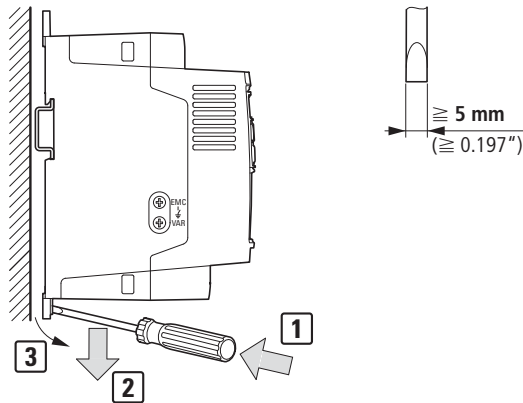


Figure 25: Dismantling from mounting rails

3 Installation

3.2 Mounting

3.2.4 Installing cable glands (IP66)

A total of six cable glands can be installed on the variable frequency drives with an IP66 degree of protection. The lower section has two knockouts for cable glands that are already open and that are intended for connecting the power section. The center knockout in the lower section is intended for an external braking resistance. The lower housing cover has three additional knockouts for routing control and bus cables.

- ▶ Use a standard screwdriver to punch out the knockouts. While doing so, make sure not to damage any internal terminal box parts.

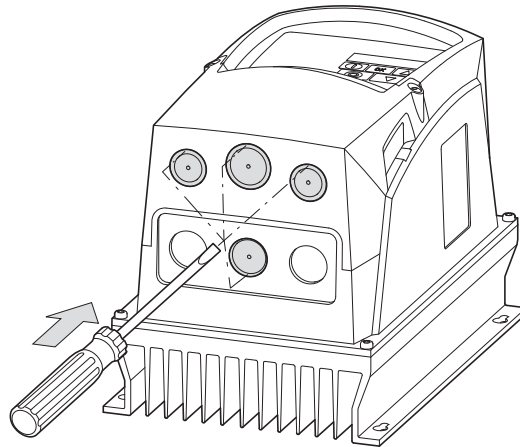


Figure 26: Punching out the knockouts

- ▶ Remove the lower housing cover as shown.

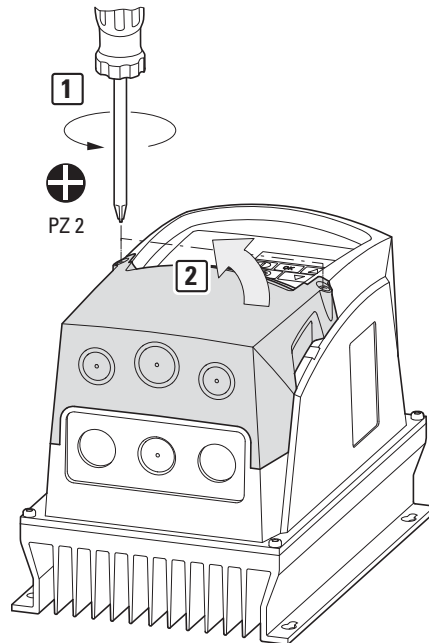


Figure 27: Removing the lower housing cover

Insert a plastic gland into the knockout on the left – which will already have been punched out at the factory – in order to thread in the power supply cord. Due to EMC reasons, you should use an EMC cable gland in the knockout on the right in order to connect the motor cable screen across a large area and ground it.

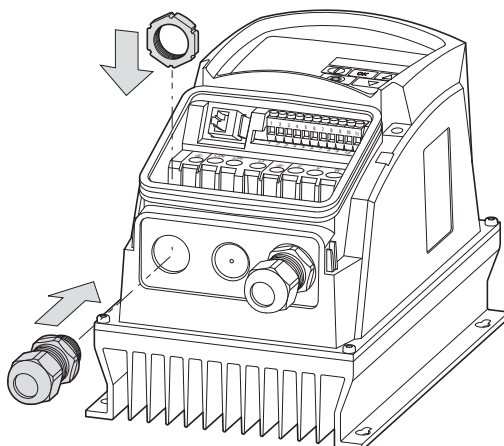


Figure 28: Installing the cable glands



Make sure that the cable glands have at least an IP66 degree of protection.

Table 5: Usable cable glands

Range	Size	Hole size	PG gland	Metric gland	Part no. Plastic ¹⁾	Part no. Metal/EMC ¹⁾
Control section	FS1	2 x 22 mm	2 x PG 13.5	2 x M20	M20: GHG9601955R0003 and GHG9601941R0033	M20: CAP189202 (6 - 13 mm) or CAP189552 (4.5 - 10 mm) and DKA12E
	FS2		1 x PG 16	1 x M25		
	FS3					
Power section	FS1	3 x 22 mm	3 x PG 13.5	3 x M20	M25: GHG9601955R0004 and GHG9061941R0034	M25: CAP189252 (10 - 18 mm) or CAP189562 (6 - 13 mm) and DKA13E
	FS2	1 x 22 mm	1 x PG 13.5	1 x M20		
	FS3	2 x 25 mm	2 x PG 16	2 x M25		

1) Part nos. for glands available from Cooper Crouse-Hinds GmbH provided as an example

3 Installation

3.2 Mounting

The EMC cable gland must be earthed properly.
A 300-mm-long ground wire is located on the DKA... lock nut. This ground wire can be cut to length in order to connect it to the PE.

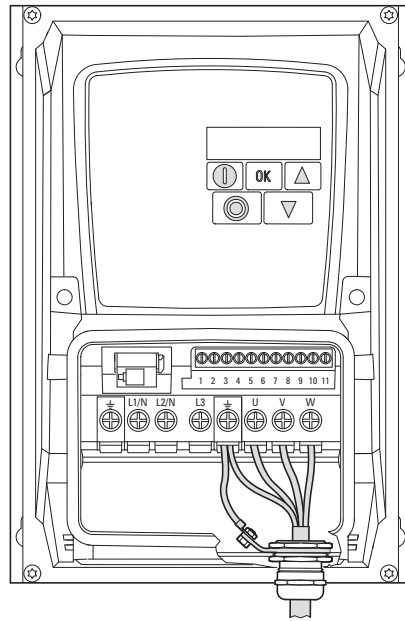


Figure 29: Grounding the EMC cable gland

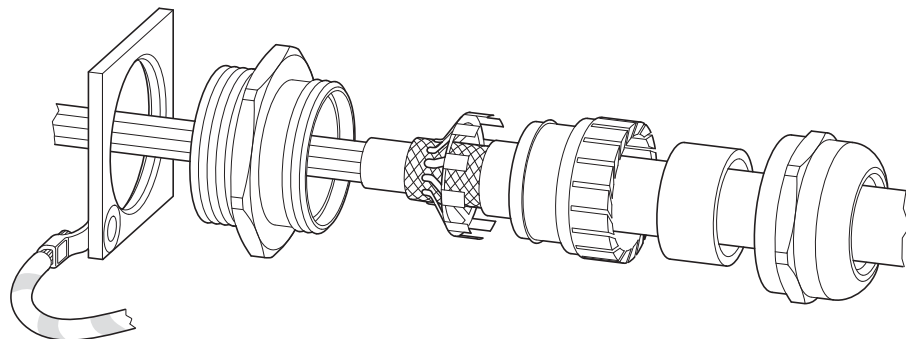


Figure 30: Schematic diagram of EMC gland assembly

3.3 EMC installation

The responsibility to comply with the legally stipulated limit values and thus the provision of electromagnetic compatibility is the responsibility of the end user or system operator. This operator must also take measures to minimize or remove emission in the environment concerned. He must also utilize means to increase the interference immunity of the devices of the system.

When implementing a magnet system (PDS) with variable frequency drives, it is advisable to take into account any necessary electromagnetic compatibility (EMC) measures during the engineering stage, as making changes during assembly and installation and retroactively fixing things at the installation location will be more expensive.

The technology and system of a variable frequency drive cause the flow of high frequency leakage current during operation. All grounding measures must therefore be implemented with low impedance connections over a large surface area.

With leakage currents greater than 3.5 mA, in accordance with VDE 0160 or EN 60335, either

- the cross-sectional area of the protective conductor must be $\geq 10 \text{ mm}^2$,
- the protective conductor must be open-circuit monitored, or
- the second protective conductor must be fitted.

For an EMC-compliant installation, we recommend the following measures:

- installation of the variable frequency drive in a metallically conductive housing with a good connection to ground,
- screened motor cables (short cables).



Ground all conductive components and housings in a magnet system using as short a line as possible with the greatest possible cross-section (Cu-drain wire).

3.3.1 EMC measures in the control panel

In order to have an installation that meets EMC requirements, make sure to connect all the metallic parts in the devices and in the control panel to each other across a large area and in a way that will make it possible to conduct high frequencies. Mounting plates and control panel doors should make good contact and be connected with short HF-drain wires. Avoid using painted surfaces (anodized, yellow chromated). An overview of all EMC measures is provided in Figure 31 on Page 53.



Install the variable frequency drive as directly as possible (without spacers) on a metal plate (mounting plate).

3 Installation

3.3 EMC installation



Route mains and motor cables in the switch cabinet as close to the ground potential as possible. This is because free moving cables act as antennas.



When laying HF cables (e.g. screened motor cables) or suppressed cables (e.g. mains supply cables, control circuit and signal cables) in parallel, a minimum clearance of 300 mm should be ensured in order to prevent the radiation of electromagnetic energy. You should also use separate cable entries if there is a great difference in voltage potentials. Any necessary crossed cabling between the control signal and power cables should always be implemented at right angles (90 degrees).



Never lay control- or signal cables in the same duct as power cables. Analog signal cables (measured, reference and correction values) must be screened.

3 Installation

3.3 EMC installation

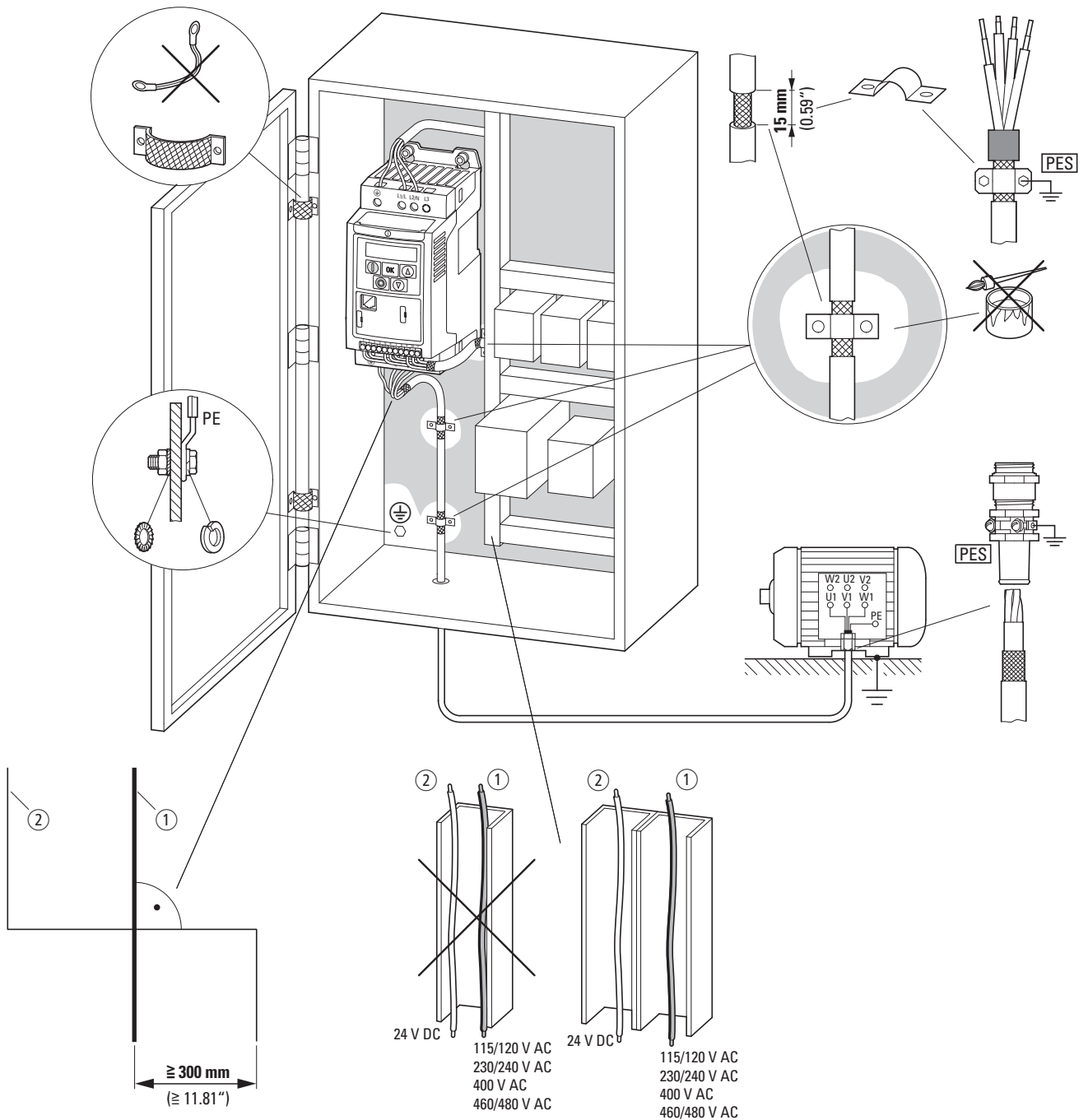


Figure 31: Setup designed to meet EMC requirements with IP20 degree of protection

① Power cable: mains voltage, motor connection, braking resistance

② Control and signal lines, fieldbus connections

Large-area connection of all metallic control panel components.

Mounting surfaces of variable frequency drive and cable screen must be free from paint.

Cable screen of cables at variable frequency drive's output with earth potential (PES) across large surface area

Large-area cable screen contacts with motor.

Large-area earth connection of all metallic parts.

3 Installation

3.3 EMC installation

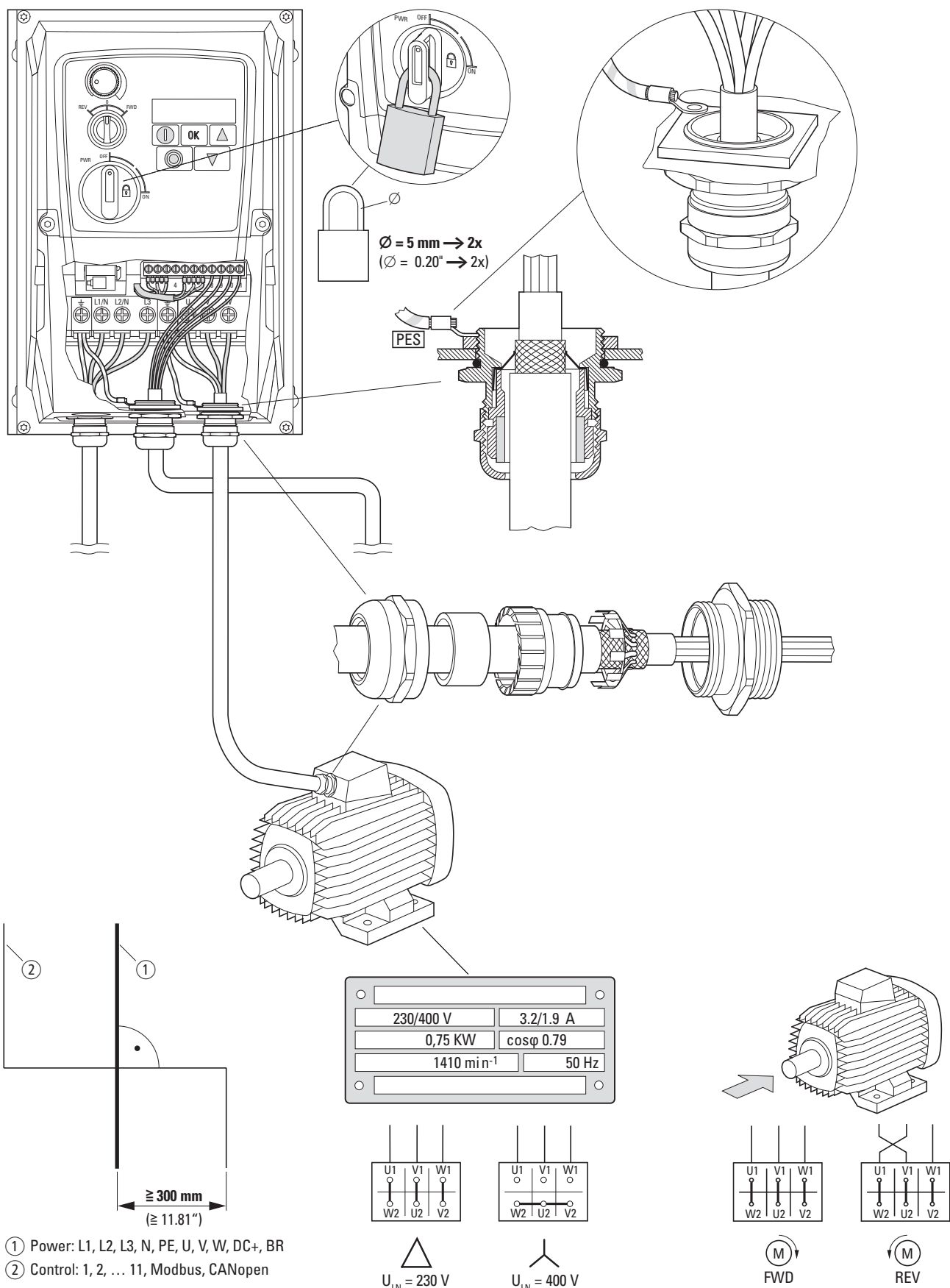


Figure 32: Setup designed to meet EMC requirements with IP66 degree of protection

- ① Power cable: mains voltage, motor connection, braking resistance
- ② Control and signal lines, fieldbus connections

Cable screen of cables at variable frequency drive's output with earth potential (PES) across large surface area

Large-area cable screen contacts with motor.

Large-area earth connection of all metallic parts.

3.3.2 EMC screw

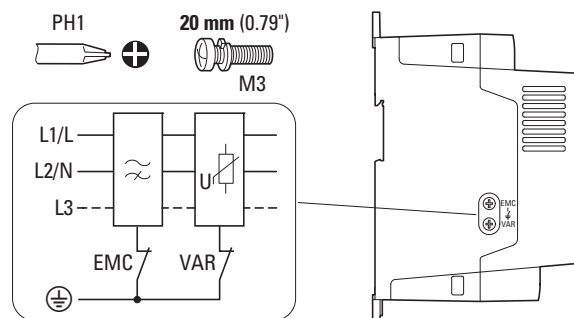


Figure 33: EMC and VAR screws in a DC1 variable frequency drive with degree of protection IP20

NOTICE

The screw labeled EMC must not be manipulated as long as the variable frequency drive is connected to the mains.



The EMC screw (in DC1-...-A20N models only) galvanically connects the EMC filter's capacitors to earth. The screw must be screwed in all the way to the stop (factory setting) in order for the variable frequency drive to comply with the EMC standard.

Due to their system characteristics, variable frequency drives with an internal EMC filter will produce a larger fault current to earth than devices without a filter. For applications in which this larger leakage current may cause malfunction messages or disconnections (residual current device), the EMC filter's internal protective earth can be disconnected (remove the EMC screw to do this).

Local EMC regulations must be taken into account when doing so. If necessary, a specific low-leakage-current EMC filter must be connected upstream.

In connections to isolated power sources (IT networks), the EMC screw should be removed. The earth fault monitors required for IT networks must be suitable for operation with power electronic devices (IEC 61557-8).

3 Installation

3.4 Earthing

3.3.3 Screen earth kit

Unscreened cables behave like antennae, i.e. they act as transmitters and receivers.



For a proper EMC connection, cables emitting interference (e.g. motor cables) and susceptible cables (analog signal and measured values) must be screened and laid separately from each other.

The effectiveness of the cable shielding depends on a good shield connection and a low shield resistance.



Use only shields with tinned or nickel-plated copper braiding. Braided steel shields are unsuitable.



Control and signal lines (analog, digital) should always be grounded on one end, in the immediate vicinity of the supply voltage source (PES).

3.4 Earthing

The protective earth (PE) in the control panel should be connected from the mains supply to a central earth point (mounting plate, system earth). The PE conductor's cross-sectional area must be at least as large as that of the incoming mains supply cable.

Every variable frequency drive must be individually connected to the power supply system's protective earth directly at the location of installation (system earthing). This protective earth must not pass through any other devices.

All protective conductors should be routed in a star topology starting from the central earth point, and all of the magnet system's conductive components (variable frequency drive, motor choke, motor filter, main choke) should be connected.

The earth-fault loop impedance must comply with all locally applicable industrial safety regulations. In order to meet UL requirements, UL-listed ring cable lugs must be used for all earth wiring connections.



Avoid ground loops when installing multiple variable frequency drives in one control panel. Make sure that all metallic devices that are to be grounded have a broad area connection with the mounting plate.

3.4.1 Protective earth

This refers to the legally required protective earth for a variable frequency drive. An earthing terminal on the variable frequency drive, or the system earth, must be connected to a neighboring steel element in the building (beam, ceiling joist), an earth electrode in the ground, or a mains earth bus. The earth points must meet the requirements set forth by the applicable national and local industrial safety regulations and/or regulations for electrical systems.

3.4.2 Motor earthing

The motor earth must be connected to one of the earthing terminals on the variable frequency drive and to a neighboring steel element in the building (beam, ceiling joist), an earth electrode in the ground, or a mains earth bus.

3.4.3 Earth-fault protection

A fault current to earth can be produced by variable frequency drives due to their system characteristics. DC1 series variable frequency drives have been designed in such a way that the smallest possible fault current will be produced in compliance with standards applicable worldwide. This fault current must be monitored by a residual current device (RCD, type B).

3.4.4 VAR screw

DC1 series variable frequency drives are equipped with an overvoltage filter for the input supply voltage that is designed to protect the devices from noise pulses in the mains voltage. Pulse spikes are typically caused by lightning strikes or by switching operations in other high-power devices on the same supply.

If high potential tests are performed on a system, these overvoltage protection components may cause the system to fail the test. In order to make it possible to perform this type of hipot tests, the overvoltage protection components can be disconnected by removing the VAR screw (in DC1-...-A20N models only). The screw must be screwed back in after the high potential tests are performed and the test must then be repeated. The system must then fail the test, indicating that the overvoltage protection components have been reconnected.

NOTICE

The screw labeled VAR (→ Figure 33, page 55) must not be manipulated as long as the variable frequency drive is connected to the mains.

3 Installation

3.5 Electrical Installation

3.5 Electrical Installation



CAUTION

Carry out the wiring work only after the variable frequency drive has been correctly mounted and secured.



DANGER

Electric shock hazard - risk of injuries!
Before carrying out any wiring work (qualified personnel only), make sure that the system is fully de-energized. Make sure to follow the safety rules on pages I and II.

NOTICE

Fire hazard!
Only use cables, circuit-breakers, and contactors that feature the indicated permissible nominal current value.



DANGER

The components in the variable frequency drive's power section remain energized up to five (5) minutes after the supply voltage has been switched off (intermediate circuit capacitor discharging time).

Pay attention to hazard warnings!



Perform the steps below with the specified insulated tools and without using force.

3.5.1 Connection to power section

The connection to the power section is normally made via the connection terminals:

- L1/L, L2/N, L3, PE for the mains-side supply voltage.
The phase sequence does not matter.
- DC+, DC-, PE when powered with DC voltage (DC1-...-A20N models only)
- U, V, W, PE for the supply cable to the motor
- BR, DC+, PE for an external braking resistance

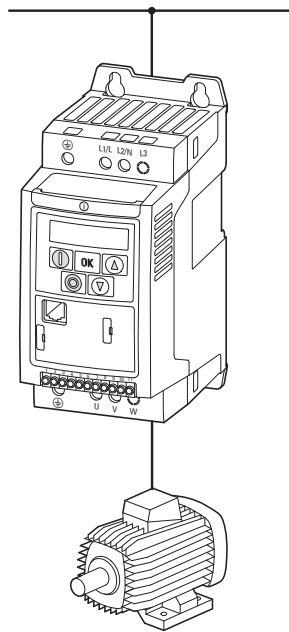


Figure 34: Connection in power section (schematic)

The number and the arrangement of the connection terminals used depend on the variable frequency drive's size and model.

NOTICE

The variable frequency drive must always be connected with ground potential via a grounding conductor (PE).

3 Installation

3.5 Electrical Installation

3.5.1.1 Terminals in power section for units with IP20 degree of protection

Table 6: Connection terminals

Size	Terminations	Description
FS1		Connection with single-phase supply voltage: <ul style="list-style-type: none"> • DC1-1D... (115 V) • DC1-12... (230 V)
		Connection with three-phase supply voltage: <ul style="list-style-type: none"> • DC1-32... (230 V) • DC1-34... (400 V, 480 V)
		Motor connection for three-phase motors: <ul style="list-style-type: none"> • DC1-1D... (230 V) • DC1-12... (230 V) • DC1-32... (230 V) • DC1-34... (400 V, 460 V)
FS2, FS3		Connection with single-phase supply voltage (115 V, 230 V): <ul style="list-style-type: none"> • DC1-1D (115 V) • DC1-12 (230 V)
		Connection with three-phase supply voltage: <ul style="list-style-type: none"> • DC1-32... (230 V) • DC1-34... (400 V, 480 V)
		Motor connection for three-phase motors: <ul style="list-style-type: none"> • DC1-1D... (230 V) • DC1-12... (230 V) • DC1-32... (230 V) • DC1-34... (400 V, 460 V) Optional: External braking resistance (R_B)

3.5.1.2 Terminals in power section for units with IP66 degree of protection

Table 7: Connection terminals

Size	Connection terminals	Description
FS1		Connection with single-phase supply voltage: <ul style="list-style-type: none"> • DC1-1D... (115 V) • DC1-12... (230 V)
		Connection with three-phase supply voltage: <ul style="list-style-type: none"> • DC1-32... (230 V) • DC1-34... (400 V, 480 V)
		Motor connection for three-phase motors: <ul style="list-style-type: none"> • DC1-1D... (230 V) • DC1-12... (230 V) • DC1-32... (230 V) • DC1-34... (400 V, 460 V)
FS2, FS3		Connection with single-phase supply voltage (115 V, 230 V): <ul style="list-style-type: none"> • DC1-1D (115 V) • DC1-12 (230 V)
		Connection with three-phase supply voltage: <ul style="list-style-type: none"> • DC1-32... (230 V) • DC1-34... (400 V, 480 V)
		Motor connection for three-phase motors: <ul style="list-style-type: none"> • DC1-1D... (230 V) • DC1-12... (230 V) • DC1-32... (230 V) • DC1-34... (400 V, 460 V) Optional: External braking resistance (R_B)



Terminal + has the same function as terminal DC+ in devices with an IP20 degree of protection.

3 Installation

3.5 Electrical Installation

3.5.1.3 Covered power terminals

In the case of sizes FS2 and FS3, the DC+/, DC-, and BR connections will be covered with plastic covers at the factory. They can be uncovered if necessary.

NOTICE

Terminal L3 will be covered with a plastic cover on all variable frequency drives that are powered with a single-phase power supply (DC1-1D..., DC1-12...). Do not uncover this terminal!

3.5.1.4 Motor connection cable

The screened cables between the variable frequency drive and the motor should be as short as possible.

- ▶ Connect the screening, on both sides and across a large area (360° overlap), to the protective earth (PE). The power screen's ground connection (PES) should be in the immediate proximity of the variable frequency drive (screening shield, cable gland) and directly on the motor terminal box.
- ▶ Prevent the screening from becoming unbraided, e.g. by pushing the opened plastic sheath over the end of the screening or with a rubber grommet on the end of the screening.
Alternatively, in addition to the large-area gland plate, you can also twist the screen braid at the end and connect it to the protective earth. In order to prevent EMC interference, this twisted screen connection should be as short as possible (recommended value for the twisted cable screen: $b \geq 1/5 a$).

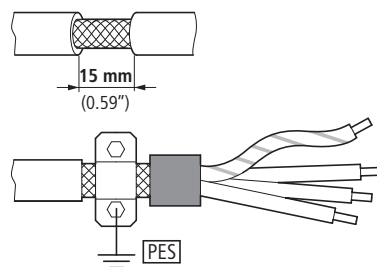


Figure 35: Screened motor connection cable

Connection examples

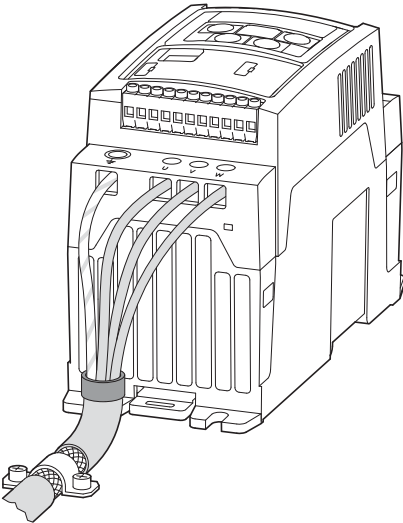


Figure 36: Connection example

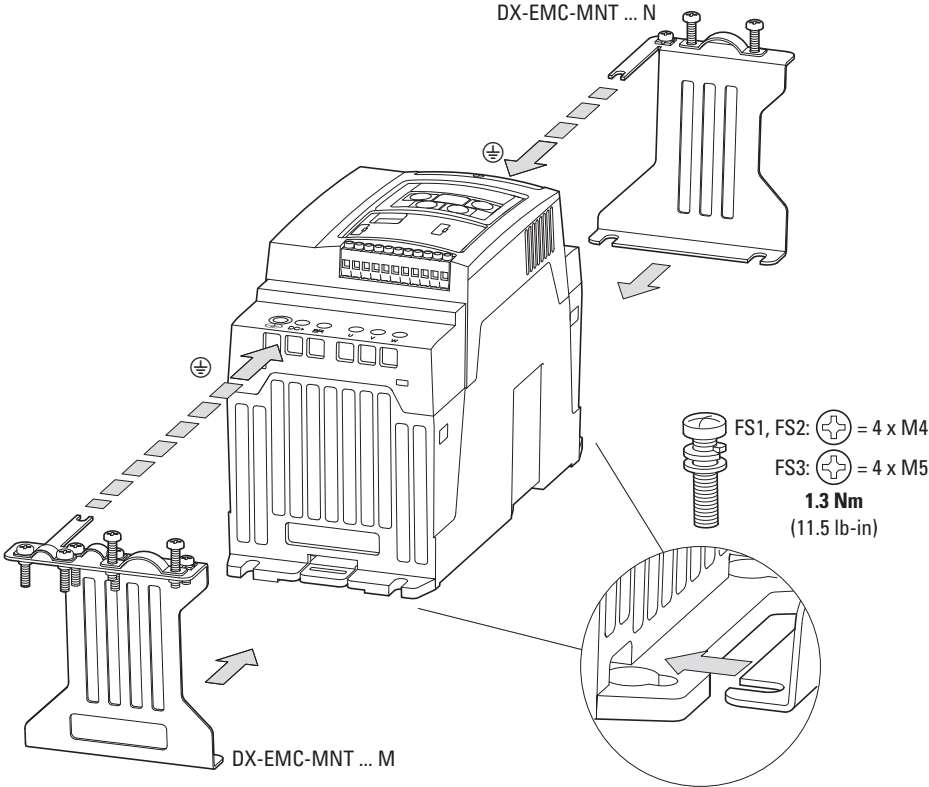


Figure 37: EMC mounting bracket

3 Installation

3.5 Electrical Installation

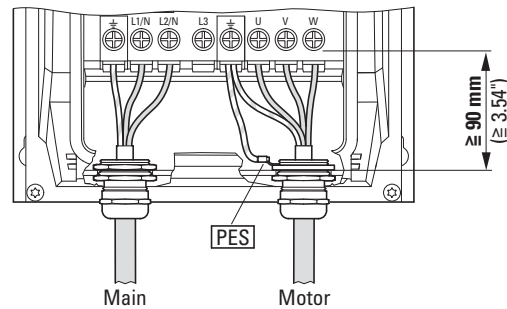


Figure 38: Connection example IP66

Screened, four-wire cable is recommended for the motor cables. The green-yellow line of this cable connects the protective ground connections from the motor and the variable frequency drive and therefore minimizes the equalizing current loads on the shielding braid.

The following figure shows the construction of a four-wire, screened motor line (recommended specifications).

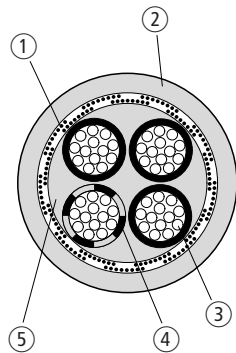


Figure 39: Four-core, screened motor supply cable

- ① Cu screen braid
- ② PVC outer casing
- ③ Drain wire (copper strands)
- ④ PVC core insulation, 3 x black, 1 x green-yellow
- ⑤ Textile and PVC fillers

If there are additional subassemblies in a motor feeder (such as motor contactors, overload relays, motor chokes, sine filters or terminals), the shielding of the motor cable can be interrupted close to these subassemblies and connected to the mounting plate (PES) with a large area connection. Free or non-screened connection cables should not be any longer than about 300 mm.

3.5.1.5 Arrangement and terminal capacity

The arrangement and size of the connection terminals depend on the size of the power section (FS1, FS2, and FS3 sizes).



The cross-sectional wire areas that can be connected and the screws' tightening torques are listed in the annex (→ Section 11.11, „Cables and fuses“, page 204).

3.5.1.6 Stripping lengths

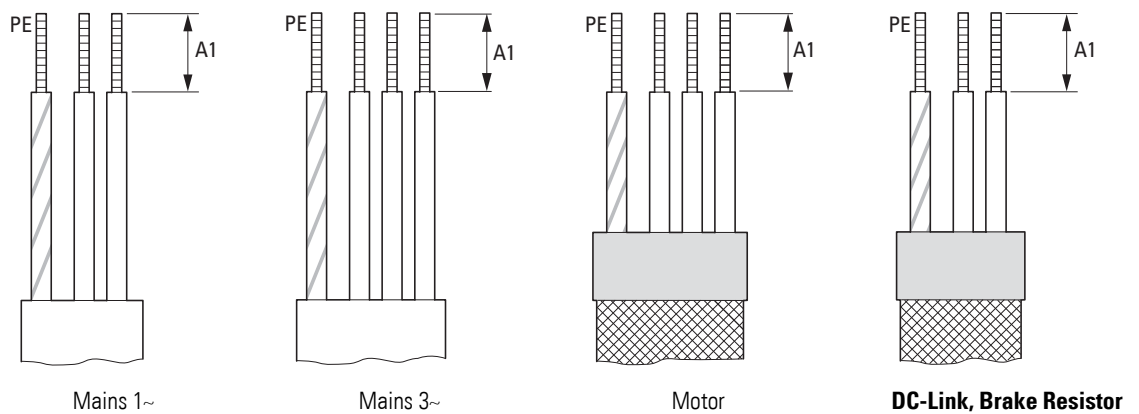


Figure 40: Stripping lengths in the power section

Frame size	A1	
	[mm]	[in]
FS1	8	0.3
FS2	10	0.39
FS3	10	0.39

Mains = Electrical supply system
 Motor = Motor connection
 DC link = Internal DC link
 Brake resistor = Braking chopper

3 Installation

3.5 Electrical Installation

3.5.2 Connection on control section

The connection terminals are used to make the connection to the control section:

- Terminals 1, 5, 7, 9: for the internal power supply
- Terminals 2, 3, 4, 6: for digital and analog input signals
- Terminal 8: for a digital or analog output signal
- Terminals 10, 11: for a potential-free relay output

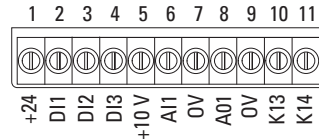



Figure 41: Control signal terminal layout and factory designations



ESD measures
 Discharge yourself on a grounded surface before touching the control signal terminals and the circuit board to prevent damage through electrostatic discharge.

3.5.2.1 Connecting the control cables

The control cables should be screened and twisted for the external connection. The screen needs to be applied on one side close to the variable frequency drive (PES).

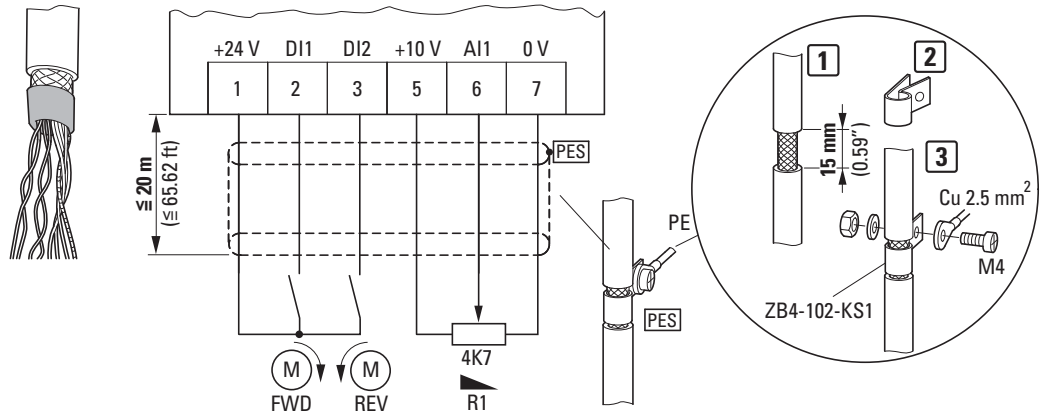


Figure 42: Connecting example with insulated control cable end and cable screen earthing (PES)



Prevent the screen from becoming unbraided, e.g. by pushing the split plastic sheath over the end of the screen or with a rubber grommet on the end of the screen.

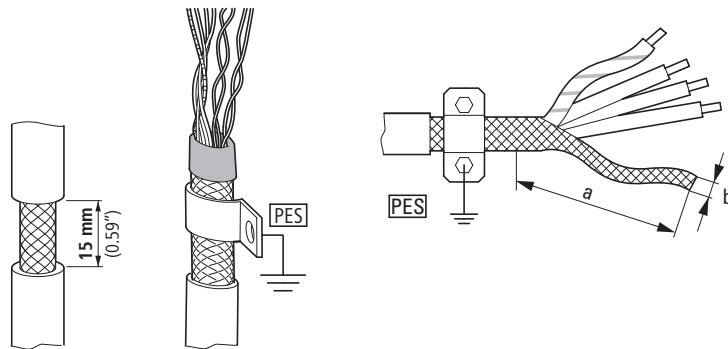


Figure 43: Screen braid connection (PES)
(recommended value for the twisted cable screen $b \geq 1/a$)

In the case of variable frequency drives with an IP20 degree of protection, the screen braid can be connected (PES) to the ground potential across a large area inside the control panel, either with a gland plate or after being twisted. To prevent EMC interference, this twisted screening connection should be as short as possible.

In the case of direct local installations (IP66), the screen braid can be connected in a metallic cable gland and connected to the PE using a connection cable.

Prevent the screen from becoming unbraided at the other end of the control cable, e.g. by using a rubber grommet. The screen braid must not make any connection with the protective ground here because this would cause problems with an interference loop.

3.5.2.2 Control signal terminals

An 11-terminal terminal strip is used to make the connection in the control section.

The control signal terminal strip is a plug-in strip and can be used to connect the cables using screw terminals.

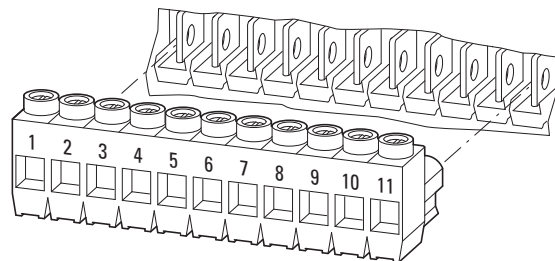


Figure 44: Plug-in control signal terminals

In the case of devices with an IP66 degree of protection and local controls (DC1-...-A6SN), the local controls (setpoint potentiometer and operating direction selector switch) will already be wired to the control signal terminal strip.

3.5.2.3 Pre-wired control signal terminals

In the case of DC1 variable frequency drives with an IP66 degree of protection, the control signal terminals will be located under the terminal cover. They can be plugged in in this configuration; the local controls will have already been connected.

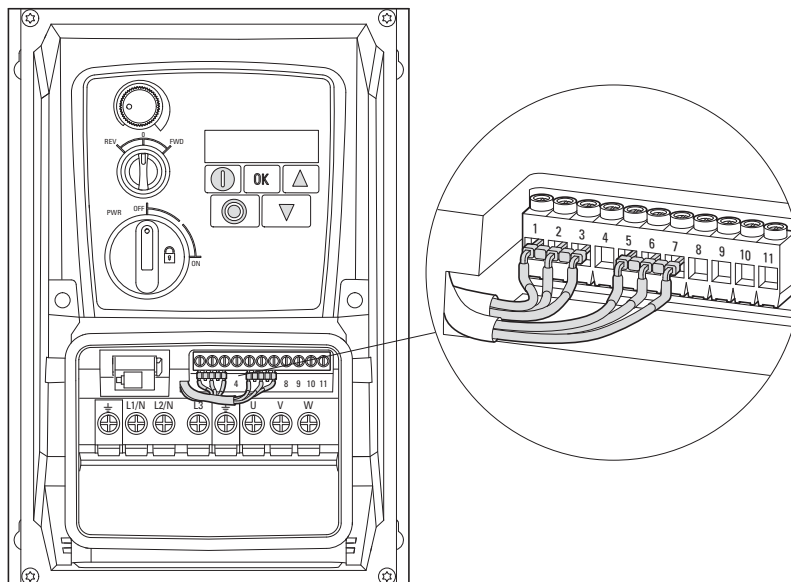


Figure 45: Wiring for local controls




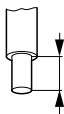


The setpoint potentiometer will be connected to control signal terminals 5, 6, and 7; the operating direction selector switch will be connected to terminals 1, 2, and 3. These two controls will only be active if the control level is assigned to the control signal terminals (P-12 = 0).

When the device is set to its default settings, the setpoint value can be set using the potentiometer. Meanwhile, the REV – 0 – FWD selector switch can be used to set the drive's operating direction (counterclockwise rotating field mode – STOP – clockwise rotating field mode).

3.5.2.4 Terminal capacities and stripping lengths

The terminal capacities and stripping lengths are listed in the following table.

Table 8: Control signal terminal sizes and designs

							
mm ²	mm ²	AWG	MM	in	N/m	ft-lbs	MM
0.2 - 2.5	0.2 - 1.5	24 - 12	5	0.2	0.4	0.3	0.4 x 2.5

3.5.2.5 Control signal terminal connection information and functions

The functions that are set in the ex-factory and the electrical connection data of all control signal terminals are listed in the following table.

Table 9: Factory-set functions of the control signal terminal

Connection terminal	Signal	Description	Default settings
1	+24 V	Control voltage for DI1 - DI4, output (+24 V)	Maximum load 100 mA, Reference potential 0 V
2	DI1	Digital input 1	+8 - +30 V (High, $R_i > 6 \text{ k}\Omega$)
3	DI2	Digital input 2	+8 - +30 V (High, $R_i > 6 \text{ k}\Omega$)
4	DI3 AI2	Digital input 3 Analog input 2	<ul style="list-style-type: none"> digital: +8 - +30 V (high) Analog: 0 - +10 V ($R_i > 72 \text{ k}\Omega$) 0/4 - 20 mA ($R_B = 500 \Omega$) Can be switched with parameter P-16 1 - 10 kΩ
5	+10 V	Reference voltage, Output (+10 V)	Maximum load: 10 mA Reference potential: 0 V
6	AI1 DI4	Analog input 1 Digital input 4	<ul style="list-style-type: none"> Analog: 0 - +10 V ($R_i > 72 \text{ k}\Omega$) 0/4 - 20 mA ($R_B = 500 \Omega$) Can be switched with parameter P-16 1 - 10 kΩ digital: +8 - +30 V (high)
7	0 V	Reference potential	0 V = connection terminal 9
8	AO1 DO1	Analog output 1 Digital output 1	<ul style="list-style-type: none"> Analog: 0 - +10 V, maximum 20 mA Can be switched with parameter P-25 digital: 0 - +24 V
9	0 V	Reference potential	0 V = connection terminal 7
10	K13	Relay 1, N/O	Maximum switching load: 250 V AC/6 A or 30 V DC/5 A
11	K14	Relay 1, N/O	Maximum switching load: 250 V AC/6 A or 30 V DC/5 A



The control signal terminals' functions and electrical parameters can be changed with

- Parameter,
- DXC-EXT-... expansion modules (see annex)

3 Installation

3.5 Electrical Installation

The DC1 variable frequency drive has four control inputs (control signal terminals 2, 3, 4, and 6). Two of these are parameterizable as digital control inputs; while the others can be set to work as digital or analog control inputs.

The variable frequency drive comes with the following default setting:

- Control signal terminal 2 as digital input 1 (DI1),
- Control signal terminal 3 as digital input 2 (DI2),
- Control signal terminal 4 as digital input 3 (DI3),
- Control signal terminal 6 as analog input 1 (AI1).

Control signal terminal 8 can be used as a digital or as an analog output. It is used as an analog output (AO) in the default configuration that comes with the variable frequency drive when it is delivered.

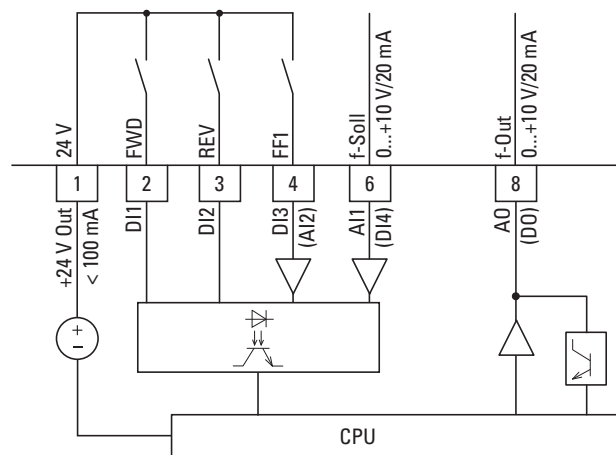


Figure 46: Control signal terminals (digital / analog)

3.5.2.6 Analog input signals

Depending on how parameters P-12 and P-15 are set, control signal terminals 4 (AI2) and 6 (AI1) can be connected to analog signals:

- 0 - 10 V,
- 0 - 10 V with scaling and operating direction change,
- 0 - 20 mA
- 4 - 20 mA or 20 - 4 mA with open-circuit monitoring (< 3 mA) .



Control signal terminals 7 and 9 are the common 0 V reference potential for all analog and digital input signals.

3.5.2.7 Analog output signal

An analog voltage signal (0 - 10 V) is available on control signal terminal 8. This output can handle a maximum load of 20 mA.

The output signal is adjusted with parameter P-25 (→ Page 119).

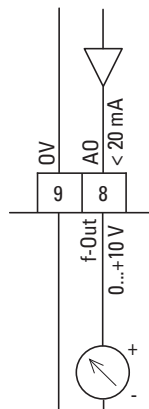


Figure 47: Analog output (AO)
(connecting example)



Control signal terminals 7 and 9 are the common 0 V reference potential for all analog and digital input signals.

3 Installation

3.5 Electrical Installation

3.5.2.8 Digital Input Signals

Control signal terminals 2, 3, 4, and 6 all have the same function and mode of operation as digital inputs (DI1 to DI4).

A logic level of +24 V (positive logic) is used:

- 8 - 30 V = High (logic "1")
- 0 - 4 V = Low (logic "0")

The internal control voltage from control signal terminal 1 (+24 V, maximum 100 mA) or an external voltage source (+24 V) can be used for this. The permissible residual ripple must be less than $\pm 5 \% \Delta U_a / U_a$.



If you use an external voltage source, make sure to connect the 0-V potentials of the external voltage source to the 0-V potentials of the variable frequency drive.



Control signal terminals 7 and 9 are the common 0 V reference potential for all analog and digital input signals.

Optional modules DXC-EXT-IO110 and DXC-EXT-IO230 can be used to optically isolate the digital inputs (DI1 to DI4) and integrate them directly into control circuits with 110 V / 230 V. Values of 80 to 110/230 V AC will be recognized as a high signal.

3.5.2.9 Digital Output (Transistor)

When using the device's default configuration, control signal terminal 8 will be configured as an analog output (AO).

It can be set to work as a digital output instead (DO) with parameter P-25 (→ Page 119).

Transistor output DO can deliver a digital signal via control signal terminal 8 using the device's internal control voltage (+24 V). The maximum permissible load current is 20 mA.

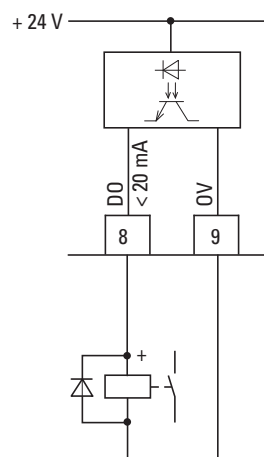


Figure 48: Connecting example (interposing relay with free-wheel diode:ETS4-VS3)



Control signal terminals 7 and 9 are the common 0 V reference potential for all analog and digital input signals.

The parameter assignment is described in → Section 7.6, „Motor current monitoring“, Page 130.

3.5.2.10 Digital Output (Relay)

Control signal terminals 10 and 11 are connected to the DC1 variable frequency drive's internal relay contact (N/O) in a potential-free manner.

The relay function can be configured with parameter P-18 (→ Table 37, Page 223).

The electrical connection specifications for control signal terminals 10 and 11 are:

- 250 V AC, max. 6 A
- 30 V DC, max. 5 A

3 Installation

3.5 Electrical Installation

We recommend connecting any connected loads as follows:

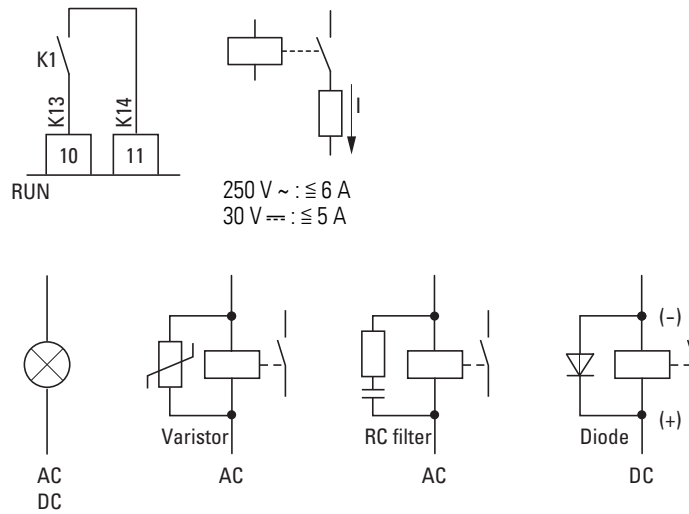


Figure 49: Connection examples with suppressor circuit

3.5.2.11 RJ 45 interface

The RJ45 port located in the front or under the connection terminal cover can be used to directly connect the device to communication modules and fieldbus connections.

The internal RS-485 connection transmits Modbus RTU and CANopen data.

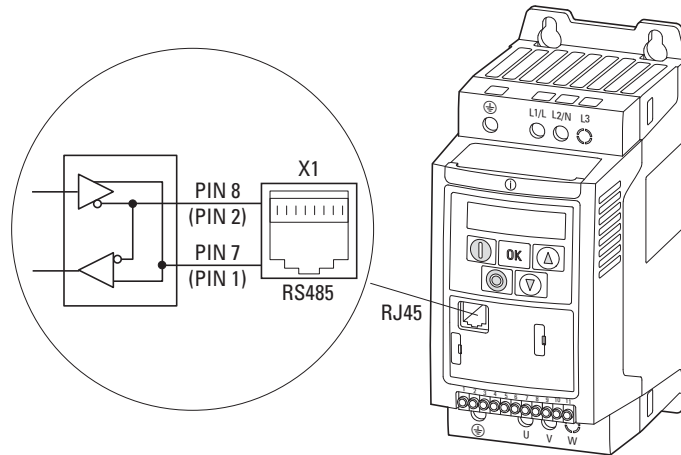


Figure 50: RJ 45 interface



DC1 variable frequency drives do not have an internal bus termination resistor.
Use DX-CBL-TERM or EASY-NT-R if necessary.

3.5.3 Block diagrams

The following block diagrams show all the connection terminals on a DC1 variable frequency drive and their functions when in their default settings.

The variable frequency drive's power section is shown on the left side of every block diagram (→ Section 3.5.1, „Connection to power section“, page 59).

The center shows the 11 control signal terminals on the DC1 variable frequency drive. Control signal terminal 2 (DI1) must be connected, as an enable contact, to +24 V when controlling the device with a fieldbus or with the keypad (→ Section 3.5.2, „Connection on control section“, page 66).

The RJ45 interface used for field bus or OP bus communications is shown at the very right (→ Section 8.1.1, „Communications“, page 135).

3 Installation

3.5 Electrical Installation

3.5.3.1 DC1-1D...Nx-...

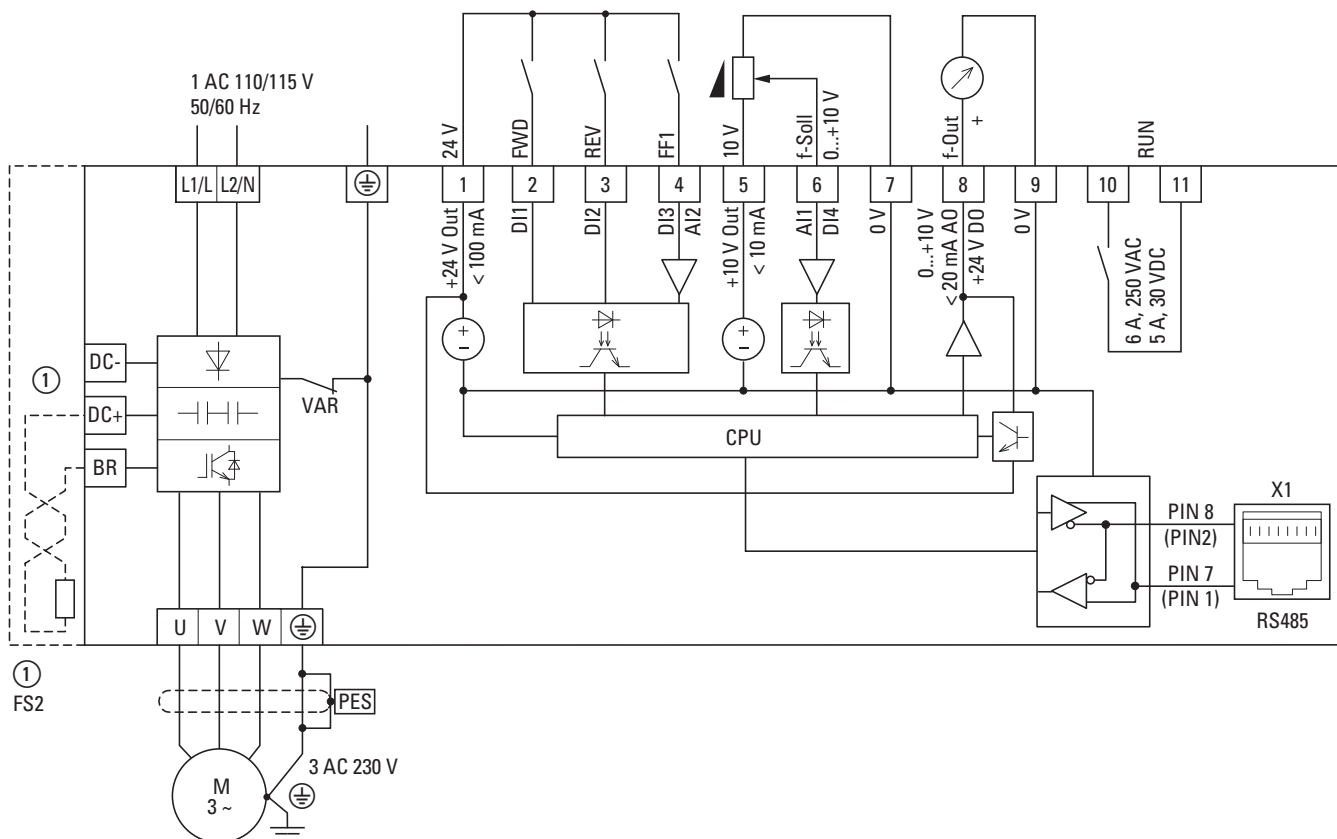


Figure 51: Block diagram for DC1-1D...Nx-...
 DC1-1D...Nx-... variable frequency drives have a voltage doubler circuit in their internal DC link. When there is a power supply of 1 AC 110 - 115 V, a motor voltage of up to 3 AC 230 V will be output.
 ① FS2 devices allow for the connection of braking resistances.

➔ DC1-1D...Nx-... variable frequency drives do not have an internal radio interference suppression filter. An external radio interference suppression filter is required for operation in accordance with EN 61800-3.

3.5.3.2 DC1-1D...Nx-A6SN

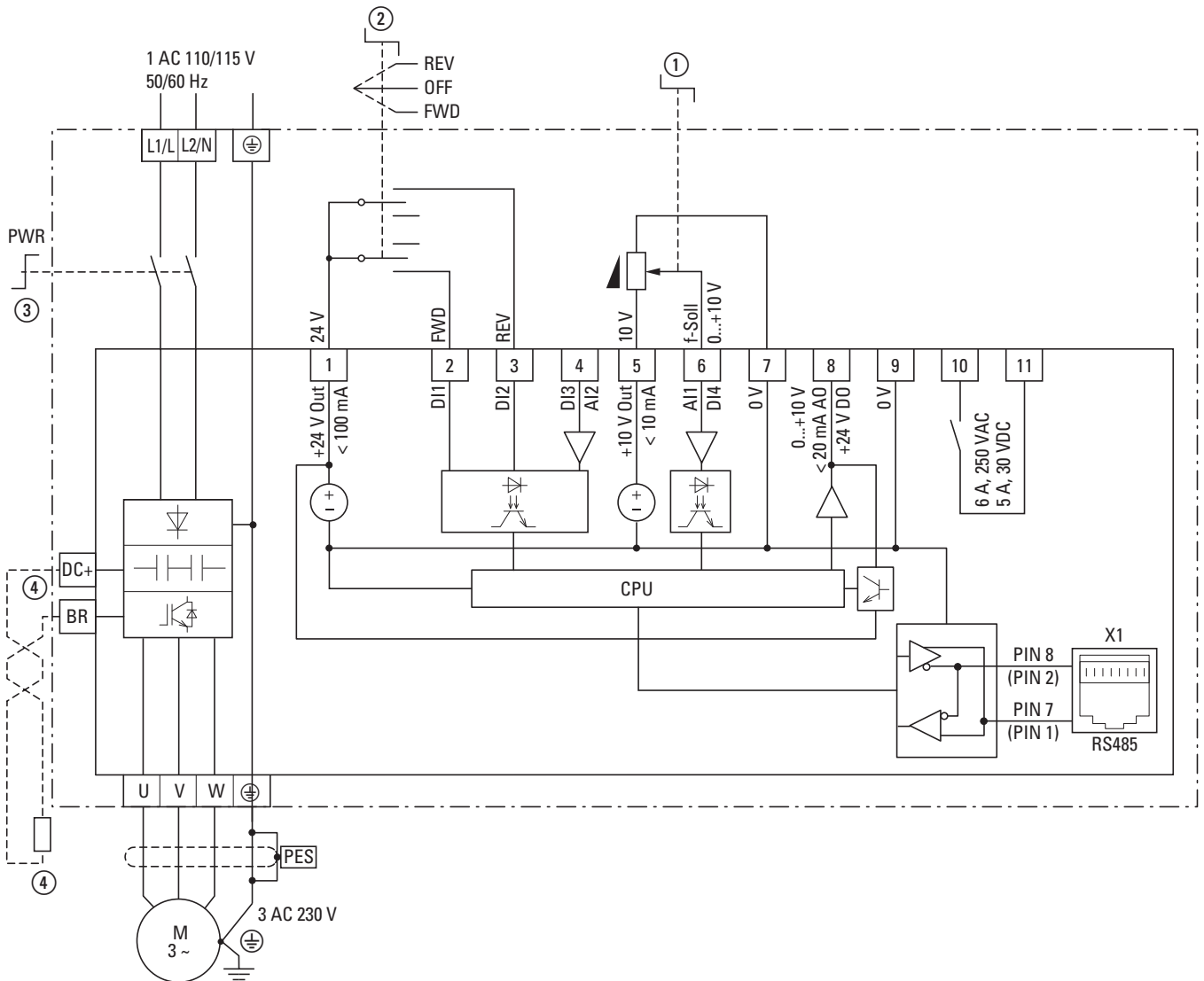


Figure 52: Block diagram for DC1-1D...Nx-A6SN
DC1-1D...Nx-A6SN variable frequency drives with an IP66 degree of protection and local controls have a voltage doubler circuit in their internal DC link.
When there is a power supply of 1 AC 110 - 115 V, a motor voltage of up to 3 AC 230 V will be output.

- ① Setpoint potentiometer
- ② Operating direction selector switch
- ③ Mains transfer switch
- ④ External braking resistances can be connected to devices with a size of FS2 or bigger



DC1-1D...Nx-A6SN variable frequency drives do not have an internal radio interference suppression filter.
An external radio interference suppression filter is required for operation as per EN 61800-3.

3 Installation

3.5 Electrical Installation

3.5.3.3 DC1-12...

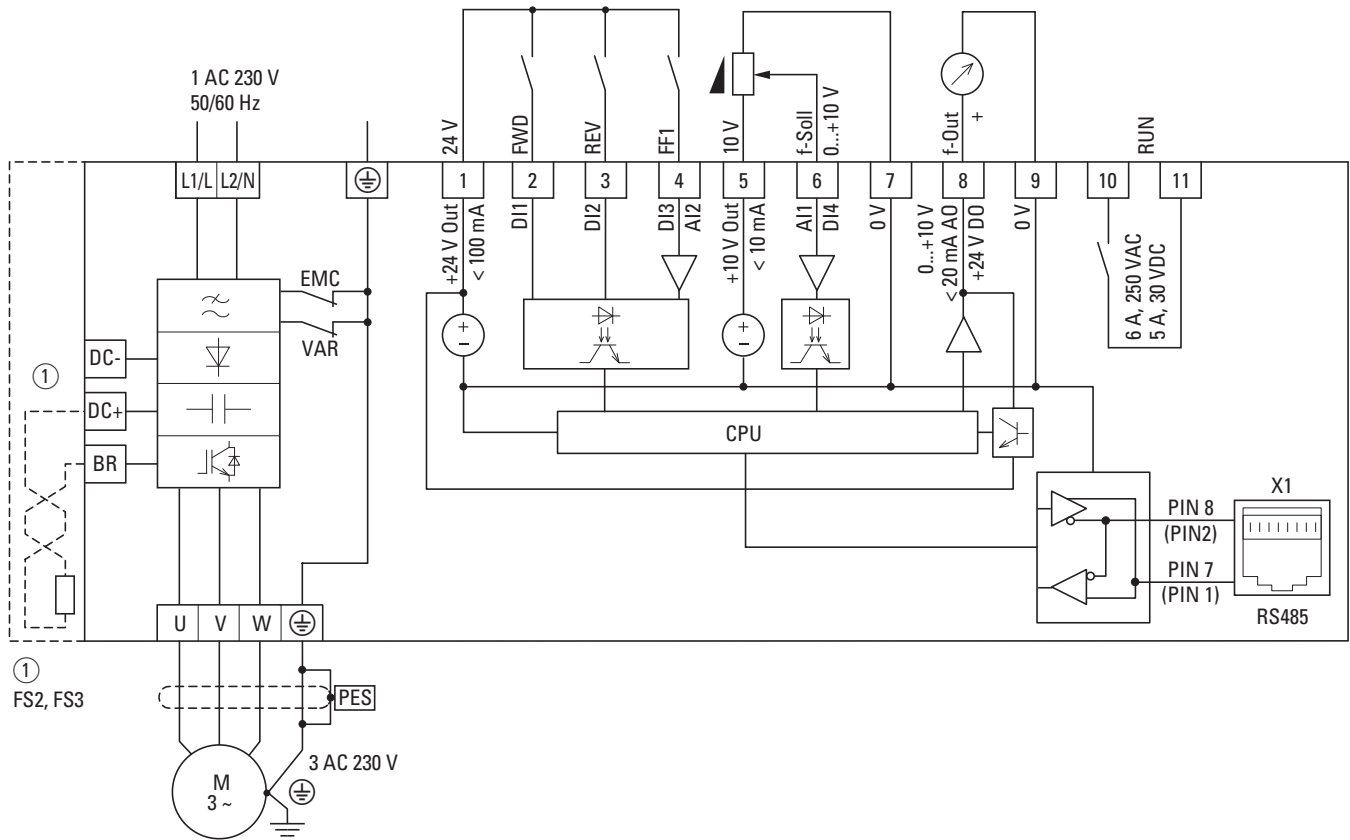


Figure 53: DC1-12... block diagram

Variable frequency drive with single-phase supply system voltage and three-phase motor connection ① FS2 and FS3 make it possible to connect external braking resistances.

3.5.3.4 DC1-12...-A6SN

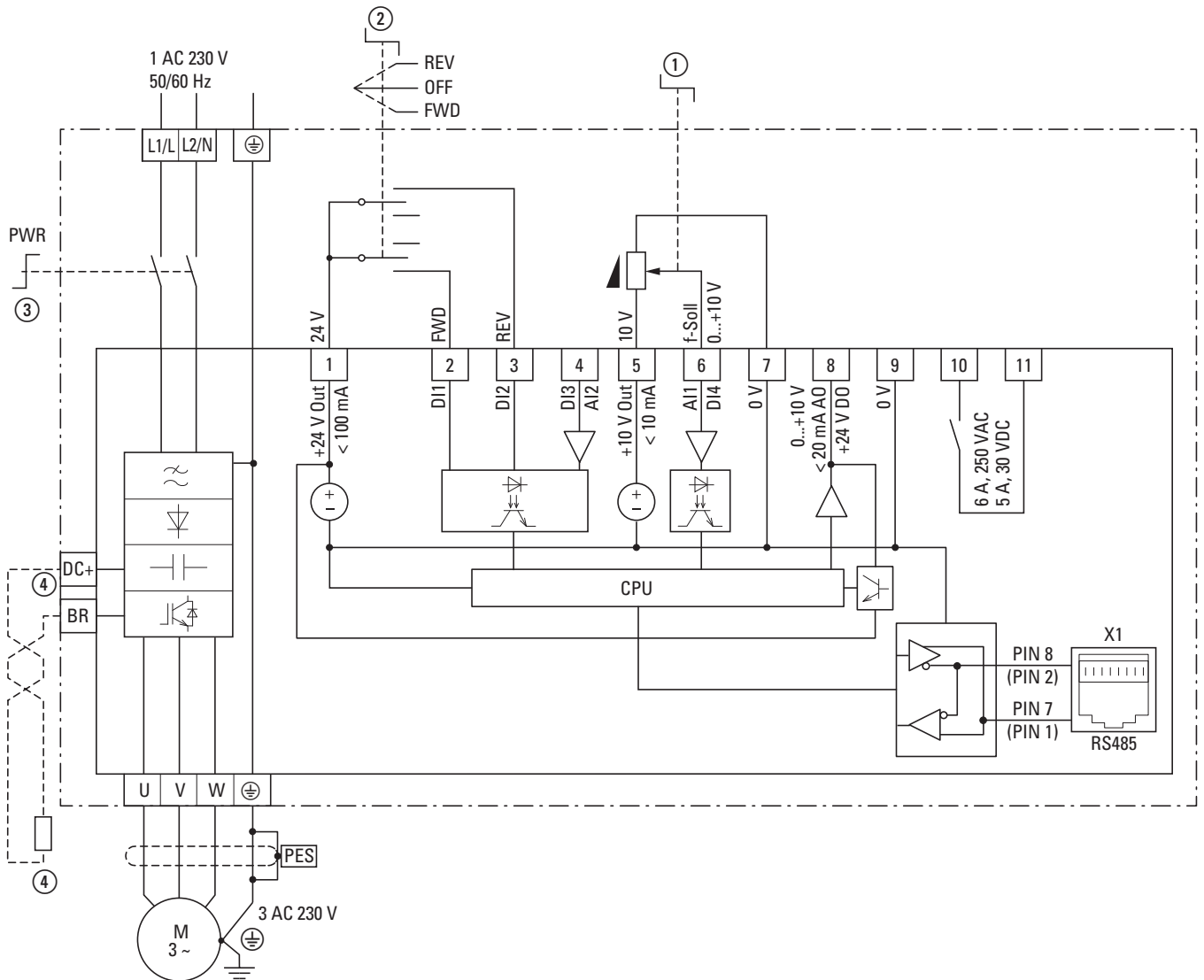


Figure 54: Block circuit diagram for DC1-12...-A6SN with an IP66 degree of protection and local controls
Variable frequency drive with single-phase mains supply voltage and three-phase motor connection.
FS2 and FS3 devices allow for the connection of external braking resistances.
① Setpoint potentiometer
② Operating direction selector switch
③ Mains transfer switch
④ External braking resistances can be connected to devices with a size of FS2 or bigger

3 Installation

3.5 Electrical Installation

3.5.3.5 DC1-32..., DC1-34...

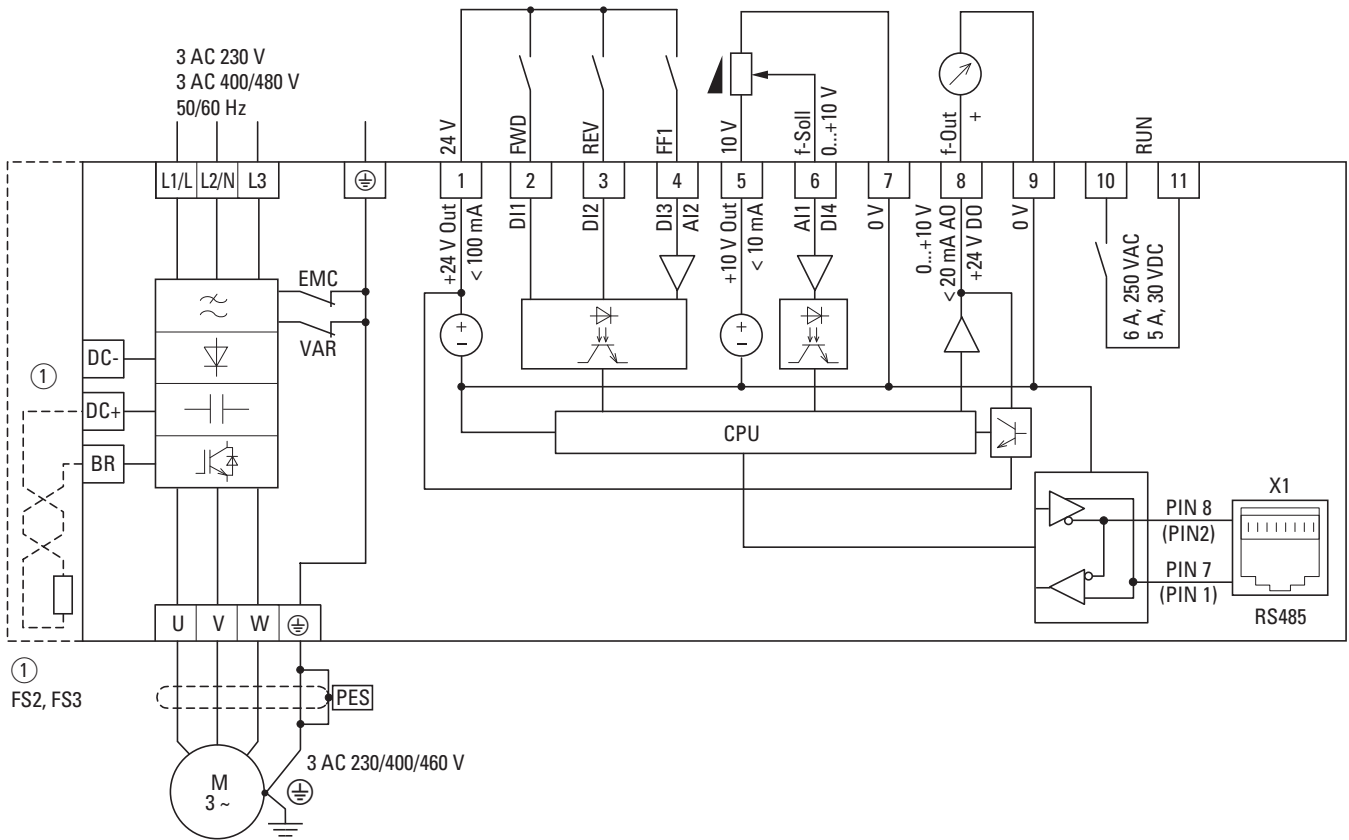


Figure 55: DC1-32..., DC1-34... block diagram
 variable frequency drive with three-phase mains supply voltage and three-phase motor connection ① FS2 and FS3 make it possible to connect external braking resistances.

3.5.3.6 DC1-32...-A6SN, DC1-34...-A6SN

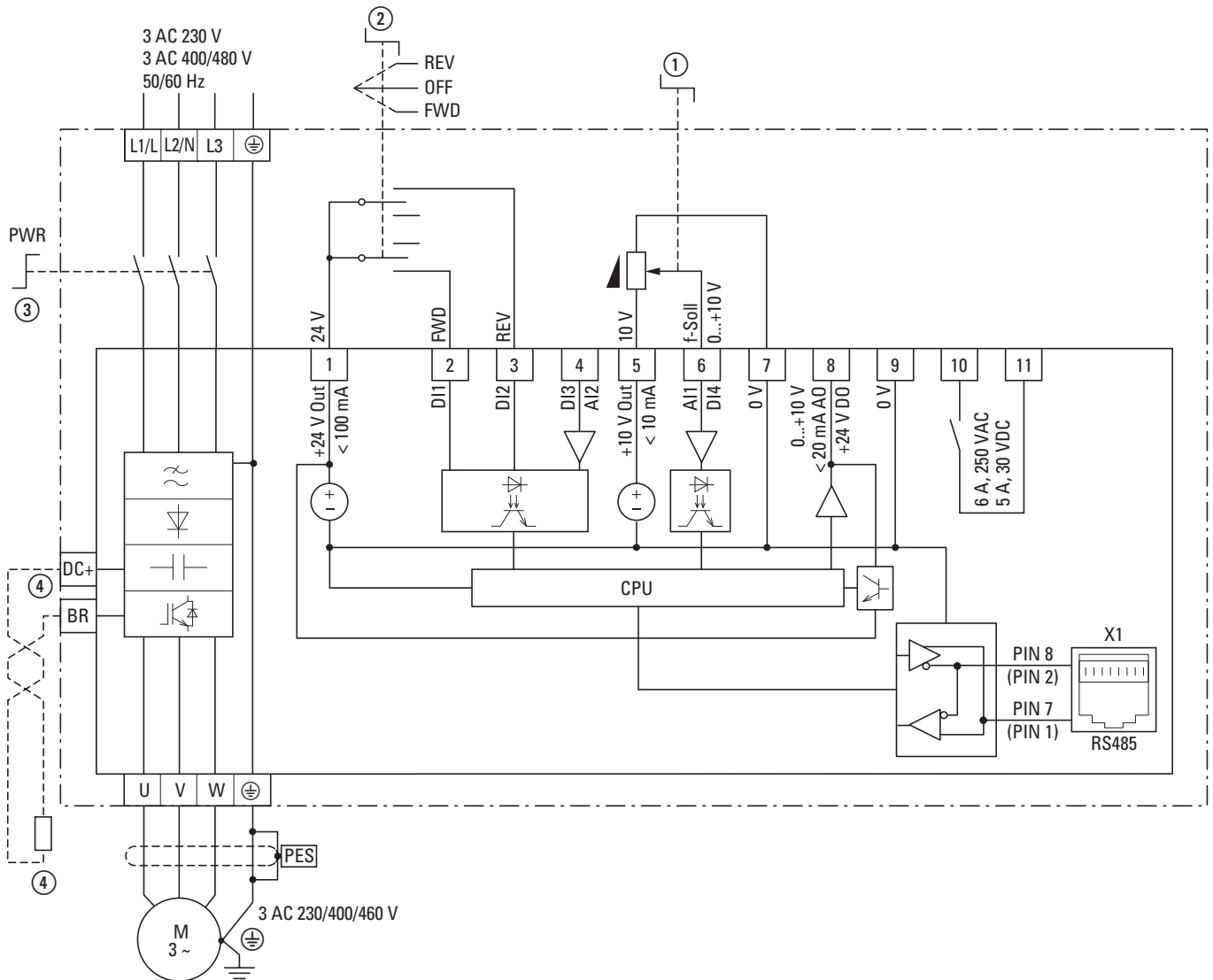


Figure 56: Block circuit diagram for DC1-32...-A6SN, DC1-34...-A6SN
Variable frequency drives with an IP66 degree of protection and local controls and with a three-phase mains supply voltage and three-phase motor connection
FS2 and FS3 devices allow for the connection of external braking resistances.
① Setpoint potentiometer
② Operating direction selector switch
③ Mains transfer switch
④ External braking resistances can be connected to devices with a size of FS2 or bigger

3.5.4 Insulation test

The variable frequency drive of the DC1 series are tested, delivered and require no additional testing.



CAUTION

On the control signal and the connection terminals of the variable frequency drive, no leakage resistance tests are to be performed with an insulation tester.



CAUTION

Wait at least 5 minutes after switching the supply voltage off before you disconnect one of the connection terminals (L1/L, L2/N, L3, DC-, DC+, BR) of the variable frequency drive.

If insulation testing is required in the power circuit of the PDS, you must consider the following measures.

3.5.4.1 Testing the motor cable insulation

- ▶ Disconnect the motor cable from the connection terminals U, V and W of the variable frequency drive and from the motor (U, V, W). Measure the insulation resistance of the motor cable between the individual phase conductors and between the phase conductor and the grounding conductor.

The insulation resistance must be greater than 1 MΩ.

3.5.4.2 Testing the mains cable insulation

- ▶ Disconnect the power cable from the mains supply network and from the connection terminals L1/L, L2/N and L3 of the variable frequency drive. Measure the insulation resistance of the mains cable between the individual phase conductors and between each phase conductor and the protective conductor.

The insulation resistance must be greater than 1 MΩ.

3.5.4.3 Testing the motor insulation

- ▶ Disconnect the motor cable from the motor (U, V, W) and open the bridge circuits (star or delta) in the motor terminal box. Measure the insulation resistance of the individual motor windings. The measurement voltage must at least match the rated operating voltage of the motor but is not to exceed 1000 V.

The insulation resistance must be greater than 1 MΩ.



Consider the notes from the motor manufacturer in testing the insulation resistance.

4 Operation

4.1 Checklist for commissioning

Before placing the frequency converter into operation, use the checklist below to make sure that all the following requirements are met:

No.	Activity	Notes
1	Mounting and wiring have been carried out as required by the corresponding instructional leaflet (→ IL04020009Z, IL04020013Z).	
2	All wiring and line section leftovers, as well as all the tools used, have been removed from the variable frequency drive's proximity.	
3	All connection terminals in the power section and in the control section were tightened with the specified torque.	
4	The lines connected to the output terminals (U, V, W, DC+, DC-, BR) of the variable frequency drive are not short-circuited and are not connected to earth (PE).	
5	The variable frequency drive has been earthed properly (PE).	
6	All electrical connections in the power section (L1/L, L2/N, L3, U, V, W, DC+, DC-, BR, PE) have been connected properly while taking into account the degree of protection and have been dimensioned in line with the corresponding requirements.	
7	Each single phase of the supply voltage (L or L1, L2, L3) is protected with a fuse.	
8	The variable frequency drive and the motor are adapted to the mains voltage. (→ Section 1.4.1, „Rated operational data on the nameplate“, page 15, connection type (star, delta) of the motor tested).	
9	The quality and volume of cooling air are in line with the environmental conditions required for the variable frequency drive and the motor.	
10	All connected control cables comply with the corresponding stop conditions (e.g., switch in OFF position and setpoint value= zero).	
11	The parameters that were preset at the factory have been checked with the list of parameters (→ Table 37, page 221).	
12	The effective direction of a coupled machine will allow the motor to start.	
13	All emergency switching off functions and safety functions are in an appropriate condition.	

4 Operation

4.2 Operational hazard warnings

4.2 Operational hazard warnings

Please observe the following notes.



DANGER

Commissioning is only to be completed by qualified technicians.



DANGER

Hazardous voltage!

The safety instructions on pages I and II must be followed.



DANGER

The components in the variable frequency drive's power section are energized if the supply voltage (mains voltage) is connected. For instance: L1/L, L2/N, L3, DC+, DC-, BR, U/T1, V/T2, W/T3 power terminals.

The control signal terminals are isolated from the line power potential.

There can be a dangerous voltage on the relay terminals (10, 11) even if the variable frequency drive is not being supplied with line voltage (e.g., integration of relay contacts in control systems with voltage > 48 V AC / 60 V DC).



DANGER

The components in the variable frequency drive's power section remain energized up to five (5) minutes after the supply voltage has been switched off (intermediate circuit capacitor discharging time).

Pay attention to hazard warnings!



DANGER

Following a shutdown (fault, mains voltage off), the motor can start automatically (when the supply voltage is switched back on) if the automatic restart function has been enabled (→ parameters P-31).

4.3 Commissioning with control signal terminals (default settings)

NOTICE

Any contactors and switching devices on the power side are not to be opened during motor operation. Inching operation using the mains contactor is not permitted.

Contactors and switchgear (repair and maintenance switches) on the motor side must not be opened while the motor is in operation.

Inching operation of the motor with contactors and switching devices in the output of the variable frequency drive is not permitted.

NOTICE

Make sure that there is no danger in starting the motor. Disconnect the driven machine if there is a danger in an incorrect operating state.



If motors are to be operated with frequencies higher than the standard 50 or 60 Hz, then these operating ranges must be approved by the motor manufacturer. The motors could be damaged otherwise.

4.3 Commissioning with control signal terminals (default settings)

DC1 variable frequency drives with local controls are configured and wired at the factory. They can be started directly via the control signal terminals when the rated motor output for the mains voltage is connected (see the connecting example below).



You can skip this section if you want to set up the parameters directly for optimal operation of the variable frequency drive based on the motor data (rating plate) and the application.

Following are a series of simplified connecting examples that use the default configuration:

4 Operation

4.3 Commissioning with control signal terminals (default settings)

Connecting example for three-phase motor

Connecting example for three-phase motor	Terminal	Designation
	L1/L	Single-phase mains connection (DC1-1D..., DC1-12...)
	L2/N	Three-phase mains connection (DC1-32..., DC1-34...)
	L3	–
	⊕	Ground connection
	1	Control voltage +24 V (output, maximum 100 mA)
	2	FWD, Start release clockwise rotating field
	3	REV, Start release left rotating field
	U	Connection for three-phase ac motor (three-phase motor)
	V	
	W	
	⊕	
	5	Setpoint value voltage +10 V (Output, maximum 10 mA)
	6	Frequency reference value f-Set (Input 0 – +10 V)
	7	Reference potential (0 V)

- ▶ Connect the variable frequency drive according to the connection example above for the simple commissioning with the specified default settings (see connecting example above).

The potentiometer should have a fixed resistance (connection to control signal terminals 5 and 7) of at least 1 k Ω and up to a maximum of 10 k Ω . A standard fixed resistance of 4.7 k Ω is recommended.

Make sure that the enable contacts (FWD/REV) are open before switching on the mains voltage.



If the connections for the setpoint value potentiometer cannot be clearly allocated with terminals 5, 6 and 7, you should set the potentiometer to about 50% before giving the start release (FWD/REV) for the first time.

When the specified supply voltage is applied at the mains connection terminals (L1/L, L2/N, L3), the switched-mode power supply unit (SMPS) in the internal DC link will be used to generate the control voltage and light up the 7-segment LED display (5 7 P). At this point, the variable frequency drive will be ready for operation (correct operating status) and in Stop mode.

The start enable signal is sent by activating one of the digital inputs with +24 V:

- Terminal 1: FWD = Clockwise rotating field (Forward Run)
- Terminal 2: REV = Counterclockwise rotating field (Reverse Run)

The FWD and REV control commands are interlocked (exclusive OR) and require a rising voltage edge.

4.3 Commissioning with control signal terminals (default settings)

The frequency is shown with a minus sign with a start release with a left rotating field (REV).

- You can now set the output frequency (0 - 50 Hz) and, as a result, the speed of the connected three-phase motor (0 - n_{Motor}), by using the potentiometer via terminal 6 (0 - +10 V proportional voltage signal). The change in output frequency here is delayed based on the specified acceleration and deceleration ramps. When using the device's default settings, these times will be set to 5 seconds.

The acceleration and deceleration ramps specify the time change for the output frequency: from 0 to f_{max} ($f_{max} = 50$ Hz) or from f_{max} back to 0.

Figure on Page 87 shows a good example of the process, if the release signal (FWD/REV) is switched on and the maximum setpoint voltage (+10 V) is applied. The speed of the motor follows the output frequency depending on the load and moment of inertia (slip), from zero to n_{max} .

If the release signal (FWD, REV) is switched off during operation, the inverter is blocked immediately (STOP). The motor comes to an uncontrolled stop (see ① in Figure).

The acceleration time is set in parameter P-03.

Information on settings and the description of the parameters used here is provided in section "Drives control", Page 105.

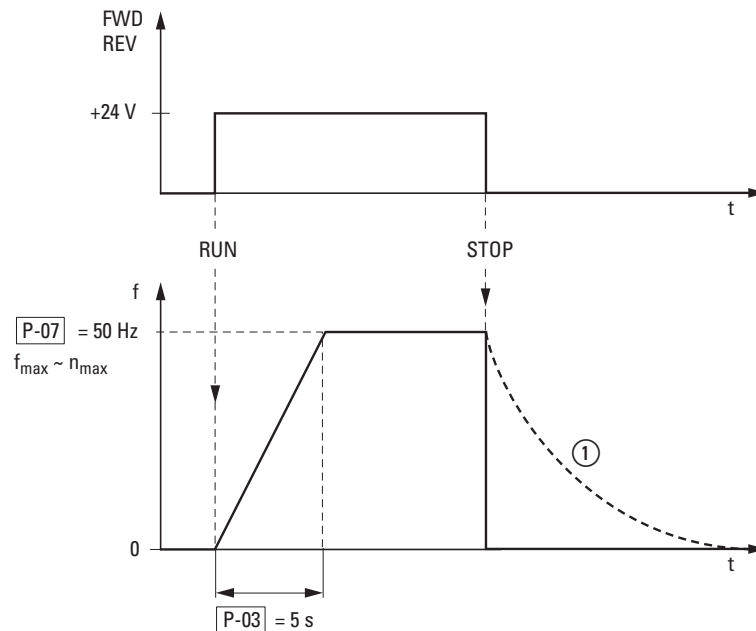


Figure 57: Start-Stop command with maximum setpoint value voltage, acceleration ramp 5 s

4 Operation

4.4 Commissioning with local controls (IP66)

4.4 Commissioning with local controls (IP66)

DC1 variable frequency drives with local controls are configured and wired at the factory. They can be started directly using the local controls when the rated motor output for the mains voltage is connected (see the connecting example below).



You can skip this section if you want to set up the parameters directly for optimal operation of the variable frequency drive based on the motor data (rating plate) and the application.

Following are a series of simplified connection examples that use the default configuration:

Connecting example for three-phase motor

Connecting example for three-phase motor	Terminal	Designation
	L1/L	single-phase mains connection (DC(DC1-1D..., DC1-12...)) ③
	L2/N	Three-phase mains connection (DC1-32..., DC1-34...)) ③
	L3	–
	⊕	Ground connection
	1	Control voltage +24 V (output, maximum 100 mA)
	2	FWD, Start release clockwise rotating field ②
	3	REV, Start release left rotating field ②
	U	Connection for three-phase ac motor (three-phase motor)
	V	
	CO	
	⊕	
	5	Setpoint value voltage +10 V (Output, maximum 10 mA)
	6	Frequency reference value f-Set (Input 0 – +10 V) ①
	7	Reference potential (0 V)

Make sure that the enable contacts (FWD/REV) are open before switching on the mains voltage.

When the specified supply voltage is applied at the mains connection terminals (L1/L, L2/N, L3) and the main switch ③ on the mains side is switched on, the switched-mode power supply unit (SMPS) in the internal DC link will be used to generate the control voltage and the 7-segment LED display will light up (5EAP). At this point, the variable frequency drive will be ready for operation (correct operating status) and in Stop mode.

The start enable signal is sent by activating one of the digital inputs with +24 V: ②



FWD = Clockwise rotation field (Forward Run)



REV = Counterclockwise rotation field (Reverse Run)

The FWD and REV control commands are interlocked (exclusive OR) and require a rising voltage edge.

- ▶ You can now set the output frequency (0 - 50 Hz) and, as a result, the speed of the connected three-phase motor (0 - n_{Motor}) by using the internal setpoint potentiometer ① (0 - +10 V proportional voltage signal). The change in output frequency here is delayed based on the specified acceleration and deceleration ramps. When using the device's default settings, these times will be set to 5 seconds.

4 Operation

4.5 Commissioning with keypad

4.5 Commissioning with keypad


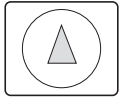
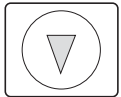
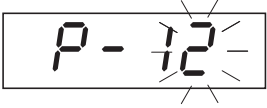
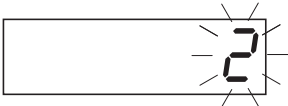
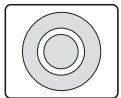
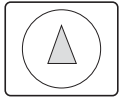
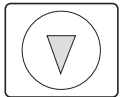


The frequency reference value settings configured via the keypad have the same effect as the function of an electronic motor potentiometer. The value set with the ▲ and ▼ buttons will be retained even after the supply voltage is switched off.



For control via the keypad, control signal terminal 1 must be connected to control signal terminal 2 in order to get an enable.



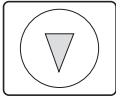


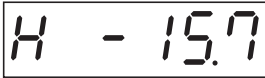
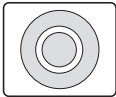
The following table shows a good example of specifying the frequency reference value via the operating unit.

Note: Your unit may behave differently from the description below depending on the setting configured for P-15.

Sequence	Commands	View	Description
1	  	 	<p>Set parameter P-12 to 1 or 2 in order to hand over control to the keypad.</p> <p>1: Operating unit (keypad FWD): one operating direction 2: Operating unit (keypad FWD/REV): both operating directions</p>
2	  	 	<p>Connect control signal terminal 1 to control signal terminal 2 in order to get a start enable.</p> <p>Press the Stop pushbutton in order to get to the setpoint input display automatically.</p> <p>Use the ▲ and ▼ arrow keys to change the setpoint value.</p>

4 Operation

4.5 Commissioning with keypad

Sequence	Commands	View	Description
3	  		<p>Press the Start button to start the variable frequency drive. It will then run with the acceleration time set in P-03 all the way to the setpoint value on the keypad.</p> <p>You can use the ▲ and ▼ arrow keys to change the setpoint value in RUN mode.</p>
4	 FWD REV	 	<p>Pressing the Start pushbutton again will change the operating direction (P-12 = 2).</p> <p>Note: When the REV operating direction is in effect, the frequency will have a minus sign.</p> <p>Minus sign for REV operating direction</p>
5			<p>When the STOP pushbutton is pressed, the variable frequency drive will be stopped with the deceleration time configured in P-04.</p>

4 Operation

4.6 Commissioning with field bus / SmartWire-DT

4.6 Commissioning with field bus / SmartWire-DT

When using a field bus / SmartWire-DT, you will need to use parameter P-12 to select the desired field bus / SmartWire-DT.

Parameter P-36 is used to set the slave address for the field bus mode.



In order to control the device via a field bus / SmartWire-DT, control signal terminals 1 and 2 must be connected with a jumper in order to get an enable signal.



For more information, please refer to chapters 7 and 8.

For more information on SmartWire-DT, please refer to manual MN04012009Z, "DX-NET-SWD. SmartWire-DT Interface Card for DC1 Variable Frequency Drives."

5 Parameters

5.1 Operating unit

The DC1 variable frequency drive's integrated keypad is designed to make it easy to commission the drive and configure its parameters. The figure below shows the elements that make up the DC1 variable frequency drive's keypad.

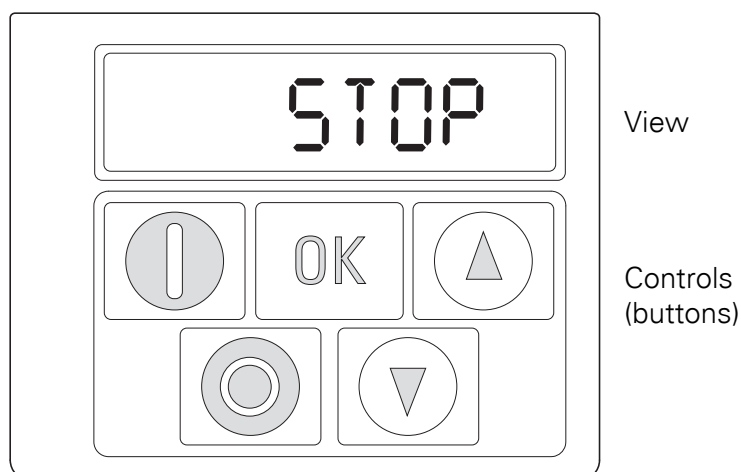
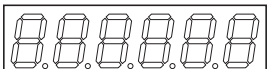

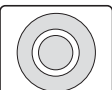

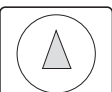



Figure 58: Operating unit view

Table 10: Keypad designations

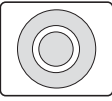
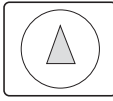
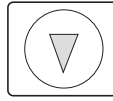
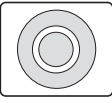
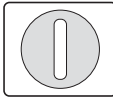

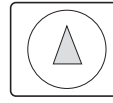
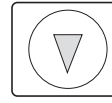
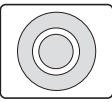


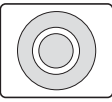
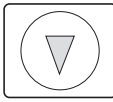
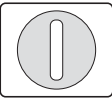
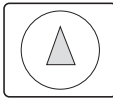
Operating unit element	Explanation
	Six-digit 7-segment LED display
	<p>Motor starter with pre-selected operating direction if parameter P-12 = 1 (FWD) or P-12 = 2 (FWD / REV).</p> <p>Note:</p> <ul style="list-style-type: none"> • Enable with +24 V on control signal terminal 2 (DI1) • P-12 = 2: The first time it is pressed (commissioning, parameter reset), a clockwise rotating field (FWD) will always be activated. Only after it is pressed for a second time will the direction of the rotating field change to a counterclockwise rotating field (REV). (The corresponding setting will be retained even after the supply voltage is switched off.)
	<ul style="list-style-type: none"> • Stops the running motor if P-12 = 1 or P-12 = 2 • Reset – Resetting after an error message
	<ul style="list-style-type: none"> • Activate parameter input (editing mode) • Activate parameter value, change (display value flashes) • Confirm (store) and activate configured value • Used to switch the display unit between Hz and rpm and A...
	<ul style="list-style-type: none"> • Increment numeric value or parameter number • Increase output frequency / motor speed if P-12 = 1 or P-12 = 2
	<ul style="list-style-type: none"> • Decrement numeric value or parameter number • Reduce output frequency / motor speed if P-12 = 1 or P-12 = 2

5 Parameters

5.1 Operating unit

5.1.1 Shortcuts

Table 11: Shortcuts

Function	Key combination
Default settings	 +  + 
Fan and display test	1)  +  +  +  + 
Keypad Port ²⁾	 +  + 
Variable frequency drive address ²⁾	 + 
Language ³⁾	 + 

1) Press the button first.

2) Only on DX-KEY... external keypads

3) Only on DX-KEY-OLED external keypads

5.1.2 Display unit

The display unit is a 7-segment LED display with five decimal points. The LED segments are red.

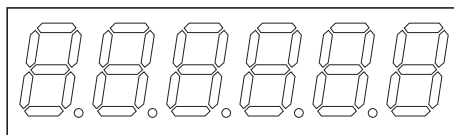


Figure 59: 7-segment LED display

5.1.3 Menu Navigation

When the specified supply voltage (L1/L, L2/N, L3 connection terminals) is applied, the DC1 variable frequency drive will automatically perform a self-test: The LED display will light up and, depending on the selected operating mode, will display $5k\ \square P$ or the appropriate value.

5.2 Setting parameters

5.2.1 Operating unit

The following table shows a good example of the general execution for selecting and setting parameters.

→ The flashing digit on the right indicates that the value being displayed can be changed with the arrow keys (Up ▲ or Down ▼).

Sequence	Commands	View	Description
0			Stop state: The variable frequency drive is ready for operation.
1			Hold down the OK button for about two seconds. Parameter P-01 will be displayed (the digit on the right, "1," will flash) Press OK button The display will switch to H 50.0 (= 50 Hz), the digit on the right, "0," will flash. The value can be confirmed and automatically stored by pressing the OK pushbutton. The display will jump back to the parameter name (P-01).
2			The numerical first value is always shown from the selected main menu.

→ Press the OK button to activate and store changes and values.

5.2.2 drivesConnect

A connection to the computer can be established by using a DX-CBL-PC-1M5 / DX-COM-PCKIT connection cable or a DX-COM-STICK Bluetooth stick. The drivesConnect program can be used to configure the variable frequency drive's parameters using a computer.

→ For more information, please refer to manual MN040003EN, "drivesConnect · Parameter Configuration Software for PowerXL™ Variable Frequency Drives"

5.2.3 Field bus/SmartWire DT

A DC1 variable frequency drive's parameters can be configured via a field bus or SmartWire-DT.

→ For more information, please refer to chapters 7 and 8 and to manual MN04012009Z-EN.

5 Parameters

5.3 List of parameters

5.3 List of parameters

The abbreviations used in the parameter lists have the following meaning:

PNU	Parameter number
ID	Identification number of the parameter
RUN	Access rights to the parameters during operation (RUN): ✓ = Modification permissible, - = Modification only possible in STOP
ro/rw	Parameter read and write permissions via a fieldbus connection (BUS): ro = read only rw = read and write
Value	<ul style="list-style-type: none"> • Parameter settings • Value ranges • Display values
WE	Default settings
Page	Page in this manual with additional configuration and application examples for the parameter



The first time the device is switched on, as well as any time after restoring its default settings, only basic parameters P-01 to P-14 will be shown. To access the extended parameter set, enter 101 (= WE and P-37) for parameter P-14.

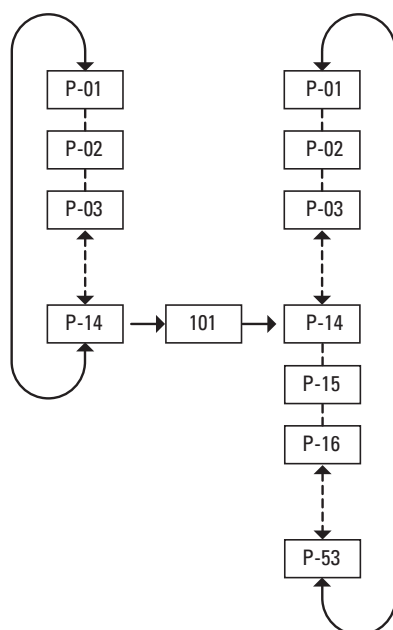


Figure 60: Parameter Access

5.3.1 Parameter Lock

Access to the DC1 variable frequency drive's parameters can be limited in order to prevent user errors. This option can be used to ensure that only authorized people will be able to make changes to the parameters.

When the device is running with its default configuration, only the "basic parameters" will be visible and editable.

- Parameter P-14 can be used to make all parameters visible and allow access to them (P-14 0 = P-37, WE = 101).
- Parameter P-37 can be used to change the access code used to access all parameters. Once you confirm the changes you make to parameter P-37, the extended parameters will be locked.
- Parameter P-38 (P-38 = 1) can be used to block access to all parameters, with the exception of parameter P-14 (read-only).

You can use the procedure below in order to block access to the parameter sets (make sure to follow the steps in the order shown!):

1. P-14 = 101 (accesses all parameters with the default settings)
2. P-37 = 123 (new code)
3. P-14 = 123 (accesses all parameters with the new code)
4. P-38 = 1 (changes all parameters to "read-only")
5. P-14 ≠ 123 (hides all extended parameters)

If you follow the steps above, only the basic parameters will be visible and it will not be possible to make any changes to them. To make any changes to the parameters, it will first be necessary to enter the new access code with P-14 = 123 and then set parameter P-38 to 0.

5.3.2 Default settings

DC1 variable frequency drives can be restored to their default configuration by using the following button combination: ▲ + ▼ + Stop button. When using this combination, hold down the buttons for two seconds until "P - DEF" is shown on the display.



The fault log (P-13) and the monitor log will not be restored to their default settings when the parameters are reset!

5.4 I/O control

Parameter P-15 is used to configure the mode of operation and function of both the digital and analog inputs. The configured value will depend on parameter P-12.

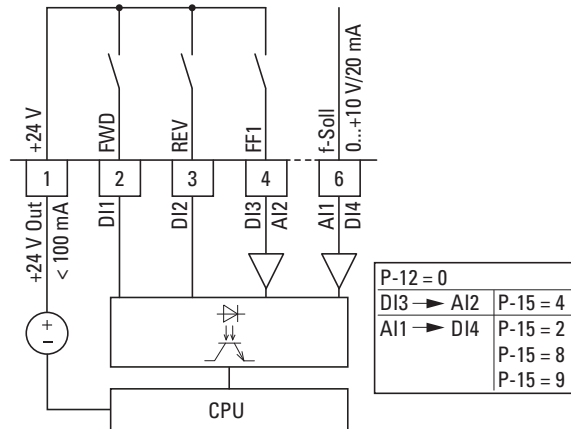


Figure 61: Digital and analog inputs

The operation of the DC1 variable frequency drive's via control signal terminals (P-12 = 0, P-15 = 5) is active with factory settings:

- DI1 (control signal terminal 2): FWD (Start enable clockwise rotating field)
- DI2 (control signal terminal 3): REV (Start enable anti-clockwise rotating field)
- DI3/AI2 (control signal terminal 4): FF1 (fixed frequency 1 = P-20; WE = 15 Hz)
- AI1/DI4 (control signal terminal 6): analog setpoint input (0 - 10 V)

When control control signal terminal 2 (FWD) and control signal terminal 3 (REV) are activated at the same time, a dec2 (P2-24) quick stop will be activated.

In the case of variable frequency drives with local controls (DC1-...-A6SN), the FWD switch position will drive DI1 and the REV switch position will drive DI2.



The FWD and REV designations refer to the default settings. The above functions may change if changes are made to the P-15 parameter.

5.5 Digital and analog inputs

Parameter P-15, which depends on P-12, is used to configure the inputs' function and mode of operation.

Parameter P-12 is used to define the control level for the device. If this control level changes, the inputs' function and mode of operation may change as well.



DI3 can become AI2; AI1 can become DI4.

The following tables show how parameter P-15 depends on parameter P-12.



For the button commands, please note that stop commands are run as N/C contact commands.

5 Parameters

5.5 Digital and analog inputs

Terminal Mode (P-12 = 0)

P-15	DI1 ¹⁾	DI2 ²⁾	DI3/AI2		AI1/DI4	Notes			
0	0 = Locked 1 = Start-Enable	0 = FWD 1 = REV	0 = Selected setpoint source 1 = Fixed frequency 1 (P-20)		Setpoint value AI1				
1	0 = Locked 1 = Start enable FWD	0 = Selected setpoint source 1 = fixed frequency 1/2	0 = Fixed frequency 1 (P-20) 1 = Fixed frequency 2 (P-21)		Setpoint value AI1				
2	0 = Locked 1 = Start enable FWD	DI2	DI3/AI2	DI3/AI2	Fixed frequency	0 = Fixed frequency 1 - 4 (P-20 - P-23) 1 = maximum frequency (P-01)	4 selectable fixed frequencies: The analog input is used as digital input. Switched at: 8 V < V _{input} < 30 V		
				0	0			0	FF1 (P-20)
				1	0			0	FF2 (P-21)
				0	1			1	FF3 (P-22)
				1	FF4 (P-23)				
3	0 = Locked 1 = Start enable FWD	0 = Selected setpoint source 1 = fixed frequency 1 (P-20)	External fault 0 = Fault 1 = Enable		Setpoint value AI1	Used to connect an external thermistor to DI3			
4	0 = Locked 1 = Start enable FWD	0 = Analog input 1 1 = Analog input 2	Setpoint value AI2		Setpoint value AI1	Changing between analog input: 1 and 2			
5	0 = Locked 1 = Start enable FWD	0 = Locked 1 = Start enable REV	0 = Selected setpoint source 1 = Fixed frequency 1 (P-20)		Setpoint value AI1	Connection of DI1 and DI2 leads to a quick stop (P-24).			
6	0 = Locked 1 = Start-Enable	0 = FWD 1 = REV	External fault 0 = Fault 1 = Enable		Setpoint value AI1	Used to connect an external thermistor to DI3			
7	0 = Locked 1 = Start enable FWD	0 = Locked 1 = Start enable REV	External fault 0 = Fault 1 = Enable		Setpoint value AI1	Connection of DI1 and DI2 leads to a quick stop (P-24). Connection of an external thermistor to DI3.			
8	0 = Locked 1 = Start-Enable	0 = FWD 1 = REV	DI3/AI2	AI1/DI4	Fixed frequency				
			0	0	FF1 (P-20)				
			1	0	FF2 (P-21)				
			0	1	FF3 (P-22)				
				1	FF4 (P-23)				
9	0 = Locked 1 = Start enable FWD	0 = Locked 1 = Start enable REV	DI3/AI2	AI1/DI4	Fixed frequency	Connection of DI1 and DI2 leads to a quick stop (P-24).			
			0	0	FF1 (P-20)				
			1	0	FF2 (P-21)				
			0	1	FF3 (P-22)				
				1	FF4 (P-23)				
10	1 = Run FWD ³⁾	0 = Stop ³⁾	0 = Selected setpoint source 1 = Fixed frequency 1 (P-20)		Setpoint value AI1				
11	1 = Run FWD ³⁾	0 = Stop ³⁾	1 = Run REV ³⁾		Setpoint value AI1	Connection of DI1 and DI2 leads to a quick stop (P-24).			
12	0 = Locked 1 = Start enable FWD	0 = Quick stop (P-24) 1 = Run FWD	0 = Selected setpoint source 1 = Fixed frequency 1 (P-20)		Setpoint value AI1				

Note:

Negative fixed frequencies are inverted if Run REV is selected.

- 1) FWD switch position only for IP66 degree of protection with local controls
- 2) REV switch position only for IP66 degree of protection with local controls
- 3) Button command

Keypad Mode (P-12 = 1, 2)

P-15	DI1 ¹⁾	DI2 ²⁾	DI3/AI2	AI1/DI4	Notes
0, 1, 5, 8 - 12	0 = Locked 1 = Start-Enable	1 = Increase frequency ³⁾	1 = Reduce frequency ³⁾	0 = FWD 1 = REV	Press the Start button or P-31 = 2 or 3
2	0 = Locked 1 = Start enable FWD	1 = Increase frequency ³⁾	1 = Reduce frequency ³⁾	0 = Source of setpoint: keypad, DI2/DI3 1 = FF1 (P-20)	Press the Start button or P-31 = 2 or 3
3	0 = Locked 1 = Start enable FWD	1 = Increase frequency ³⁾	External fault 0 = Fault 1 = Enable	1 = Reduce frequency	Press the Start button or P-31 = 2 or 3. Used to connect an external thermistor to DI3.
4	0 = Locked 1 = Start enable FWD	1 = Increase frequency ³⁾	0 = Source of setpoint: keypad, DI2 1 = Frequency via AI1	Setpoint value AI1	Press the Start button or P-31 = 2 or 3
6	0 = Locked 1 = Start-Enable	0 = FWD 1 = REV	External fault 0 = Fault 1 = Enable	0 = Source of setpoint: keypad 1 = FF1 (P-20)	Press the Start button or P-31 = 2 or 3. Used to connect an external thermistor to DI3.
7	0 = Locked 1 = Start enable FWD	0 = Locked 1 = Start enable REV	External fault 0 = Fault 1 = Enable	0 = Source of setpoint: keypad 1 = FF1 (P-20)	Press the Start button or P-31 = 2 or 3. Connecting DI1 and DI2 will trigger a quick stop (P-24). Used to connect an external thermistor to DI3.

CANopen / Modbus control mode (P-12 = 3, 4, 7, 8)

P-15	DI1 ¹⁾	DI2 ²⁾	DI3/AI2	AI1/DI4	Notes
0, 1, 2, 4, 5, 8 - 12	0 = Locked 1 = Start enable FWD	Not assigned	Not assigned	Not assigned	Run and stop commands will be transmitted via the RS-485 connection; in order for the variable frequency drive to run, DI1 must be switched.
3	0 = Locked 1 = Start enable FWD	0 = Source of setpoint: Modbus 1 = FF1 (P-20)	External fault 0 = Fault 1 = Enable	Not assigned	Used to connect an external thermistor to DI3.
6	0 = Locked 1 = Start enable FWD	0 = Source of setpoint: Modbus 1 = Source of setpoint: AI1	External fault 0 = Fault 1 = Enable	Setpoint value AI1	Master speed reference value: Start and stop controlled via RS-485. Keypad speed reference value: The variable frequency drive will run automatically: if DI1 is closed – depending on P-31. Used to connect an external thermistor to DI3.
7	0 = Locked 1 = Start enable FWD	0 = Source of setpoint: Modbus 1 = Source of setpoint: keypad	External fault 0 = Fault 1 = Enable	Not assigned	

User PI control mode (P-12 = 5, 6)

P-15	DI1 ¹⁾	DI2 ²⁾	DI3/AI2	AI1/DI4	Notes
0, 2, 4, 5, 8 - 12	0 = Locked 1 = Start enable FWD	0 = PI Regulation 1 = FF1 (P-20)	PI feedback Analog input	Not assigned	
1	0 = Locked 1 = Start enable FWD	0 = PI Regulation 1 = Source of setpoint: AI1	PI feedback Analog input	Setpoint value AI1	
3, 6, 7	0 = Locked 1 = Start enable FWD	0 = PI Regulation 1 = FF1 (P-20)	External fault 0 = Fault 1 = Enable	PI feedback Analog input	Used to connect an external thermistor to DI3.

- 1) FWD switch position only for IP66 degree of protection with local controls
- 2) REV switch position only for IP66 degree of protection with local controls
- 3) Button command

5 Parameters

5.5 Digital and analog inputs

SmartWire-DT (P-12 = 10)

P-15	DI1 ¹⁾	DI2 ²⁾	DI3/AI2	AI1/DI4	Notes	
0, 5, 10, 11, 12	0 = Locked 1 = Start enable FWD	Not assigned	0 = Setpoint value AI1 1 = Fixed frequency 1	Setpoint value AI1		
1	0 = Locked 1 = Start enable FWD	0 = Selected setpoint source 1 = fixed frequency 1/2	0 = Fixed frequency 1 1 = Fixed frequency 2	Setpoint value AI1		
2	0 = Locked 1 = Start enable FWD	DI2	DI3/AI2	Fixed frequency	0 = Fixed frequency 1 - 4 (P-20 - P-23) 1 = maximum frequency (P-01)	
		0	0	FF1 (P-20)		
		1	0	FF2 (P-21)		
		0	1	FF3 (P-22)		
		1	1	FF4 (P-23)		
3	0 = Locked 1 = Start enable FWD	0 = Selected setpoint source 1 = Fixed frequency 1	External fault 0 = Fault 1 = Enable	Setpoint value AI1	Used to connect an external thermistor to DI3	
4	0 = Locked 1 = Start enable FWD	0 = Setpoint value AI1 1 = setpoint value AI2	Setpoint value AI2	Setpoint value AI1	Changing between analog input: 1 and 2	
6, 7	0 = Locked 1 = Start enable FWD	Not assigned	0 = Selected setpoint source 1 = Fixed frequency 1 (P-20)	Setpoint value AI1	Connection of DI1 and DI2 leads to a quick stop (P-24).	
8, 9	0 = Locked 1 = Start-Enable	0 = FWD 1 = REV	DI3	AI1	Fixed frequency	4 selectable fixed frequencies: The analog input will be used as a digital input. Switched if: 8 V < V _{input} < 30 V
			0	0	FF1 (P-20)	
			1	0	FF2 (P-21)	
			0	1	FF3 (P-22)	
			1	1	FF4 (P-23)	

Note:

Negative fixed frequencies are inverted if Run REV is selected.

- 1) FWD switch position only for IP66 degree of protection with local controls
- 2) REV switch position only for IP66 degree of protection with local controls
- 3) Button command

5.6 Operational data indicator

When the specified supply voltage is applied (L1/L, L2/N, L3), the 7-segment LED display will light up (Power ON); the display will show $5E \square P$.

You can use arrow keys ▲ and ▼ to select the operational data indicator you want (parameter number P00-...) in the "Monitor" (P-00...) menu. You can tell the display to stop alternating between the parameter number and the display value and only show the display value instead by pressing the OK button. In order to access other operational data indicators, you will have to press the OK button again. You can then make your selection using the ▲ and ▼ arrow keys and confirm it with the OK button.



The values of the operating data display cannot be changed by hand (i. e. by value entry).

PNU	ID	Access right ro/rw	Value	Description
P-00 - Display values				
P00-01	20	ro	%	Analog input 1 100 % = Maximum input voltage
P00-02	21	ro	%	Analog Input 2 100 % = Maximum input voltage
P00-03	22	ro	Hz/rpm	Frequency reference value / Motor shaft speed Shown in Hz if P-10 = 0; otherwise shown in revolutions per minute
P00-04	11	ro	Status DI1 - DI4	Digital inputs 1 - 4 State of the variable frequency drive's digital input
P00-05		ro	0	Reserved
P00-06		ro	0	Reserved
P00-07		ro	V	Motor voltage: the value of the rms voltage being applied at the motor
P00-08	23	ro	V	Internal DC bus voltage
P00-09	24	ro	°C	Unit Temperature Heatsink temperature in °C
P00-10		ro	HH:MM:SS	The variable frequency drive's operating time Not affected when the parameters are reset to their default settings.
P00-11		ro	HH:MM:SS	The variable frequency drive's operating time since the last trip Operating time clock stopped by variable frequency drive lockup (or trip). Reset with next enable only if a trip occurred. Also reset with next enable after the variable frequency drive's mains power is switched off.
P00-12		ro	HH:MM:SS	The variable frequency drive's operating time since the last trip Operating time clock stopped by variable frequency drive lockup (or trip). Reset with next enable only if a trip occurred (undervoltage does not count as a trip) – Not reset when mains power is switched off/on unless a trip occurred before the mains power was switched off.

5 Parameters

5.6 Operational data indicator

PNU	ID	Access right ro/rw	Value	Description
P00-13		ro	HH:MM:SS	The variable frequency drive's operating time since the last lockup The variable frequency drive's operating time clock was stopped with the lockup. → Reset the value on next enable signal.
P00-14		ro	4 - 32 kHz	Pulse frequency The variable frequency drive's actual effective output pulse frequency. If the variable frequency drive gets too hot, this value can be lower than the frequency selected in P-17. The variable frequency drive will automatically reduce the pulse frequency in order to prevent a trip due to excess temperature and keep the system going.
P00-15		ro	0 - 1000 V	DC bus voltage log (256 ms) The eight most recent values before the trip Updated every 250 ms.
P00-16		ro	-20 - 120 °C	Heat sink temperature memory The last eight values before the trip. Updated every 500 ms.
P00-17		ro	(0 - 2) x rated operational current	Motor current memory The last eight values before the trip. Updated every 250 ms.
P00-18	15	ro	–	Control section software version
	16		–	Power section software version
P00-19		ro	–	Serial number of variable frequency drive
				Unique variable frequency drive serial number (example: 540102 / 32 / 005)
P00-20	12	ro	–	Variable frequency drive part no.
	13			Rated power of variable frequency drive
	14			Firmware Version

Example: Status displays

The status displays of the digital inputs and outputs are equivalent. They can be used to check whether an output control signal (e.g. from an external controller) is activating the variable frequency drive's inputs (DI1 - DI4). This provides you with an easy way to check the wiring (wire breakage).

The following table shows a few examples.

Display value: 1 = Activated = High; 0 = Not activated = Low

PNU	ID	Display value	Description
P00-04	11	0000	No digital input (DI1, DI2, DI3, DI4) is actuated
		1000	Control signal terminal 2 actuated (DI1)
		0100	Control signal terminal 3 actuated (DI2)
		0010	Control signal terminal 4 actuated (DI3)
		0001	Control signal terminal 6 actuated (DI4)
		0101	Control signal terminals 3 and 6 actuated (DI2 + DI4)

6 Drives control

6.1 Control level

Parameter P-12 can be used to define the control level for the DC1 variable frequency drive.

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
P-12	140	–	rw		Control level	0
				0	Control signal terminals (I/O) The variable frequency drive will respond directly to signals applied to the control signal terminals.	
				1	Keypad (KEYPAD FWD) The variable frequency drive can only be controlled in the forward direction if an external or remote control keypad is used.	
				2	Keypad (KEYPAD FWD/REV) The variable frequency drive can be controlled in both the forward and reverse directions if an external or remote control keypad is used. The keypad can be used to switch between a clockwise rotating field (FWD) and a clockwise rotating field (REV) by pressing the START pushbutton.	
				3	Modbus Control via Modbus RTU (RS485) with the internal acceleration/deceleration ramps.	
				4	Modbus Control via Modbus RTU (RS485) port; the acceleration/deceleration ramps will be updated via Modbus.	
				5	PI controller with external actual value	
				6	PI controller with external actual value and totalized value of AI1	
				7	CANopen Control via CANopen using the internal acceleration/deceleration ramps	
				8	CANopen Control via CANopen, with the acceleration/deceleration ramps being updated via CANopen	
				9	Control commands and setpoint values via SmartWire-DT (DI1 = Hardware enable, P-15: no function)	
				10	Control commands via SmartWire-DT, setpoint value set locally (P-15 for local settings)	
				11	Control commands issued locally, setpoint value via SmartWire-DT (DI1 = Start/Stop)	
				12	SmartWire-DT control – control will depend on the configuration in the event of a loss of communications; automatic switch to local control	
13	Control commands and setpoint values via SmartWire-DT In addition, an enable signal via DI1 and an enable setpoint via DI2					



If the control level changes, the inputs' mode of operation and function (P-15) via the control signal terminals will change.

6 Drives control

6.2 Second acceleration and deceleration time

6.2 Second acceleration and deceleration time

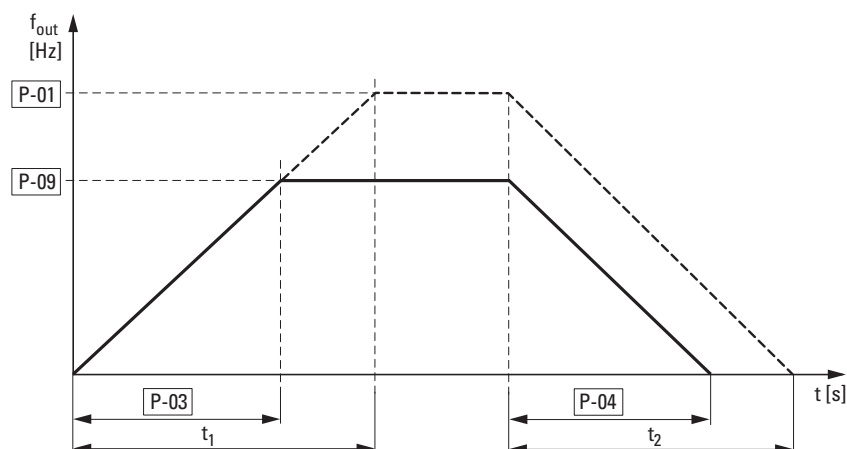


Figure 62: Acceleration and deceleration times

A frequency of 0 Hz and maximum output frequency f_{\max} (P-01) will always be the reference points for the acceleration and deceleration times set in parameters P-03 and P-04.

The values for the acceleration time t_1 and the deceleration time t_2 are calculated as follows:

$$t_1 = \frac{P-01 \times P-03}{P-09} \qquad t_2 = \frac{P-01 \times P-04}{P-09}$$



The defined acceleration (P-03) and deceleration times (P-04) apply for all changes to the frequency reference value.

If the start-release (FWD, REV) is switched off, the output frequency (f_{Out}) is immediately set to zero. The motor runs down uncontrolled. If a controlled run-down is requested (with value from P-04), parameter P-05 must be 0.

Starting friction and load inertia can lead to longer acceleration times for the drive than those configured in P-03. Large gyrating masses and the load being driven can lead to longer deceleration times for the drive than that configured in P-04.

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
P-01	129	✓	rw	0 - 250 Hz (max. 500 Hz)	Maximum frequency / maximum speed – shown in Hz or rpm (for P-10 > 0) P-10 = 0 → P-02 - 5 x P-09 → Hz P-10 > 0 → P-02 - 5 x P-09 x 60 s → rpm	50.0
P-03	131	✓	rw	0.1 - 600 s	Acceleration time (acc1)	5.0
P-04	132	✓	rw	0.1 - 600 s	Deceleration time (dec1)	5.0
P-09	137	–	rw	25 - 500 Hz	Rated motor frequency (→ motor rating plate) Note: This parameter value is also automatically applied as the cut-off frequency for the V/Hz characteristic curve.	50.0 ¹⁾

6.2.1 Stop function with two different deceleration times

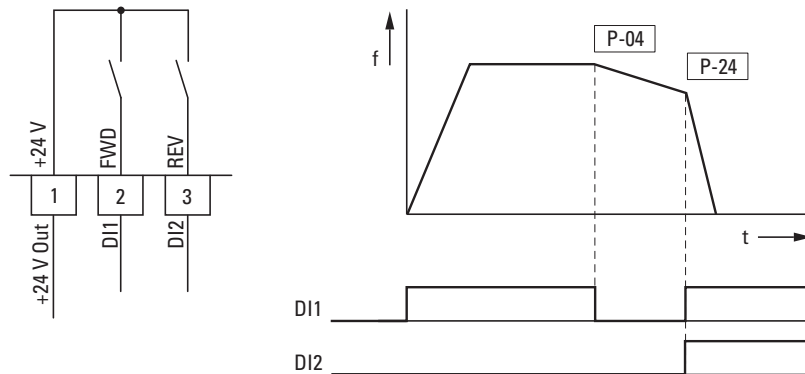


Figure 63: Stop function with two different deceleration times

The stop function with a deceleration time is activated with P-05 = 0 or P-05 = 2. If the enable signal on digital input DI1 (FWD, control signal terminal 2) is switched off, the variable frequency drive's output frequency will be reduced as required by the deceleration time (dec1) set in P-04.

The second deceleration time is set with parameter P-24.

When the device is running with its default configuration, the second deceleration time is activated by activating DI1 and DI2 (control signal terminals 2 and 3) simultaneously.

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
P-04	132	✓	rw	0.1 - 600 s	Deceleration time (dec1)	5.0
P-24	152	✓	rw	0.1 - 25.0 s	Second deceleration time (dec2)	0.0

6.3 Motor

For optimum operating behavior, you should enter the specifications on the motor's rating plate here. They are the base values used to control the motor.

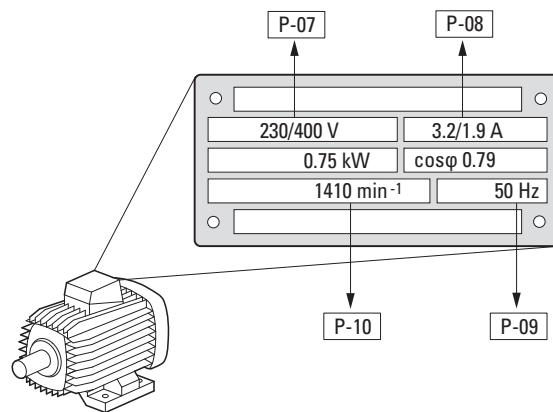


Figure 64: Motor parameters from ratings plate



The motor data is set to the rated operational data for the variable frequency drive and depends on the performance variables in default settings.

6.3.1 Circuit types for motor stator windings

When selecting the rating data, take the dependency of the type of switching on the strength of the feeding mains voltage into account:

- 230 V (P-07) → delta circuit → P-08 = 4 A
- 400 V (P-07) → star-connected circuit → P-08 = 2.3 A

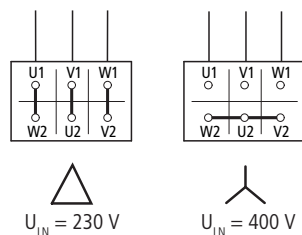


Figure 65: Circuits (delta, star)

Example

Single-phase connection of DC1-124D8... variable frequency drive to a mains voltage of 230 V. The motor's stator winding has a delta connection (motor rated current of 4 A as per rating plate in Figure 64). See ¹⁾ in the default settings.

Required changes for electrically mapping the motor:
P-07 = 230, P-08 = 4.0, P-09 = 50

6.3.2 87-Hz Characteristic curve

In order to have the motor from → Figure 16, page 39 run with an 87-Hz characteristic curve, the parameters need to be configured as follows:

- P-01 → 87 Hz
- P-07 → 400 V
- P-08 → 3.2 A (Δ)
- P-09 → 87 Hz

The motor must be in a delta configuration for this purpose. When this setup is used, the motor will have a motor voltage of 230 V at a frequency of 50 Hz and a motor voltage of 400 V at a frequency of 87 Hz. The field-weakening range will start above 87 Hz.

Table 12 below shows which motor is needed for which mains voltage.

Table 12: Motor ratings for mains voltage for 87-Hz characteristic curve

Part no.	Mains voltage	Motor
DC1-1D DC1-12 DC1-32	230 V	127 V /230 V
DC1-34	400 V	230 V/400 V

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
P-07	135	–	rw	0.20 - 230/500 V	Nominal motor voltage (→ Motor rating plate) Pay attention to the mains voltage and the type of circuit in the stator winding! Note: This parameter has a direct influence on the V/Hz characteristic curve (e.g. operation with the 87-Hz characteristic curve). This must be especially taken into account in the case of values (P-07) that deviate from the variable frequency drive's rated operational data ($U_{LN} = 100\%$). This may cause the over-excitation of the motor and thus lead to an increased thermal load.	230
P-08	136	✓	rw	Depending on device	Rated motor current Setting range: $0.2 \times I_e - 2 \times I_e$ [A] I_e = variable frequency drive's rated operational current (→ Motor rating plate)	4.8
P-09	137	–	rw	25 - 500 Hz	Rated motor frequency (→ Motor rating plate) Note: This parameter value is also automatically applied as the cut-off frequency for the V/Hz characteristic curve.	50.0

6 Drives control

6.3 Motor

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
P-10	138	✓	rw	0 - 30000 rpm (min ⁻¹)	<p>Nominal speed of the motor</p> <p>(→ motor rating plate)</p> <p>Note: This parameter can be optionally set to the motor's rated speed (revolutions per minute, rating plate). If it is set to a value of 0 (the default setting), all speed-related parameters will be shown in Hz. In addition, the slip compensation function for the motor will be locked. Entering the value on the motor's rating plate will unlock the slip compensation function, and the variable frequency drive's display will show the motor speed in the estimated rpm. All speed-related parameters (such as the minimum and maximum frequencies and the fixed frequencies) will also be shown in rpm.</p>	0

6.3.3 U/f characteristic curve

The inverter in the DC1 variable frequency drive works with sinusoidal pulse width modulation (PWM). The IGBTs are switched with two control methods based on V/Hz control:

U/f (P-10 = 0)

- Frequency control (Hz),
- Parallel Connection of several motors,
- Large power difference ($P_{FU} \gg P_{Motor}$),
- Switching in the output.

U/f with slip compensation (P-10 > 0)

- Speed control (min^{-1} , rpm) with slip compensation,
- Single operation (only one motor),
maximum one power rating smaller $P_{FU} > P_{Motor}$,
- High torque (requirement: exact motor data for the motor model).

The U/f-characteristic curve (voltage/frequency characteristic curve) designates a control process for the variable frequency drive, with which the motor voltage is controlled in a certain ratio to the frequency. If the voltage/frequency ratio is constant (linear characteristic curve), the magnetizing flux and the torque curve of the connected motor is virtually constant.

In a standard application, the benchmark values for the V/Hz characteristic curve match the rated operational data of the connected motor (see the motor's rating plate):

- Output voltage P-28 = Nominal motor voltage P-07
- Cut-off frequency P-29 = Rated motor frequency P-09 = Maximum frequency P-01



The rating data of the U/f-characteristic curve is assigned automatically and corresponds with the values of parameter P-07 (nominal motor voltage) and P-09 (rated motor frequency).

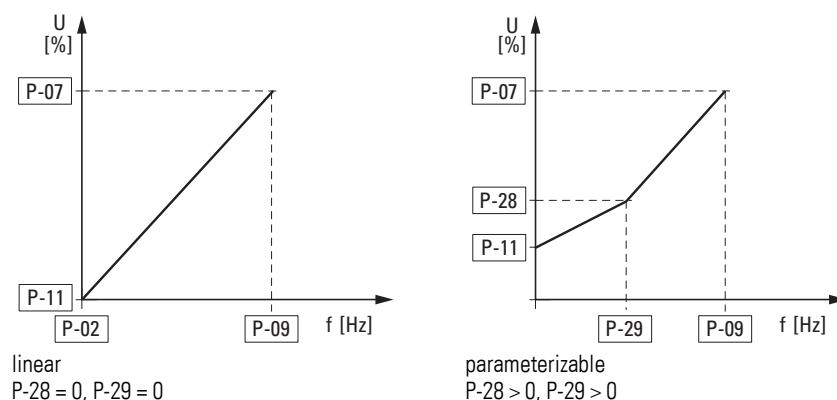


Figure 66: U/f-characteristic curve

6 Drives control

6.3 Motor

6.3.4 Speed behavior without slip compensation

On the constant three-phase AC supply, the three-phase asynchronous motor has a constant rotor speed (n_1 , P-10, rating plate specifications) according to the number of pole pairs and mains frequency. The slip here represents the difference between the rotating field of the stator and that of the rotor. In static operation, the slip is constant.

Load changes (①) at the motor shaft cause a larger slip (Δn) and thus a reduced rotor speed (②).

In controlled operation (V/F characteristic curve), the variable frequency drive cannot compensate this load-related speed difference. The speed behavior of the motor corresponds to that of a motor in a constant AC supply system.

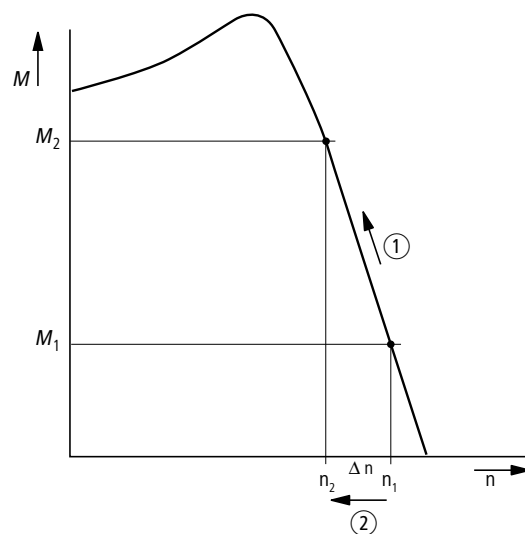


Figure 67: Speed behavior Without slip compensation

6.3.5 Speed behavior with slip compensation

In the control mode (V/Hz with slip compensation, P-10 > 0), the variable frequency drive can compensate for fluctuations caused by the load's characteristics. To do this, the internal motor model uses the measured voltage and current values of the stator winding (u_1 , i_1) to calculate the required manipulated values for flux variable i_μ and torque variable i_w . In the three-phase motor's equivalent circuit diagram, the load-related slip is shown as resistor R'_2/s . During no-load operation, this resistance approaches infinity, and approaches zero as the load increases.

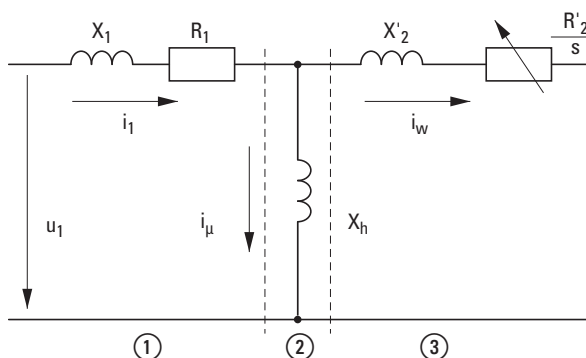


Figure 68: Equivalent circuit diagram for an asynchronous motor

- ① Stator winding
- ② Air gap
- ③ Transformed rotor winding

An exact calculation requires the precise rating specifications of the motor (P-07, P-08, P-09). The speed control P-10 > 0) can then compensate the load-related slip deviations.

The simple illustration shows that, as the load torque increases (①), the resulting speed reduction is compensated by an increase in the output frequency (②) (→ Figure 69).

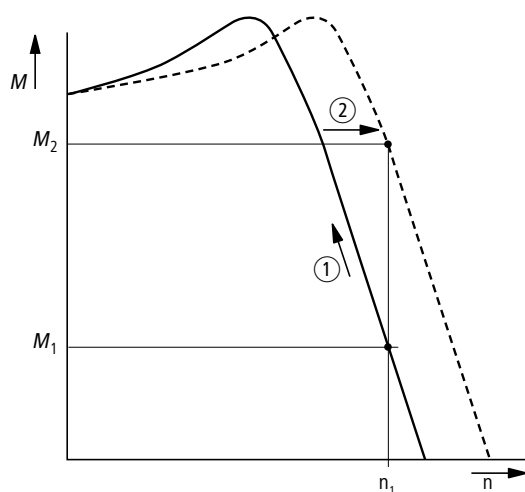


Figure 69: Speed behavior with slip compensation

6 Drives control

6.3 Motor

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
P-01	129	✓	rw	0 - 250 Hz (max. 500 Hz)	Maximum frequency / maximum speed – shown in Hz or rpm (for P-10 > 0) P-10 = 0 → P-02 - 5 x P-09 → Hz P-10 > 0 → P-02 - 5 x P-09 x 60 s → rpm	50.0
P-02	130	✓	rw	0 - 250 Hz (max. 500 Hz)	Minimum frequency / minimum speed – shown in Hz or rpm (for P-10 > 0) P-10 = 0 → 0 - P-01 → Hz P-10 > 0 → 0 - P-01 → rpm	0
P-07	135	–	rw	0.20 - 230/500 V	Nominal motor voltage (→ Motor rating plate) Pay attention to the mains voltage and the type of circuit in the stator winding! Note: This parameter has a direct influence on the V/Hz characteristic curve (e.g. operation with the 87-Hz characteristic curve). This must be especially taken into account in the case of values (P-07) that deviate from the variable frequency drive's rated operational data ($U_{LN} = 100\%$). This may cause the over-excitation of the motor and thus lead to an increased thermal load.	230
P-09	137	–	rw	25 - 500 Hz	Rated motor frequency (→ Motor rating plate) Note: The parameter value will automatically be used as the cut-off frequency for the V/Hz characteristic curve as well.	50.0
P-11	139	✓	rw	0.00 - 20.0 %	Voltage amplification Voltage amplification is used in order to increase the motor voltage applied at low output frequencies so as to improve the torque at low speeds, as well as the starting torque. Note: A high start voltage enables a high torque at the start. Notice: A high torque at low speed causes a high thermal load on the motor. If temperatures are too high, the motor should be equipped with an external fan.	3.0
P-28	156	–	rw	0.00 - P-07 V	V/Hz characteristic curve modification voltage	0
P-29	157	–	rw	0.00 - P-09 Hz	V/Hz characteristic curve modification frequency	0

6.4 Braking

Various braking functions can be configured:

- DC braking,
- Generative braking (brake chopper),
- Mechanical braking (actuation).

The brake functions allow you to reduce undesired coasting and long coasting times. Mechanical braking also ensures safe operating states.

6.4.1 DC-braking

With DC braking, the variable frequency drive supplies the three-phase stator winding of the three-phase motor with DC current. This generates a stationary magnetic field which induces a voltage in the rotor while the rotor is in motion. As the electrical resistance of the rotor is very low, even small induction can generate high rotor currents and thus a strong braking effect.

As the speed slows down, the frequency of the induced voltage and with it the inductive resistance drops. The resistive load becomes more effective and increases the braking effect.



DC braking is not suitable for holding loads or for intermediate braking. Nor for intermediate braking.

NOTICE

DC braking will cause increased motor heating. Accordingly, make sure to configure a braking torque that is as low as possible using the voltage amplification (P-11) and braking duration (P-32) parameters.

6.4.2 Regenerative braking

If the rotor of an asynchronous motor is driven oversynchronously in the operating direction of the rotating field, it generates electric power via its stator windings. The motor then becomes a generator. In the variable frequency drive, this generative energy causes an increase in the DC link voltage. Oversynchronous speeds occur, for example, when the output frequency in variable frequency drive operation is reduced with short deceleration times, the connected machine has a large flywheel mass or when the flowing medium in pumps and fans works against the speed reduction.

The increase in the DC link voltage is monitored by the DC1 variable frequency drive and always enables a braking torque of approx. 30% of the rated motor torque. A higher braking torque can be achieved with a more powerful variable frequency drive. A braking chopper is integrated into DC1 variable frequency drives with a size of FS2 or bigger. When used in conjunction with an external high-capacity resistor, this brake chopper makes it possible to achieve braking torques of up to 100% of the rated motor torque. The braking chopper will be activated at a DC link voltage of 390 V or higher in DC1-x2... part nos. and 780 V or higher in DC1-34... part nos. If the voltage falls down to 378 V in DC1-x2... part nos. / 756 V in DC1-34... part nos., the braking chopper will be deactivated. The external braking resistance is connected via terminals DC+ and BR.

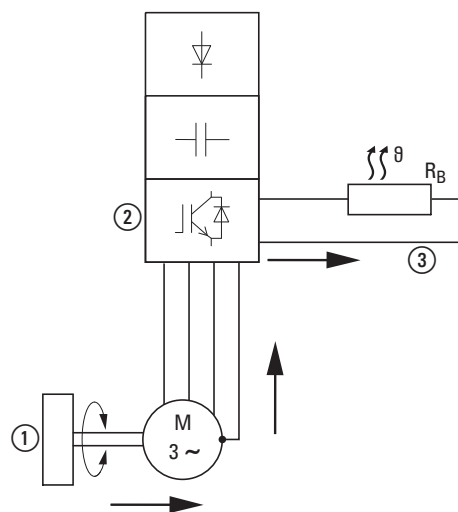


Figure 70: Regenerative braking with external braking resistance

- ① Machine flywheel mass
- ② Inverter with brake chopper (braking transistor)
- ③ Braking resistance (R_B) → Energy flow (braking torque)

The brake chopper can be activated in parameter P-34. This function is only available in variable frequency drives of size FS2 and FS3.

- ➔ In variable frequency drives without a braking transistor, parameter P-34 has no function.
- ➔ If the DX-BR-100 integrated braking resistance is being used, parameter P-34 should be set to 1.
If an external braking resistance is being used, parameter P-34 should be set to 2 and the braking resistance should be protected externally.

6.4.3 Mechanical brake (actuation)

An external mechanical brake can be actuated using one of the following outputs:

- Transistor output DO: control signal terminals 8 and 9, maximum 24 VDC, P-25 = 6
- Relay output K1: N/O control signal terminals 10 and 11, maximum 250 VAC / 6 A or 30 VDC / 5 A, P18 = 6

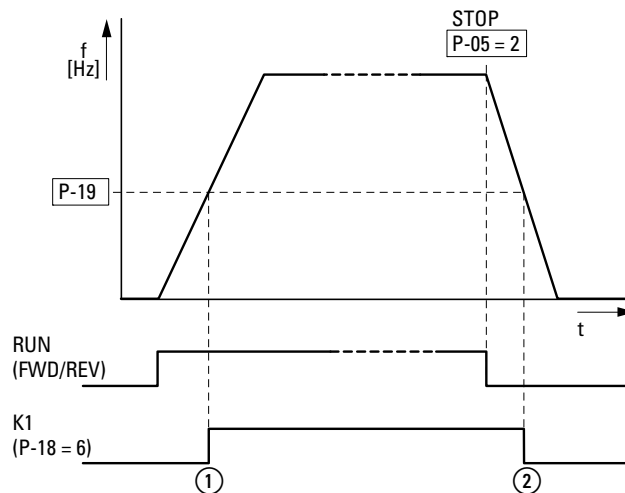


Figure 71: External brake actuated via K1

- ① Brake, released
- ② Brake activates and brakes the drive mechanically.

6 Drives control

6.4 Braking

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
P-05	133	✓	rw		Stop Function	1
				0	Ramp, deceleration = dynamic braking Deceleration time with the value set under P-04 (dec1). If the energy that is fed back by the motor during dynamic braking is too high, the deceleration time must be increased. In devices with an internal braking transistor, the excess energy can be dissipated with an external braking resistance (optional) (→ Section 6.4.2, „Regenerative braking“, page 116).	
				1	Free coasting After the start enable (FWD/REV) is switched off or the STOP button is pressed (P-12 and P-15), the motor will coast uncontrolled.	
				2	Ramp, quick stop = dynamic braking Deceleration time 2 with the value set under P-24 (dec2) If the energy that is fed back by the motor during dynamic braking is too high, the deceleration time must be increased. In devices with an internal braking transistor, the excess energy can be dissipated with an external braking resistance (optional)	
P-18	146	✓	rw		K1 signal (Relay Output 1)	0
					Used to select the function assigned to the relay output. The relay has two output terminals: Logic 1 indicates that the relay is active: This is why terminals 10 and 11 are connected to each other. Output terminals; logic 1 indicates that the relay is active.	
				0	RUN, enable (FWD, REV)	
				1	READY, variable frequency drive ready for operation	
				2	Output frequency = frequency reference value	
				3	Error message (variable frequency drive not ready)	
				4	Output frequency \geq limit value (P-19)	
				5	Output current \geq limit value (P-19)	
				6	Output frequency < limit value (P-19)	
7	Output current < limit value (P-19)					
P-19	147	✓	rw		K1-Limit value (relay)	100.0
					P-02 - 200.0 %	
					The adjustable limit value that is being used in connection with settings 4 to 7 of P-18 and P-25	

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
P-25	153	✓	rw		A01-Signal (Analog Output) Switch to digital output	8
					DO1 (digital output 1) → +24 VDC (values 0 - 7)	
				0	RUN (variable frequency drive enabled and running – FWD, REV)	
				1	READY, variable frequency drive ready for operation / no faults	
				2	Output frequency = frequency reference value	
				3	Error message (variable frequency drive is not ready)	
				4	Output frequency ≥ limit value (P-19)	
				5	Output current ≥ limit value (P-19)	
				6	Output frequency < limit value (P-19)	
				7	Output current < limit value (P-19)	
					Analog output → 0 - 10 V DC (value 8, 9)	
	8	Output frequency f-Out → 0 - 100 % f _{max} (P-01)				
	9	Output current → 0 - 200 % I _e (P-08)				
P-32	160	✓	rw	0 - 25 s	DC-braking	0
					Used to define the length of time during which direct current will be applied to the motor if the output frequency reaches a value of 0.0 Hz. Note: The voltage level will be the same as the voltage amplification set in P-11.	
P-33	161	✓	rw		Motor pick-up control function (to catch spinning motors) (in sizes FS2 and FS3) / DC braking, braking time at start (in size FS1)	0
					If this parameter is enabled, the variable frequency drive will attempt to determine whether the motor is already turning during a start. It will then start to control the motor starting from the motor's current speed. A brief deceleration will occur if motors that are not already turning are started. Note: Direct current connection time when starting (FS1-size variable frequency drives only): Used to set the length of time during which a direct current will be applied to the motor in order to ensure that it will be stopped if the variable frequency drive is activated.	
				0	Deactivated	
	1	Activated				
P-34	162	✓	rw		Brake chopper activation (only with sizes FS2 and FS3)	0
				0	Locked	
				1	Enabled with overload protection braking resistance (for integrable braking resistances)	
				2	Enabled without overload protection braking resistance (for external braking resistances)	

6 Drives control

6.4 Braking

7 Applications

7.1 Analog inputs changeover

Control signal terminals 4 and 6 can be used as analog inputs (AI). The corresponding signal range will depend on parameter P-16 for analog input AI1 and parameter P-47 for analog input AI2.

The reference potential for the two analog inputs AI1 and AI2 is 0 V (control signal terminals 7 and 9).

➔ The function of control signal terminals 4 and 6 is defined by the selection made in parameter P-15 and depends on the control mode in parameter P-12.

With the default settings, control signal terminal 6 (AI1) will be configured for a setpoint voltage of 0 to +10 VDC and control signal terminal 4 as a digital input (DI3).

Example

Desired options:

- Analog input AI2 suitable for 4 to 20 mA with wire breakage monitoring.
- Switching the setpoint source between AI1 and AI2 via DI2.

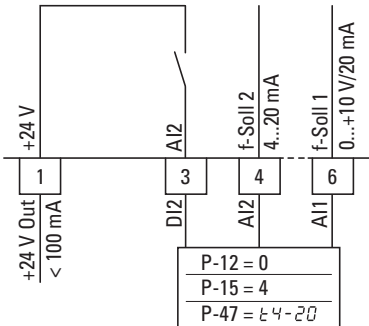


Figure 72: Switching setpoint sources

Table 13: Analog and digital input wiring (P-12 = 0, P-47 = 44-20)

P-15	DI1	DI2	AI1	AI2
4	0 = Locked 1 = Start enable FWD	0 = AI1 1 = AI2	Setpoint value AI1 (0 - 10 V)	Setpoint value AI2 (4 - 20 mA)

- DI1 (control signal terminal 2): FWD (Forward = Start enable clockwise rotating field)
- DI2 (control signal terminal 3): AI1/AI2 (change of setpoint source from AI1 to AI2)
- AI1 (control signal terminal 6): analog setpoint value 1
- AI2 (control signal terminal 4): analog setpoint value 2

7 Applications

7.1 Analog inputs changeover

7.1.1 Scaled value range (AI1)

The following graphs show examples of the curve characteristics of the scaled and non-scaled input signals.

Example: P-35 = 200 %

If parameter P-16 is configured for a 0 - 10 V signal and parameter P-35 is set to 200%, a 5-V input will result in the variable frequency drive running at its maximum frequency / speed (P-01). Values lower than 100% will limit the maximum frequency; values greater than 100% will be used for low signal levels, e.g. for sensors with a 0 to 5 V output.

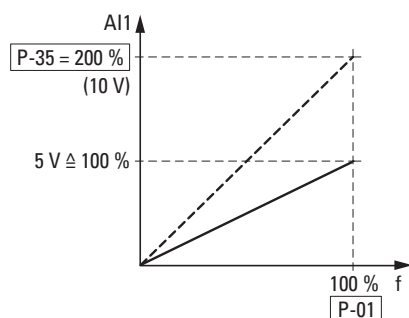


Figure 73: Scaled input signal

PNU	ID	Access right		Value	Description	DS
		RUN	ro/rw			
P-01	129	✓	rw	0 - 250 Hz (max. 500 Hz)	Maximum frequency / maximum speed – shown in Hz or rpm (for P-10 > 0) P-10 = 0 → P-02 - 5 x P-09 → Hz P-10 > 0 → P-02 - 5 x P-09 x 60 s → rpm	50.0
P-35	163	✓	rw	0 - 500 %	Analog input 1 will be scaled by this factor Example: For P-16 and a 0 - 10 V signal and a scaling factor of 200.0%, a 5-V input will make the variable frequency drive run at the maximum frequency / speed (P-01).	100

7.2 External fault (EXT)

Digital input 3 (DI3) is intended for use as an external fault input.

In the following configurations, DI3 is being used as an input for an external fault:

P-15 = 0	→	P-12 = 3, P-12 = 6, P-12 = 7
P-15 = 1, P-15 = 2	→	P-12 = 3, P-12 = 6, P-12 = 7
P-15 = 3, P-15 = 4, P-15 = 7, P-15 = 8	→	P-12 = 3, P-12 = 6, P-12 = 7
P-15 = 5, P-15 = 6	→	P-12 = 3, P-12 = 6, P-12 = 7

An overload relay, for example, can be connected to the external fault input. When connecting it, make sure to use the N/C contact.

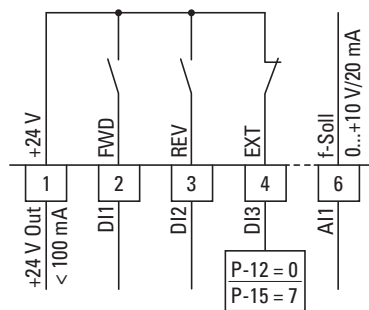


Figure 74: Connecting example: external fault (EXT)

7.3 Connecting a thermistor

A thermistor (PTC thermistor) installed in the motor can be connected to digital output 3 (DI3). In order to be able to do this, digital input 3 must be reconfigured as an external fault input as described in section "External fault (EXT)" above.

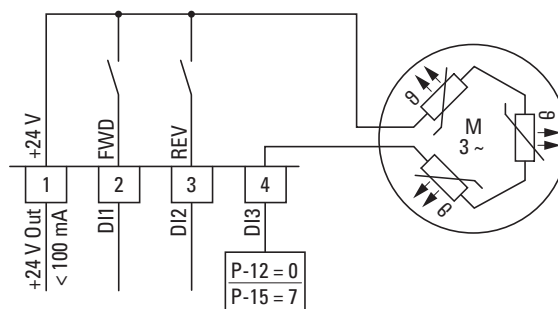


Figure 75: Thermistor connection



The switching threshold for the external fault input is fixed and cannot be changed:
Fault when $\geq 2.5 \text{ k}\Omega$; reset fault when $\leq 1.9 \text{ k}\Omega$

7 Applications

7.4 Fixed frequency setpoint values

7.4 Fixed frequency setpoint values

Fixed frequency reference values have a higher priority than other frequency reference values. They can be accessed individually, or in binary code, via digital inputs DI1 to DI4.



The maximum permitted setting for a fixed frequency is limited by parameter P-01.

A fixed frequency value cannot go below a minimum limit frequency set at parameter P-02.

If a fixed frequency is lower than the minimum frequency (P-02), the DC1 variable frequency drive will move to the minimum frequency.



The fixed frequency values can be changed during operation (RUN).

7.4.1 Fixed frequency

Four different fixed frequency reference values can be set in parameters P-20 to P-23 (FF1 to FF4).

PNU	ID	RUN	ro/rw	Value	Description	DS
P-20	148	✓	rw	0 - 50 Hz	Fixed frequency FF1 / speed 1	15.0
P-21	149	✓	rw	0 - 50 Hz	Fixed frequency FF2 / speed 2	0.0
P-22	150	✓	rw	0 - 50 Hz	Fixed frequency FF3 / speed 3	0.0
P-23	151	✓	rw	0 - 50 Hz	Fixed frequency FF4 / speed 4	0.0

When the device is running with its default configuration, fixed frequency FF1 = 15 Hz can be accessed via digital input DI3 (control signal terminal 4).

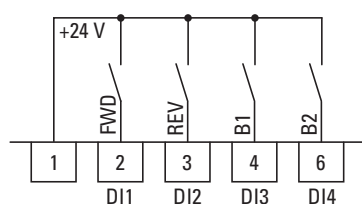


Figure 76: Example: fixed frequencies FF1 to FF4

Example

P-12 = 0; P-15 = 9; P-21 = 20; P-22 = 30; P-23 = 40

b1	m2	Fixed frequency
0	0	FF1 (P-20)
1	0	FF2 (P-21)
0	1	FF3 (P-22)
1	1	FF4 (P-23)

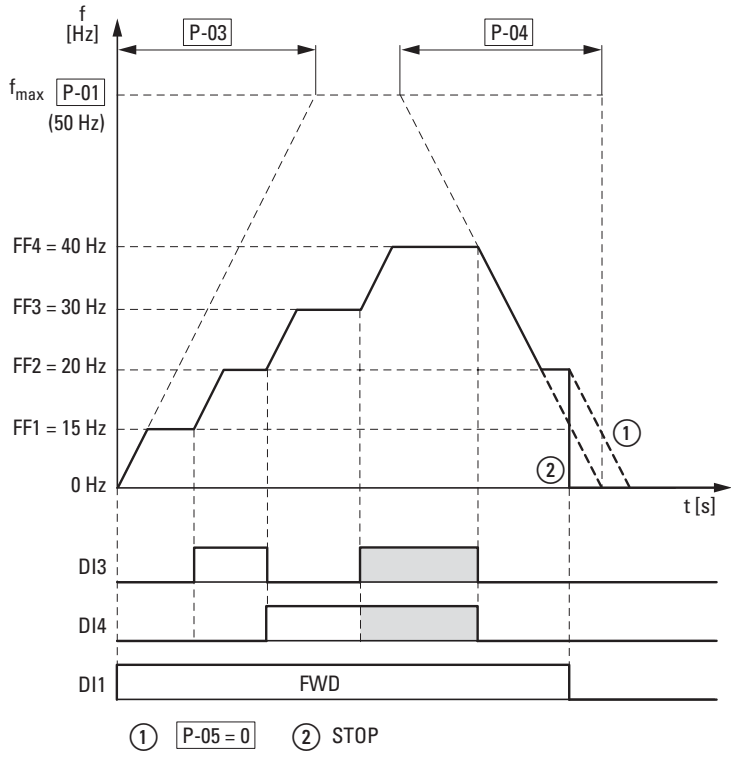


Figure 77: Example: Activation of the fixed frequencies with acceleration and deceleration ramps

The change between the individual fixed frequencies is done with the acceleration times and deceleration times set at P-03 and P-04. (→ Figure 77). When the FWD or REV enables are revoked, the output frequency is inhibited directly ② (coasting to halt). When P-05 = 0, the drive performs a controlled deceleration ①.

7.4.2 Frequency jump

In systems with mechanical resonances, you can skip this frequency range for stationary operation.

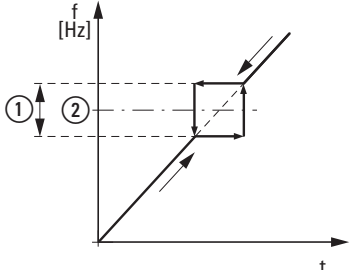


Figure 78: Setting range for frequency masking
 ① P-26
 ② P-27

7 Applications

7.4 Fixed frequency setpoint values

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
P-26	154	✓	rw	0.00 - 50.00 Hz	Frequency skip 1, bandwidth (hysteresis range)	0
					0.00 - P-01 (f_{max})	
P-27	155	✓	rw	0.00 - 50.00 Hz	Frequency skip 1, center	0
					P-02 (f_{min}) - P-01 (f_{max})	
					<p>The skip frequency function is used to prevent the variable frequency drive from being run at a specific output frequency, e.g. at a frequency that will cause mechanical resonance in a specific machine.</p> <p>Parameter P-27 is used to define the center of the skip frequency band and is used together with parameter P-26. The output frequency will run through the specified band at the speeds set in P-03 or P-04 without holding an output frequency that falls within the defined band.</p> <p>If the frequency reference value applied to the variable frequency drive falls within the band, the output frequency will remain at the upper or lower limit of the band.</p>	

7.5 Motor potentiometer

The function of an electronic motor potentiometer for entering setpoints can be set with parameters P-12, P-15 and P-31.

Example

P-12 = 2; P-15 = 0; P-31 = 2 or = 3

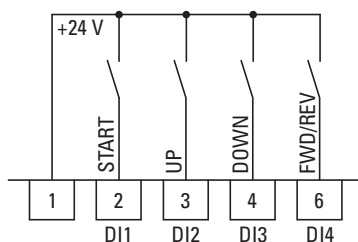


Figure 79: Motor potentiometer for both operating directions (FWD / REV)

The start enable signal is issued with a continuous signal at control signal terminal 2 (DI1); the operating direction (FWD or REV) is selected with control signal terminal 6 (DI4).

The frequency reference value can then be increased with a pulse on terminal 3 (DI2) (UP). The acceleration will be based on the time set in P-03 (acc1) and go all the way to just under the maximum output frequency set in P-01.

Parameter P-31 is used to define the behavior of the variable frequency drive in the event of a restart:

- P-31 = 2: The variable frequency drive will start off from the minimum frequency (P-02).
- P-31 = 3: The variable frequency drive will store the set value and start from the previously set frequency reference value.
The frequency reference value set here will be retained even after the supply voltage is switched off.

Control signal terminal 4 (DI3) can be used to reduce the configured frequency reference value of the motor potentiometer (DOWN). The deceleration will take place using the time set in P-04 (dec1) all the way to 0 Hz if a minimum frequency has not been set in P-02.



For more information, please refer to application note AP040042.

7 Applications

7.5 Motor potentiometer

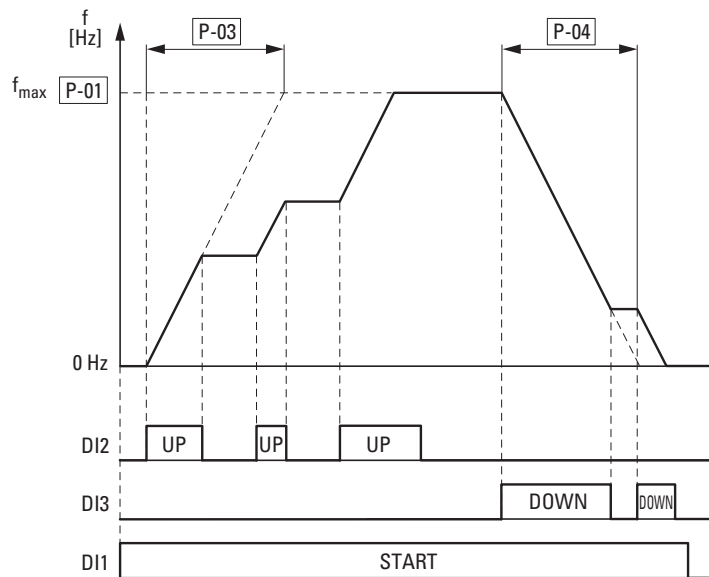


Figure 80: Motor potentiometer example

If a minimum frequency has been configured (P-02), the motor potentiometer will always start at $f = 0$ Hz. After the configured minimum frequency is exceeded, the motor potentiometer will work within the range up to the maximum frequency (P-01). The frequency will not fall below the minimum frequency value unless the start enable (D11) is switched off.

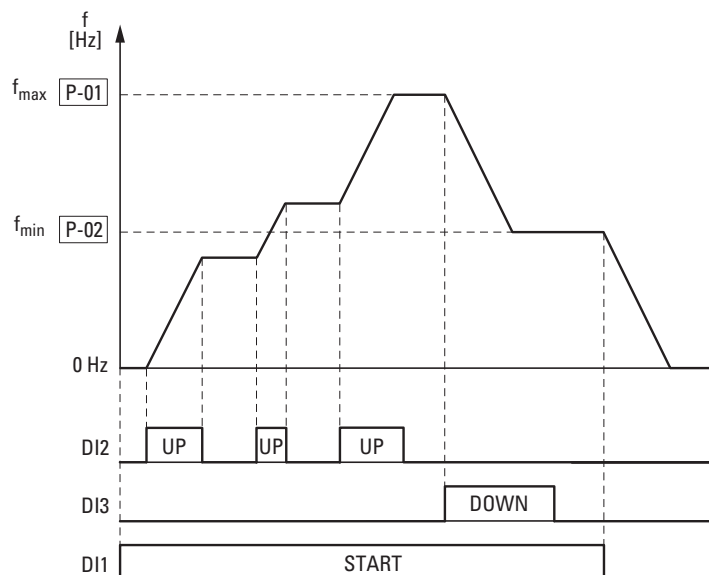


Figure 81: Motor potentiometer with f_{min} limit

PNU	ID	RUN	ro/rw	Value	Description	DS
P-31	159	✓	rw		Start function with automatic restart Operating unit This parameter will only be active if the keypad control operating mode is being used (P-12 = 1 or P-12 = 2).	1
				0	Minimum frequency/speed; keypad The keypad's start and stop pushbuttons are enabled, and control signal terminals 1 and 2 must be connected. The variable frequency drive will always start with the minimum frequency/speed (P-02).	
				1	Previous speed, keypad The keypad's start and stop pushbuttons are enabled; control signal terminals 1 and 2 must be connected. The variable frequency drive will always start with the most recent operating frequency/speed.	
				2	Minimum frequency/speed; terminal The variable frequency drive will be started directly from the control signal terminals; the keypad's start and stop buttons will be ignored. The variable frequency drive will always start with the minimum frequency/speed (P-02).	
				3	Previous speed, terminal The variable frequency drive will be started directly from the control signal terminals; the keypad's start and stop buttons will be ignored. The variable frequency drive will always start with the most recent operating frequency/speed (P-02).	

7 Applications

7.6 Motor current monitoring

7.6 Motor current monitoring

Desired options (example):

- Relay output K1 should output an alarm message if there is a 10% over-current.
- Analog output AO should show the rated motor current within a range of 0 to 10 V for more precise monitoring (5 V = motor rated current (P-08)).

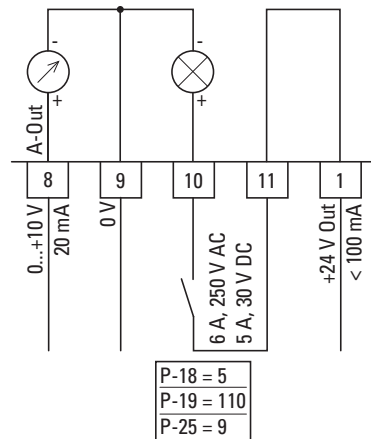


Figure 82: Example: overcurrent monitoring
Error message: $I.L - LrP$

If the motor ($I_e = 1.9$ A) from → Figure 9, page 22 is used as an example, relay K1 will switch as soon as the motor draws a current of 2.09 A. The analog output will output a voltage of 5.5 V.

The variable frequency drive will then switch off automatically due to an overload ($I_e > 100\%$).

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
P-18	146	✓	rw		K1 signal (Relay Output 1)	0
					Used to select the function assigned to the relay output. The relay has two output terminals: Logic 1 indicates that the relay is active. This is why terminals 10 and 11 are connected to each other. Output terminals; logic 1 indicates that the relay is active.	
				0	RUN, enable (FWD, REV)	
				1	READY, variable frequency drive ready for operation	
				2	Output frequency = frequency reference value	
				3	Error message (variable frequency drive not ready)	
				4	Output frequency \geq limit value (P-19)	
				5	Output current \geq limit value (P-19)	
				6	Output frequency < limit value (P-19)	
7	Output current < limit value (P-19)					

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
P-19	147	✓	rw	0 - 200 %	K1-Limit value (relay) The adjustable limit value that is being used in connection with settings 4 to 7 of P-18 and P-25	100.0
P-25	153	✓	rw		A01 signal (Analog Output) Switch to digital output	8
					DO1 (digital output 1) → +24 VDC (values 0 - 7)	
				0	RUN (variable frequency drive enabled and running – FWD, REV)	
				1	READY, variable frequency drive ready for operation / no faults	
				2	Output frequency = frequency reference value	
				3	Error message (variable frequency drive is not ready)	
				4	Output frequency \geq limit value (P-19)	
				5	Output current \geq limit value (P-19)	
				6	Output frequency < limit value (P-19)	
				7	Output current < limit value (P-19)	
					Analog output → 0 - 10 V DC (value 8, 9)	
				8	Output frequency f-Out → 0 - 100 % f_{max} (P-01)	
				9	Output current → 0 - 200 % I_e (P-08)	

7.7 Autostart function

Example: P-30: $RUt_{\alpha-2}$

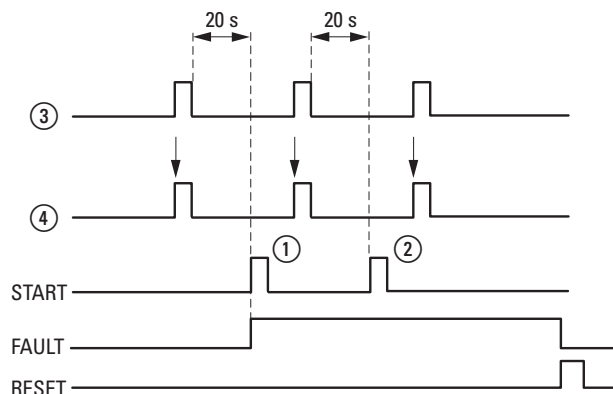


Figure 83:Automatic restart after error message (two start attempts)

- ① First automatic restart
 - ② Second automatic restart
 - ③ Switch-off when error detected
 - ④ Motor Stop Signal
- TEST = monitored test time
 FAULT = switch off when error message occurs
 RESET = reset error message (FAULT)

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
P-30	158	✓	rw		Start function with automatic restart, control signal terminals Used to define the variable frequency drive's behavior concerning the enable digital input and to configure the automatic restart function.	$Ed9E-r$
				$Ed9E-r$	Disabled	
					The variable frequency drive will not start after being switched on, or after a reset, if digital input 1 remains closed (the variable frequency drive will need a new start edge). The input must be closed after switching on, as well as after a reset, in order to start the variable frequency drive.	
				$RUt_{\alpha-0}$	The variable frequency drive will start automatically. (The variable frequency drive does not need a start edge; the signal will continue to be applied.)	
					The variable frequency drive will start automatically after being switched on, as well as after a reset, if digital input 1 is closed.	
				$RUt_{\alpha-1}$	The variable frequency drive will start automatically once.	
					After a trip, the variable frequency drive will make up to five attempts to restart, with these attempts being made at 20-second intervals. The variable frequency drive must be de-energized in order to reset the counter. The number of restart attempts is counted. If the variable frequency drive does not start after the last attempt, it will switch to an error condition and request the user to reset the error manually.	
				$RUt_{\alpha-2}$	The variable frequency drive will start automatically twice.	
				$RUt_{\alpha-3}$	The variable frequency drive will start automatically three times.	
				$RUt_{\alpha-4}$	The variable frequency drive will start automatically four times.	
$RUt_{\alpha-5}$	The variable frequency drive will start automatically five times.					

7.8 Setpoint input via keypad

REF: Setpoint input (Reference) via keypad



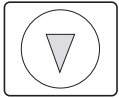
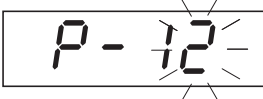
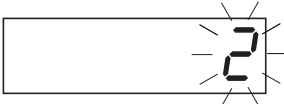
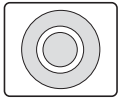
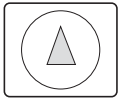
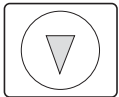


The frequency reference value settings configured via the keypad have the same effect as the function of an electronic motor potentiometer. The value set with the ▲ and ▼ buttons will be retained even after the supply voltage is switched off.



For control via the keypad, control signal terminal 1 must be connected to control signal terminal 2 in order to get an enable.



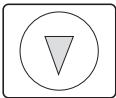


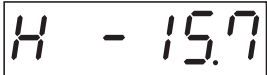
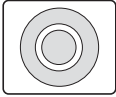
The following table shows a good example of specifying the frequency reference value via the operating unit.

Note: Your unit may behave differently from the description below depending on the setting configured for P-15.

Sequence	Commands	View	Description
1	  	 	<p>Set parameter P-12 to 1 or 2 in order to hand over control to the keypad.</p> <p>1: Operating unit (keypad FWD): one operating direction 2: Operating unit (keypad FWD/REV): both operating directions</p>
2	  	 	<p>Connect control signal terminal 1 to control signal terminal 2 in order to get a start enable.</p> <p>Press the STOP pushbutton in order to get to the setpoint input display automatically.</p> <p>Use the ▲ and ▼ arrow keys to change the setpoint value.</p>

7 Applications

7.8 Setpoint input via keypad

Sequence	Commands	View	Description
3	  		<p>Press the Start button to start the variable frequency drive. It will then run with the acceleration time set in P-03 all the way to the setpoint value on the keypad.</p> <p>You can use the ▲ and ▼ arrow keys to change the setpoint value in RUN mode.</p>
4	 FWD REV	 	<p>Pressing the Start pushbutton again will change the operating direction (P-12 = 2).</p> <p>Note: When the REV operating direction is in effect, the frequency will have a minus sign.</p> <p>Minus sign for REV operating direction</p>
5			<p>When the Stop pushbutton is pressed, the variable frequency drive will be stopped with the deceleration time configured in P-04.</p>

8 Modbus RTU

8.1 General

Modbus is a centrally polled bus system in which a so-called master (PLC) controls the entire data transfer on the bus. Internode communication between the individual modules (slaves) is not possible.

Every single data transfer operation is initiated by the master with a request. Only one request can be sent on the cable at a time. Slaves are not able to initiate transfers, and are only able to respond to requests.

Two types of dialog are possible between master and slave:

- The master sends a request to a slave and waits for a response.
- The master sends a request to all slaves and does not wait for a response (broadcast).



For more information on Modbus, please visit: www.modbus.org

8.1.1 Communications

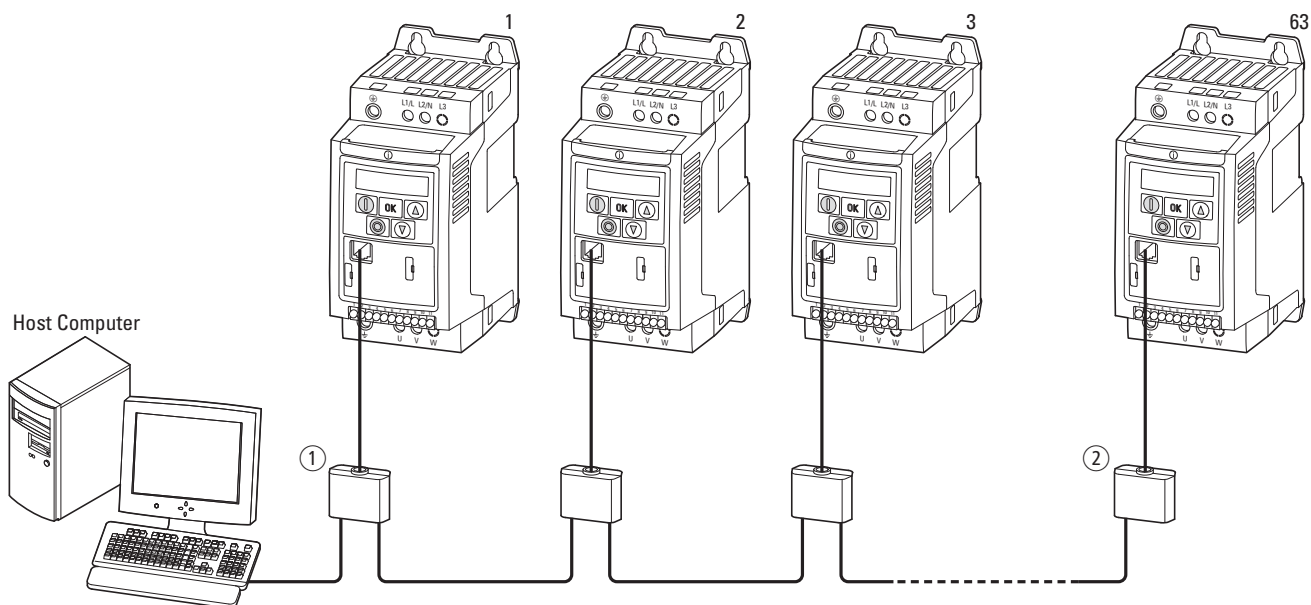


Figure 84: Modbus network with DC1

The figure shows a typical setup with a host computer (master) and any number (a maximum of 63 modules) of DC1 variable frequency drives (slaves). Each variable frequency drive has a unique address on the network. Addresses are assigned individually to each DC1 variable frequency drive with the P-36 parameter and are independent of their physical connection (position) within the network.

8 Modbus RTU

8.1 General

8.1.2 COM Port

The electrical connection between the master and the slaves is established with RJ45 cables. If you use multiple slaves, they will need to be connected in parallel by using RJ45 cables and splitters.

The DC1 variable frequency drive built-in RJ45 port supports the Modbus RTU protocol and therefore allows a direct network connection without an additional interface module. The network cable must be provided at each physical end (last station) with a bus termination resistor of 120 Ω in order to prevent signal reflections and the resulting transfer errors.

EASY-NT-R resistors can be plugged into the splitter version.

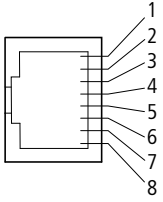
	Pin	Meaning
	1	CANopen -
	2	CANopen +
	3	0 V
	4	OP bus (operation bus) / External keypad / PC connection -
	5	OP bus (operation bus) / External keypad / PC connection +
	6	24 V DC power supply
	7	RS485- Modbus RTU (A)
	8	RS485+ Modbus RTU (B)

Figure 85: RJ-45 socket wiring

8.1.3 Enable

In order to use bus mode, there must also be a "high" signal at DI1.

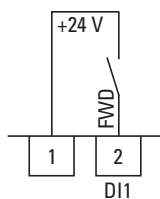


Figure 86: Enable signal for bus mode

8.1.4 Modbus data format

The data format is fixed for DC1 variable frequency drives and cannot be changed.

- 1 start bit
- 8 data bits
- 1 stop bit
- No parity

8.2 Modbus parameters

Table 14 below shows the Modbus parameters in DC1 variable frequency drives.

RUN Indicates the access right during operation (FWD or REV)

- = No parameter change possible,

✓ = Parameter change possible.

ro/rw Indicates the access right via the field bus

ro = Read only possible,

rw = Read and write possible.



P-36 – Timeout

Parameter P-36 indicates the time after which there will be a response to a loss of communications.

If P-36 = 0, the function will be disabled.

"t" at the beginning means: error message and coasting

"r" at the beginning means: stop with second braking ramp time

8 Modbus RTU

8.2 Modbus parameters

Table 14: Modbus parameters

PNU	ID	Access right		Designation	Value range	DS
		RUN	ro/rw			
P-36	164	–	rw	Variable frequency drive slave address	0 - 63	1
			rw	Baud rate	2 = 9.6 kBit/s 3 = 19.2 kBit/s 4 = 38.4 kBit/s 5 = 57.6 kBit/s 6 = 115.2 kBit/s	2
			rw	TimedOut	0 - 3000 ms	3000 ms
P-12	140	–	rw		Control level	0
			0	Control signal terminals (I/O) The variable frequency drive will respond directly to signals applied to the control signal terminals.		
			1	Keypad (KEYPAD FWD) The variable frequency drive can only be controlled in the forward direction if an external or remote control keypad is used.		
			2	Keypad (KEYPAD FWD/REV) The variable frequency drive can be controlled in both the forward and reverse directions if an external or remote control keypad is used. The keypad can be used to switch between a clockwise rotating field (FWD) and a anticlockwise rotating field (REV) by pressing the START push-button.		
			3	Modbus Control via Modbus RTU (RS485) with the internal acceleration/deceleration ramps.		
			4	Modbus Control via Modbus RTU (RS-485) port; the acceleration/deceleration ramps will be updated via Modbus.		
			5	PI controller with external actual value		
			6	PI controller with external actual value and totalized value of AI1		
			7	CANopen Control via CANopen using the internal acceleration/deceleration ramps		
			8	CANopen Control via CANopen, with the acceleration/deceleration ramps being updated via CANopen		
			9	Control commands and setpoint values via SmartWire-DT (DI1 = Hardware enable, P-15: no function)		
			10	Control commands via SmartWire-DT, setpoint value set locally (P-15 for local settings)		
			11	Control commands issued locally, setpoint value via SmartWire-DT (DI1 = Start/Stop)		
			12	SmartWire-DT control – control will depend on the configuration in the event of a loss of communications; automatic switch to local control		
13	Control commands and setpoint values via SmartWire-DT In addition, an enable signal via DI1 and an enable setpoint via DI2					

8.3 Operating mode Modbus RTU

The Modbus RTU (Remote Terminal Unit) operating mode transmits data in binary format (higher data throughput) and defines the transfer format for data requests and data responses.

Each message byte that is sent will contain two hexadecimal characters (0 - 9, A - F).

The data transfer between a master (PLC) and the DC1 variable frequency drive is carried out according to the following sequence:

- Master request: the master sends a Modbus frame to the variable frequency drive.
- Slave response: the variable frequency drive sends a Modbus frame as a response to the master.

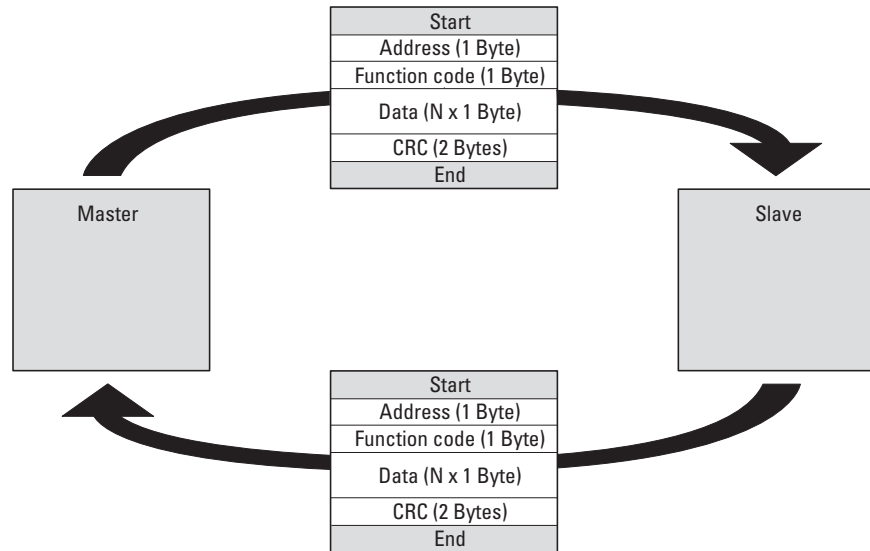


Figure 87: Data exchange between master and slave



The variable frequency drive (slave) only sends a response if it has received a request from the master beforehand.

8 Modbus RTU

8.3 Operating mode Modbus RTU

8.3.1 Structure of the master request

8.3.1.1 Address

- P-36 is used to enter the address (1 to 63) of the variable frequency drive to which the request is being sent. Only the variable frequency drive with this address can respond to the request.
- Address 0 is used as a so-called Broadcast (message to all bus users) from the master. In this mode, individual modules cannot be addressed and data cannot be output from the slaves.

8.3.1.2 Function code

The function code defines the type of message. The following actions can be performed in the case of DC1 variable frequency drives:

Function code [hex]	Designation	Description
03	Read Holding Registers	Reading of the holding registers in the slave (process data, parameters, configuration). A master request enables up to 11 registers to be read.
06	Write Single Register	Writing of a holding register in the slave. With a general telegram (Broadcast) the appropriate holding registers are written in all slaves. The register is read back for comparison.

8.3.1.3 Data

The length of the data block (data: N x 1 bytes) depends on the function code. The function code is made up of two hexadecimal values and has a range of 00 to FF. The data block contains additional information for the slave that will enable the latter to perform the operation specified by the master in the function code (this information may specify the parameters that need to be processed, for example).

8.3.1.4 Cyclic redundancy check (CRC)

Frames in the Modbus RTU operating mode include a cyclic redundancy check (CRC). The CRC field is made up of two bytes that contain a binary 16-bit value. The CRC check is always run independently of the parity check for the individual characters of the telegram. The CRC result is appended to the frame by the master. While receiving the frame, the slave performs a new calculation and compares the calculated value to the actual value in the CRC field. If both values are not identical, an error is set.

8.3.2 Structure of the slave response

8.3.2.1 Required transfer time

- The time between receiving a request from the master and the response of the variable frequency drive is at least 3.5 characters (rest time).
- Once the master has received a response from the variable frequency drive, it must wait for at least the rest time before it can send a new request.

8.3.2.2 Normal slave response

- If the master request contains a write register function (function code 06), the variable frequency drive immediately returns the request as a response.
- If the master request contains a read register function (function code 03), the variable frequency drive returns the read data with the slave address and the function code as a response.

8.3.2.3 No slave response

In the following cases, the variable frequency drive ignores the request and does not send a reply:

- on receiving a broadcast request.
- if the request contains a transmission error.
- If the slave address in the request does not match the variable frequency drive's address.
- with a CRC or parity error.
- If the time interval between the messages is less than 3.5 characters.



The master must be programmed to repeat the request if it does not receive a response within a specified time.

8 Modbus RTU

8.3 Operating mode Modbus RTU

8.3.3 Modbus: Register mapping

Register mapping makes it possible to process, in DC1 variable frequency drives, the contents in the following table via Modbus RTU.

Group	ID range	Assignment of the ID numbers
Mode parameter	129 - 175	List of parameters → Table 37, page 221
Input process data	1 - 4	→ Section 8.3.3.1, „Input process data“, page142
Output process data	6 - 24	→ Section 8.3.3.2, „Output process data“, page144



The interface driver in certain controllers (e.g. PLCs) may have an offset of +1 for Modbus RTU communications



The decimal point is not taken into account when processing values!

For example, if the motor current (ID 8) shown on the DC1 variable frequency drive's display is 0.3 A, it will be transmitted as 003_{dez} via Modbus.

8.3.3.1 Input process data

The input process data is used to control the DC1 variable frequency drive.

ID	Designation	Scaling Factor	Unit
1	Field bus command	–	Binary code
2	Field bus speed reference value	0.1	Hz
3	Reserved	–	–
4	Modbus ramp time	0.01	S

Command (ID 1)

These bits are used to control the DC1 variable frequency drive. You can modify the content as required for your own specific application and then send it as a command to the variable frequency drive.

Bit	Description	
	Value = 0	Value = 1
0	Stop	Operation
1	Clockwise rotating field (FWD)	Anticlockwise rotating field (REV)
2	No action	Reset error
3	No action	Free coasting
4	Not used	
5	No action	Quick stop (ramp)
6	No action	Fixed frequency (FF1)
7	No action	Overwrite setpoint value with 0
8	Not used	
9	Not used	
10	Not used	
11	Not used	
12	Not used	
13	Not used	
14	Not used	
15	Not used	

Field bus speed reference value (ID 2)

The permissible values fall within a range of P-02 (min. frequency) to P-01 (max. frequency).

This value is scaled with a factor of 0.1 in the application.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MSB															LSB

8 Modbus RTU

8.3 Operating mode Modbus RTU

8.3.3.2 Output process data

The output process data is used to monitor the variable frequency drive.

ID	Designation	Scaling Factor	Unit/Format
6	Status and fault word	–	Binary code
7	Field bus actual speed	0.1	Hz
8	Motor current	0.1	A
9	Reserved	–	–
10	Reserved	–	–
11	DI status	–	Binary code
12	Type	–	WORD
13	Power	1	kW/HP
14	Voltage level	1	V
15	Control section software version	–	WORD
16	Power section software version	–	WORD
17	variable frequency drive recognition	–	WORD
18	Reserved	–	–
19	Reserved	–	–
20	Value AI1	0.1	%
21	Value AI2	0.1	%
22	Reference input speed	1	RPM
23	DC link voltage	1	V
24	Variable frequency drive temperature	1	°C
25	Variable frequency drive operating time	1	h
26	Variable frequency drive operating time	1	min/s
27	The variable frequency drive operating time since the last fault	1	h
28	The variable frequency drive operating time since the last fault	1	min/s

Status and fault word (ID 6)

Information regarding the device status and error messages is specified in the status and fault word.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MSB															LSB
Fault word								Statusword							

Statusword

Bit	Description	
	Value = 0	Value = 1
0	Drive not ready	Ready for operation (READY)
1	Stop	Running operation message (RUN)
2	Clockwise rotating field (FWD)	Anticlockwise rotating field (REV)
3	No error	Fault detected (FAULT)
4	Acceleration ramp	Frequency actual value equals setpoint value definition
5	–	Zero speed
6	Speed control deactivated	Speed control activated
7	Not used	Not used

Fault word

➔ → Chapter 10 "Error Messages"

Actual speed (ID 7)

The variable frequency drive's actual speed will fall within a range of P-02 (min. frequency) to P-01 (max. frequency). This value will be scaled by a factor of 0.1 in the application.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MSB															LSB

Current (ID 8)

The current is specified with one decimal place.

Example: 34 \triangleq 3.4 A.

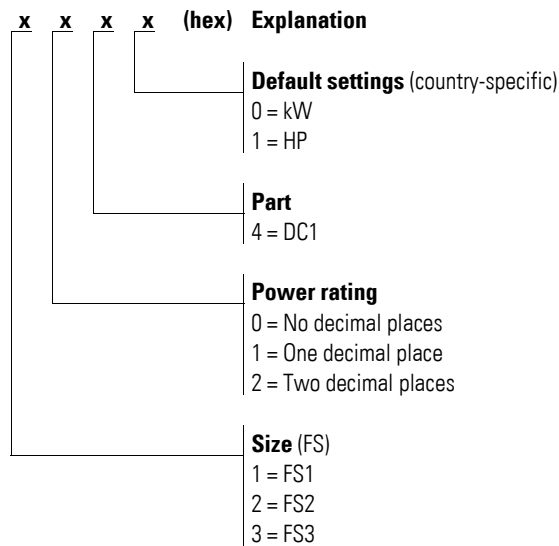
Status DIs (ID 11)

This value indicates the digital inputs' state. The lowest bit indicates the state of DI 1.

8 Modbus RTU

8.3 Operating mode Modbus RTU

Type (ID 12)



Rated powers (ID 13)

Together with the second value from register 12, the value in this register gives the device's output.

Examples:

Register 12 = x1x0h

Register 13 = 15 → The device has an output of 1.5 kW

Voltage (ID 14)

Specifies the device's specified input voltage.

Example: 230 \triangleq 230 V

Control part software version (ID 15)

Specifies the software version of the control section with two decimal places.

Power section software version (ID 16)

Specifies the software version of the power section with two decimal places.

Variable frequency drive recognition (ID 17)

The device's unique serial number.

8.3.4 Explanation of function code

8.3.4.1 Function code 03_{hex}: Reading of holding registers

This function reads the content of a number of consecutive holding registers (specified register addresses).

Example

Reading the status and fault word (ID 6) of the DC1 variable frequency drive with slave address 1.

Master request: 01 03 0005 0001 940B_{hex}

Register [hex]	Name
01	Slave address
03	Function code (reading of holding registers)
0005	5 _{dez} : The ID is 6, since the master controller has an offset of +1.
0001	Total number of requested registers
940B	CRC

Slave response: 01 03 02 0000 B844_{hex}

Register [hex]	Name
01	Slave address
03	Function code (reading of holding registers)
02	Number of consecutive data bytes (1 register = 2 byte)
0000	Content (2 byte) for register 6: 0
B844	CRC

8 Modbus RTU

8.3 Operating mode Modbus RTU

8.3.4.2 Function code 06_{hex}: Writing a holding register

This function writes data to a holding register.

Example

Writing of the command (ID 1) of a DC1 variable frequency drive with the slave address 1.

Master request: 01 06 0000 0001 480A_{hex}

Register [hex]	Name
01	Slave address
06	Function code (writing a holding register)
0000	0: The ID of the register for the writing operation is 1, since the master controller has an offset of +1.
0001	Content (2 byte) for register 0000 0000 0000 001 _{bin} → RUN
480A	CRC

Slave response: 01 06 0000 0001 480A_{hex}

The slave response is a copy of the master request if it is a normal response.

Register [hex]	Name
01	Slave address
06	Function code (here. Writing of a holding register)
0000	1: The ID of the register for the writing operation is 1, since the master controller has an offset of +1.
0001	Content (2 byte) for register 0000 0000 0000 001 _{bin} → RUN
B844	CRC



Function code 06_{hex} can be used for a broadcast.

9 CANopen

This chapter is intended for automation experts and engineers. Readers are expected to be thoroughly familiar with the CANopen field bus and with how to program a CANopen master controller. In addition, readers must be familiar with how to use the DC1 variable frequency drive.



Further information about CANopen can be found in Internet on: www.can-cia.org

References

[1] CANopen – Application Layer and Communication Profile
CiA Draft Standard DS301, Version 4.02, February, 13, 2002

9.1 Data Types

CANopen has specifications for its own data types. The following types are used for the DC1 variable frequency drive's CANopen protocol handler.

Table 15: CANopen data types

Name	Description	Range	
		Minimum	Max Length
UNSIGNED8	8-bit unsigned integer (b7 to b0)	0	255
UNSIGNED16	16-bit unsigned integer (b15 to b0)	0	65535
UNSIGNED32	32-bit unsigned integer (b31 to b0)	0	4294967295
INTEGER8	8-bit signed integer (b7 to b0)	-128	127
INTEGER16	16-bit signed integer (b15 to b0)	-32768	32767
INTEGER32	32-bit signed integer (b31 to b0)	-2147483648	2147483647
RECORD	Data structure with fixed number of any types	–	–

The following abbreviations are used throughout this chapter:

CAN	Controller Area Network
COB ID	Communication Object Identifier
CONST	Constant variable (read access only)
EDS	Electronic Data Sheets
EMCY	Emergency Object
NMT	Network Management
PDO	Process Data Object
ROM	Read Only Memory
Rx	Receive
SDO	Service Data Object
Tx	Transmit

9.2 System overview

The DC1 variable frequency drive's CANopen slaves are integrated into a CANopen fieldbus system.

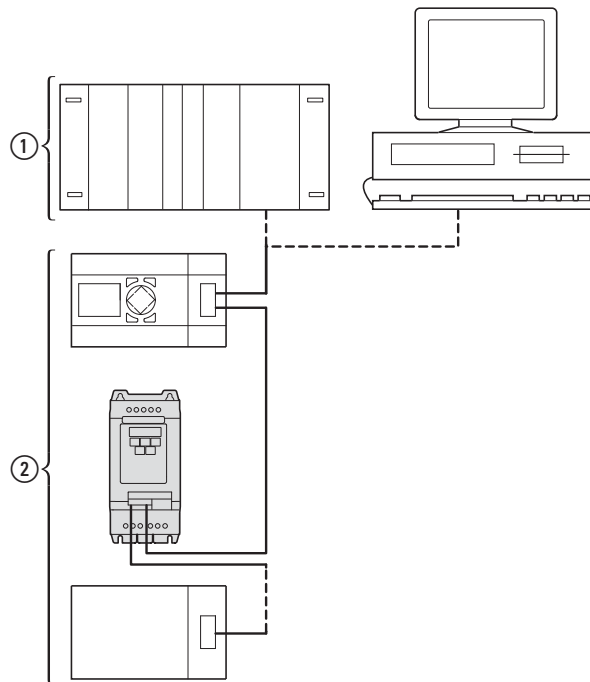


Figure 88: Integration into a CANopen network

- ① Master section, PLC (e. g.: XC100, XC200) or PC with CANopen card
- ② Slave area: Variable frequency drives with CANopen interface

The RJ45 plug makes it possible to connect DC1 variable frequency drives to a CANopen communications network. The CiA DS-301 CANopen communication profile documents the "How" of communications.

The CANopen communications protocol draws a distinction between process data objects (PDOs) and service data objects (SDOs).

The variable frequency drive is controlled with fast, cyclic process data (PDOs). The process data channel can be used not only to specify the speed setpoint, but also to trigger various drive functions, such as enables, operating directions, and resets. At the same time, it can also be used to read actual values, such as the actual speed, current, and device status, from the variable frequency drive. As a general rule, the variable frequency drive's parameters are configured using SDOs. The parameter data channel makes it possible to store all application-related drive parameters in the higher-level controller and transfer them to the variable frequency drive if necessary. All of the variable frequency drive's parameters can be transferred with CANopen by using the appropriate SDOs/PDOs.

Table 16: Technical Data

Size	Value
Communication profile	DS-301 V4.02
Bus addresses	1 - 63
Baud rate	125 kBit/s - 1 MBit/s
Total distance (depending on the baud rate / the repeater)	<ul style="list-style-type: none"> • up to 500 m at 125 kBit/s • up to 300 m at 1 MBit/s
Transmission medium	Screened twisted-pair cable
Bus termination resistor	120 Ω, suitable for separate mounting
Number of SDOs	1 server, 0 clients
Number of PDOs	2 Rx-PDO 2 Tx-PDO Note: Only the first one of each is enabled in the default settings.
PDO mapping	Variable
Terminal type	Plug-in RJ-45 connector

9.2.1 COM Port

The electrical connection between the master and the slaves is established with RJ45 cables. If you use multiple slaves, they will need to be connected in parallel by using RJ45 cables and DX-SPL-RJ45-2SL1PL splitters. Please note that the stub lines should be as short as possible.

The DC1 variable frequency drive's built-in RJ45 port supports the CANopen protocol, making it possible to establish a direct network connection without the need for an additional interface module. A bus termination resistor with a resistance of 120 Ω needs to be connected at each physical end (last module) of the network cable in order to prevent signal reflections and the associated transfer errors.

Pin	Meaning
1	CANopen -
2	CANopen +
3	0 V
4	RJ-45 connection / external operating unit / PC connection -
5	RJ-45 connection / external operating unit / PC connection +
6	24 V DC power supply
7	RS485- Modbus RTU (A)
8	RS485+ Modbus RTU (B)

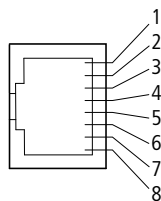


Figure 89: Configuration of the RJ45 interface



If you are using an easy network, keep in mind that CAN- and CAN+ need to be swapped.

9.2.2 Enable

In order to use the bus mode, there must also be a "high" signal at DI1.

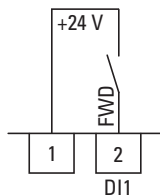


Figure 90: Enable signal for bus mode

9.2.3 Bus termination resistor

The first and last modules on a CANopen network must be terminated with a 120 Ω bus termination resistor. This resistor needs to be connected between CAN_H and CAN_L. To do this, you can plug the EASY-NT-R bus termination resistor into the last splitter (②).

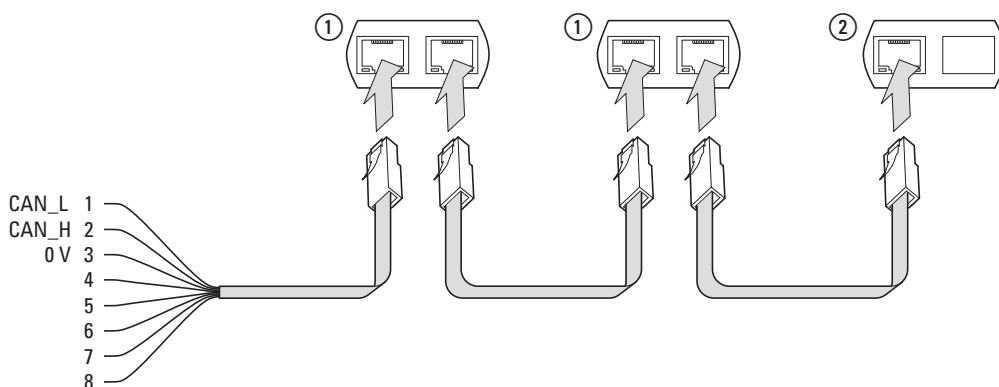


Figure 91: Sample network configuration

9.2.4 Baud rate

The baud rate is set using parameter P-50 (→ Page 226). It must be set to the same value for all the communication modules on the CANopen bus. The baud rate for DC1 variable frequency drives can be set to a value between 125 and 1,000 kBit/s.

The maximum cable length will depend on the baud rate you use.

Table 17: Maximum cable length and baud rate

Baud Rate	Maximum cable length
125 kbit/s	500 m
250 kBit/s	M 250
500 kBit/s	100 m
800 kBit/s	50 m
1000 kBit/s	30 m

9.2.5 Set CANopen user address

Every CANopen module needs a unique address (node ID) within the CANopen structure. All node IDs must be unique within the entire bus structure. A maximum of 127 addresses (1 to 127) can be assigned within a CANopen structure.

Parameter P-36 is used to set the CANopen address in DC1 variable frequency drives (value between 1 and 63).

9.2.6 Parameters that need to be configured

PNU	ID	Access right		Value	Description	DS	Value that must be configured
		RUN	ro/rw				
P-12	140	–	rw		Control level	0	7.8
				0	Control signal terminals		
				1	Keypad (FWD)		
				2	Keypad (FWD/REV)		
				3	Modbus (internal ramp times)		
				4	Modbus (internal ramp times)		
				5	PI controller with external actual value		
				6	PI controller with external actual value and totalized value of AI1		
				7	CANopen (internal ramp times)		
				8	CANopen (CANopen ramp times)		
				9	SmartWire-DT (SWD control command and setpoint value)		
				10	SmartWire-DT (SWD control command; internal setpoint value)		
				11	SmartWire-DT (SWD setpoint value; internal control command)		
				12	SmartWire-DT (control will depend on the configuration in the event of a loss of communications; automatic switch to local control)		
P-36	164	–	rw		Serial communication configuration		
				1 - 63	Variable frequency drive slave address	1	
					Modbus RTU baud rate	6	
				2	9.6 kBit/s		
				3	19.2 Kbit/s		
				4	38.4 kBit/s		
				5	57.6 kBit/s		
				6	115.2 kBit/s		

9 CANopen

9.2 System overview

PNU	ID	Access right		Value	Description	DS	Value that must be configured
		RUN	ro/rw				
P-36	164	-	rw		TimedOut	3000	
				0	0		
				1	t 30 ms		
				2	t 100 ms		
				3	t 1000 ms		
				4	t 3000 ms		
				5	r 30 ms		
				6	r 100 ms		
				7	r 1000 ms		
P-50	178	-	rw	Baud Rate	0 = 125 kBit/s 1 = 250 kBit/s 2 = 500 kBit/s 3 = 1000 kBit/s	2	0 - 3

Difference between P-12 = 7 and P-12 = 8

- P-12 = 7
If parameter P-12 is set to a value of 7, both the setpoint value and the command will be provided via CAN; meanwhile, the ramp times will have to be set using parameters P-03 and P-04.
- P-12 = 8
If parameter P-12 is set to a value of 8, the DC1 variable frequency drive will behave the same way as with P-12 = 7, except when it comes to the ramp times. Ramp times will now be cyclically transmitted instead. When the device is running with its default configuration, the ramp time will be the third word in the first receive PDO. The corresponding value will be scaled by a factor of 0.01.
Example: 500 \triangleq 5.00 s

9.2.7 Transmission Type

There are four different transmission options available for selection in DC1 variable frequency drives.

Table 18: CANopen transmission options

Transmission type	Mode	Explanation
0	Acyclical – synchronous	Transmissions will only be sent if a SYNC comes and process data has changed.
1 - 240	Cyclical – synchronous	Transmissions will be sent and received after every nth SYNC.
254	Asynchronous – manufacturer-specific	The value in the default settings. Transmissions will only be sent if a value has been received and something has changed. Received data will be processed directly.
255	Asynchronous – device profile-specific	Transmissions will be sent directly if there is a change. Received data will be processed directly.



When the device is running with its default configuration, the value will be set to 254, "Asynchronous – manufacturer-specific."

9.3 Object list

9.3.1 EDS file

DC1 variable frequency drives can be integrated into a CANopen structure by using a standardized EDS file (Eatn1000100.eds). This EDS (EDS = Electronic Data Sheet) file describes the functionality of a CANopen device in machine-readable format. EDS files list all objects, the supported baud rates, the manufacturer, and other information as well.

The latest version of the EDS file will be included in the CD-ROM enclosed with every DC1 variable frequency drive.

It can also be downloaded from Eaton's website at:

<http://www.eaton.com/moeller> → **Support**

The object dictionary contains all the objects corresponding to a CANopen module. Objects are used to map a device's functionality/parameters. They are accessed with SDOs or PDOs. As per the corresponding specification, the object dictionary is subdivided into the following ranges:

Table 19: Object dictionary ranges

Range	Description
0000 _{hex} - 1FFF _{hex}	Communication-specific objects
2000 _{hex} - 5FFF _{hex}	Manufacturer-specific objects (the variable frequency drive's parameters)

The object dictionary for the DC1 variable frequency drive contains the entries described below.

9.3.2 Communication-specific objects

A detailed description of the communication parameters is provided in the CiA specification [1] Section 9.6.3.

Objects 1000hex, 1001hex, and 1018hex are required for all CANopen devices; all other objects are optional. The DC1 variable frequency drive supports the objects listed in the following tables.

Index [hex]	Subindex [hex]	Objectname	Data type	Access right	DS [hex]	Meaning
1000	00	Device Type	UNSIGNED32	ro	0	Variable frequency drive – CANopen device
1001	00	Error Register	UNSIGNED8	ro	–	Error indication: 00 _{hex} = No error
1002	00	Manufacturer Status Register	UNSIGNED16	ro	00	
1005	00	COB-ID SYNC Message	UNSIGNED32	rw	80	COB-ID of the SYNC object, device consumes the SYNC message
1008	00	Manufacturer Device Name	STRING	ro	DC1	The variable frequency drive's device name: DC1
1009	00	Manufacturer Hardware Version	STRING	ro	1.11 (Example)	Hardware version of the module
A 100	00	Manufacturer Software Version	STRING	ro	1.00 (Example)	Software version of the module
C 100	00	Guard Time	UNSIGNED16	rw	0000 _{hex} Resolution in 1 ms	Monitoring time in milliseconds
100D	00	Life Time Factor	UNSIGNED8	rw	00 _{hex}	Multiplier for the Guard Time, the result is equivalent to the maximum interval between the transfer of two Guarding message frames
1014	00	COB-ID EMCY Message	UNSIGNED32	rw	00000080 + Node ID	CAN identifier of the emergency message
1018	00	Identity Object	UNSIGNED8	ro	04	General device information
	01	Vendor ID	UNSIGNED32	ro	000001CA	Manufacturer: Eaton Industries GmbH
	02	Product Code	UNSIGNED32	ro	0	Product Number
	03	Revision Number	UNSIGNED32	ro	1.01 (Example)	version
	04	Serial Number	UNSIGNED32	ro	00000001 (Example)	Serial number

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9.3 Object list

9.3.3 Server SDO Parameter

Index [hex]	Subindex	Objectname	Data type	Access right	DS [hex]	Meaning
1200	00	Number of Entries	UNSIGNED8	ro	02	Number of inputs
	01	COB-ID Client → Server (rx)	UNSIGNED32	ro	00000600 + Node ID	COB-ID of the RxSDO. The ID is derived from the Predefined Connection Set.
	02	COB-ID Server → Client (tx)	UNSIGNED32	ro	00000580 + Node ID	COB-ID of the TxSDO. The ID is derived from the Predefined Connection Set.

DC1 variable frequency drives support two receive PDOs (receive PDO communication parameters 1400_{hex} and 1401_{hex}). Objects 1600_{hex} and 1601_{hex} contain the mapping parameters for the Rx PDOs.

Index [hex]	Subindex [hex]	Objectname	Data type	Access right	DS [hex]	Meaning
1400 1401		1st Receive PDO Parameter 2nd Receive PDO Parameter	RECORD	ro	03	Number of valid subindexes
	00	Number of Entries	UNSIGNED8	ro	02	Maximum number of entries
	01	PDO COB-ID	UNSIGNED32	rw	400000200 400000300 + Node ID	COB-ID of 1st Rx PDO COB-ID of 2nd Rx PDO
	02	Transmission Type	UNSIGNED8	rw	FE	PDO transmission type: asynchronous
1600	00	Number of Mapped Application Objects	UNSIGNED8	rw	03	Highest subindex used
	01	1st Mapping Object	UNSIGNED32	rw	20000010	
	02	2nd Mapping Object	UNSIGNED32	rw	20010010	
	03	3rd Mapping Object	UNSIGNED32	rw	20030010	
1601	00	Number of Mapped Application Objects	UNSIGNED8	rw	0	Highest subindex used

DC1 variable frequency drives support two transmit PDOs (transmit PDO communication parameters 1800_{hex} and 1801_{hex}). Objects 1A00_{hex} and 1A01_{hex} contain the mapping parameters for the Tx PDOs.

Index [hex]	Subindex [hex]	Objectname	Data type	Access right	DS [hex]	Meaning
1800 1801		1st Transmit PDO Parameter 2nd Transmit PDO Parameter	RECORD	ro	04	Number of valid subindexes
	00	Number of Entries	UNSIGNED8	ro	03	Maximum number of entries
	01	PDO COB-ID	UNSIGNED32	rw	40000180 40000280 + Node ID	COB-ID of 1st Tx PDO COB-ID of 2nd Tx PDO
	02	Transmission Type	UNSIGNED8	rw	FE	PDO transmission type: asynchronous
	03	Inhibit time (100 µs)	UNSIGNED16	ro	0	
1A00		1st Transmit PDO Mapping	RECORD			applies for Tx PDO 1
	00	Number of Mapped Application Objects	UNSIGNED8	rw	4	Highest subindex used
	01	1st Mapping Object	UNSIGNED32	rw	200A0010	
	02	2nd Mapping Object	UNSIGNED32	rw	200B0010	
	03	3rd Mapping Object	UNSIGNED32	rw	200D0010	
	04	4th Mapping Object	UNSIGNED32	rw	20100010	
1A01		2nd Transmit PDO Mapping	RECORD			applies for Tx PDO 2
	00	Number of Mapped Application Objects	UNSIGNED8	rw	4	Highest subindex used
	01	1st Mapping Object	UNSIGNED32	rw	20110010	
	02	2nd Mapping Object	UNSIGNED32	rw	20120010	
	03	3rd Mapping Object	UNSIGNED32	rw	20130010	
	04	4th Mapping Object	UNSIGNED32	rw	20140010	

9.3.4 Manufacturer-specific objects

In addition to communication-specific objects, manufacturer-specific objects are also defined in the object dictionary. These objects fall within the range between index 2000_{hex} and index 2096_{hex} in the DC1 variable frequency drive's object dictionary.

Table 20: Manufacturer-specific objects

Index [hex]	Property Name	Data type	Access right	Description
2000	Control command register	UNSIGNED16	rw	Command
2001	Speed reference	Integer16	rw	Frequency reference value
2003	User ramp reference	UNSIGNED16	rw	User ramp time
200A	Drive status register	UNSIGNED16	ro	Statusword
200B	Motor speed Hz	UNSIGNED16	ro	Actual value in Hertz (Hz)
200D	Motor current	UNSIGNED16	ro	Motor current
2010	Drive temperature	Integer 16	ro	variable frequency drive temperature
2011	DC bus value	UNSIGNED16	ro	DC link voltage
2012	Digital input status	UNSIGNED16	ro	State of digital inputs
2013	Analog input 1 (%)	UNSIGNED16	ro	Analog input 1 in %
2014	Analog input 2 (%)	UNSIGNED16	ro	Analog input 2 in %
2015	Analog input 1	UNSIGNED16	ro	Analog input 1
2017	Relay output 1	UNSIGNED16	ro	Relay output 1
203E	Total run hours	UNSIGNED16	ro	Operating time in hours
203F	Total run minute/second	UNSIGNED16	ro	Operating time in minutes/seconds
2040	Current run hours	UNSIGNED16	ro	Current operating time in hours
2041	Current run minute/second	UNSIGNED16	ro	Current operating time in minutes/seconds
2065	P-01		rw	DC1 variable frequency drive parameters
2066	P-02		rw	
...	
2095	P-49		rw	
2096	P-50		rw	

Control word (Index 2000_{hex})

The "control word" object is used to control the variable frequency drive. It contains manufacturer-specific commands.

Name	Description	
	Value = 0	Value = 1
0	stop	Operation
1	Clockwise rotating field (FWD)	Anticlockwise rotating field (REV)
2	No action	Fault Reset
3	No action	free run-down
4	Not used	
5	No action	Quick stop (ramp 2)
6	No action	Fixed frequency 1 (FF1)
7	No action	Overwrite setpoint value with 0
8	No action	Control via field bus
9	Not used	
10	Not used	
11	Not used	
12	Not used	
13	Not used	
14	Not used	
15	Not used	

Frequency reference value (Index 2001_{hex})

The frequency reference value is specified in hertz with a single decimal place.

Example:

258_{dec} $\hat{=}$ 25.8 Hz

User ramp time (Index 2003_{hex})

The user ramp time is specified in seconds with two decimal places.


Status word (Index 200A_{hex})

Information regarding the variable frequency drive's device status and error messages is specified in the status word.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MSB															LSB
Error Messages								Statusword							

Name	Description	
	Value = 0	Value = 1
0	Drive not ready	READY
1	stop	Running operation message (RUN)
2	Clockwise rotating field (FWD)	Anticlockwise rotating field (REV)
3	No error	Fault detected (FAULT)
4	Acceleration ramp	Frequency actual value equals setpoint input
5	–	Zero speed
6	Speed control deactivated	Speed control activated
7	Not used	

Fault word

 → Chapter 10 "Error Messages"

Frequency actual value (Index 200B_{hex})

The frequency reference value is specified in hertz with a single decimal place.

Example:
125_{dec} \triangleq 12.5 Hz

Current (Index 200D_{hex})

The current is specified with one decimal place.

Example:
34 \triangleq 3.4 A

10 Error Messages

10.1 Introduction

DC1 series variable frequency drives come with several internal monitoring functions. When a deviation from the correct operating state is detected, an error message will be displayed; in the inverter's default settings, the relay contact will open (control signal terminals 10 and 11).

10.2 Error Messages

The most recent four error messages will be stored in the order in which they occurred (with the most recent one in the first place). Error messages can be read from parameter P-13.

10.2.1 Acknowledge error message (Reset)

To acknowledge and reset the current error message, you can either switch off the supply voltage or press the STOP pushbutton. Error messages (a maximum of four) are stored in parameter P-13. Error messages can also be reset with an additional positive edge at control signal terminal 2/D11 or 3/D12 (new start signal).

10.2.2 Fault log

The fault log (P-13) stores the most recent four error messages in the order in which they occurred. The most recent error message will always be shown as the first value when P-13 is accessed. To see the remaining error messages one after the other, press the ▲ (Up) button. Their order will be indicated by means of flashing dots in the 7-segment digital display assembly.



The values in the fault log (P-13) will not be deleted if the variable frequency drive is reset to its default settings!

10 Error Messages

10.2 Error Messages

The example below shows how to access the fault log.

View	Explanation
	<p>Operating state Stop</p>
	<p>Press the OK button and hold it down for two seconds.</p>
	<p>The parameter that was last accessed will be shown. The last digit on the display will flash.</p>
	<p>Use the ▲ (Up) or ▼ (Down) arrow buttons to select parameter P-13 and confirm your selection by pressing the OK pushbutton.</p>
	<p>Last error message. Example: P-def (Parameter default = Default settings loaded).</p>
	<p>Use the arrow key ▲ (Up) to go to the next error message.</p>
	<p>Second most recent error message: Example: V-Volt (undervoltage message). The dot on the right will flash.</p>
	<p>The third most recent error message will be shown after pressing the ▲ arrow key (Up).</p>
	<p>Example: E-trip (external error message). The two dots on the right will flash.</p>
	<p>The oldest error message will be shown after you press the ▲ arrow key (Up) once more.</p>
	<p>Example: V-Volt (undervoltage message) The three dots on the right will flash.</p>

10.3 Error list

The following table shows the failure codes, the possible causes and indicates corrective measures.

Table 21: Error messages list

Failure code [hex]	View	Designation	Possible cause	Notes
01	01 - b	Braking chopper over-current	Overcurrent braking resistance	<ul style="list-style-type: none"> Overcurrent in braking resistor circuit. Check the wiring to the braking resistance. Check the brake resistor value. Make sure that the minimum resistance values are being adhered to.
02	0L - br	Thermal overload braking resistance	Braking resistance overload	<ul style="list-style-type: none"> Increase the deceleration time, reduce the load's moment of inertia, or connect additional braking resistors in parallel. Make sure that the minimum resistance values are being adhered to.
03	0 - I	Overcurrent motor	<ul style="list-style-type: none"> Overcurrent at output Motor overload Overtemperature at heat sink Short circuit / ground fault 	<ul style="list-style-type: none"> Motor with constant speed: Determine the overload or fault. Motor starts: The load stalled or has seized. Check whether there is a star/delta motor wiring error. Motor accelerates/decelerates: The excessively short acceleration/deceleration time is requiring too much power. If P-03 or P-04 cannot be increased, a more powerful variable frequency drive is required. Cable fault between variable frequency drive and motor.
04	1.E - t r F	Thermal motor overload	The DC1 variable frequency drive was switched off after more than 100 % of the value set in P-08 was delivered for a period of time.	<ul style="list-style-type: none"> Check whether the decimal places are flashing (variable frequency drive overloaded) and either raise the acceleration ramp (P-03) or reduce the motor load. Make sure that the cable length matches the variable frequency drive specifications. Check the load mechanically in order to make sure that it is free, that nothing is getting jammed or locked, and there are no other mechanical faults.
05	P5 - t r F	Fault in power section	Fault in power section	<ul style="list-style-type: none"> Check the wiring to the motor. Check whether there is a short-circuit between the phases or an earth fault in a phase. Check the variable frequency drive's ambient air temperature. Check whether additional clearance or cooling is required. Make sure that the variable frequency drive is not being overloaded.
06	0Uol t	Overvoltage	<ul style="list-style-type: none"> Overvoltage at DC link Mains overvoltage 	<ul style="list-style-type: none"> Power supply problem Increase deceleration ramp time P-04.
07	0Uol t	Undervoltage	<ul style="list-style-type: none"> DC link undervoltage Mains undervoltage 	<ul style="list-style-type: none"> Usually occurs if the power is switched off. If it occurs during operation, check the power supply voltage.
08	0 - t	Overtemperature	Heat sink overtemperature	<ul style="list-style-type: none"> Check the variable frequency drive's ambient air temperature. Check whether additional clearance or cooling is required.

10 Error Messages

10.3 Error list

Failure code [hex]	View	Designation	Possible cause	Notes
09	<i>U - t</i>	Excessively low temperature (frost)	Excessively low heat sink temperature	<ul style="list-style-type: none"> The variable frequency drive will be switched off if the ambient air temperature is lower than -10 °C. Raise the temperature over -10 °C in order to start the variable frequency drive.
0A	<i>P - dEF</i>	Parameter Default	The parameter's default setting has been loaded.	Press the STOP pushbutton. The DC1 variable frequency drive is ready for an application-specific configuration.
0B	<i>E - t r i P</i>	External fault	<ul style="list-style-type: none"> External shutdown (on digital input 3) PTC overtemperature (motor) 	<ul style="list-style-type: none"> External safety shutdown at digital input 3. The N/C contact has opened due to some reason. If a motor thermistor is connected, check whether the motor is too hot.
0C	<i>SC - t r F</i>	Communication fault	Communication loss error	<ul style="list-style-type: none"> Check the communications connection between the variable frequency drive and the external devices. Make sure that each individual variable frequency drive on the network has a unique address.
0E	<i>P - L o S S</i>	Mains connection phase fault	Input phase loss Shutdown	<ul style="list-style-type: none"> A variable frequency drive intended for use with a three-phase power supply has lost one of its input phases.
0F	<i>S P I n - F</i>	Motor pick-up control fault	Motor pick-up control function (for catching spinning motors) failed	<ul style="list-style-type: none"> The motor pick-up control function did not determine the motor speed.
10	<i>t h - F r t</i>	Thermistor fault	Defective thermistor on heat sink	<ul style="list-style-type: none"> Please contact your closest Eaton representative.
11	<i>d A t A - F</i>	Data error	Internal memory error	<ul style="list-style-type: none"> Parameter not stored; restore default settings. If the problem occurs again, please contact your closest Eaton representative.
12	<i>4 - 2 0 F</i>	Live zero error	Analog input current outside range	<ul style="list-style-type: none"> Make sure that the input current falls within the range defined in parameter P-16.

11 Annex

The following tables show the technical data of the variable frequency drive DC1 in the individual power classes with the allocated motor output.



The motor output allocation is based on the rated operational current.



The motor output designates the respective active power output to the drive shaft of a normal, four pole, internally or externally ventilated alternating current asynchronous motor with 1.500 rpm at 50 Hz or 1.800 rpm at 60 Hz.

11 Annex
11.1 Features

11.1 Features

Part no.	Rated operational current I_e [A]	Assigned motor output				Radio interference suppression N = No F = Yes	Brake chopper (integrated) N = No B = Yes	Degree of protection IP	Size FS
		P (230 V, 50 Hz)		P (220 - 240 V, 60 Hz)					
		[kW]	[A] ¹⁾	[HP]	[A] ¹⁾				

Mains supply voltage: 1 AC 115 V, 50/60 Hz (voltage doubler); EMC: no integrated radio interference suppression filter

Note: The 115-V mains supply voltage is increased to 230 V (output voltage) by an internal voltage doubler.

Motor connection voltage: 3 AC 230 V, 50/60 Hz

DC1-1D2D3...	2.3	0.37	2	1/2	2.2	N	N	IP20, IP66	FS1
DC1-1D4D3...	4.3	0.75	3.2	1	4.2	N	N	IP20, IP66	FS1
DC1-1D5D8...	5.8	1.1	4.6	1-1/2 ²⁾	6 ²⁾	N	B	IP20, IP66	FS2

Mains supply voltage: 1 AC 230 V, 50/60 Hz

Motor connection voltage: 3 AC 230 V, 50/60 Hz

DC1-122D3...	2.3	0.37	2	1/2	2.2	N, F	N	IP20, IP66	FS1
DC1-124D3...	4.3	0.75	3.2	1	4.2	N, F	N	IP20, IP66	FS1
DC1-127D0xN...	7	1.5	6.3	2	6.8	N, F	N	IP20, IP66	FS1
DC1-127D0xB...	7	1.5	6.3	2	6.8	N, F	B	IP20, IP66	FS2
DC1-12011...	10.5	2.2	8.7	3	9.6	N, F	B	IP20, IP66	FS2
DC1-12015...	15	4	14.8	5	15.2	N	B	IP20, IP66	FS3

Mains supply voltage: 3 AC 230 V, 50/60 Hz

Motor connection voltage: 3 AC 230 V, 50/60 Hz

DC1-322D3...	2.3	0.37	2	1/2	2.2	N	N	IP20, IP66	FS1
DC1-324D3...	4.3	0.75	3.2	1	4.2	N	N	IP20, IP66	FS1
DC1-327D0xN...	7	1.5	6.3	2	6.8	N	N	IP20, IP66	FS1
DC1-327D0xB...	7	1.5	6.3	2	6.8	N, F	B	IP20, IP66	FS2
DC1-32011...	10.5	2.2	8.7	3	9.6	N, F	B	IP20, IP66	FS2
DC1-32018...	18	4	14.8	5	15.2	N, F	B	IP20, IP66	FS3

1) The rated motor currents apply to normal internally and surface-cooled three-phase motors with

2) (1500 rpm at 50 Hz, 1800 rpm at 60 Hz).

3) Keep motor specifications in mind (6 A = normalized rated value in accordance with UL 580 C).

4) In certain cases, only operation with a reduced motor load may be possible.

Part no.	Rated operational current I_e [A]	Assigned motor output				Radio interference suppression N = No F = Yes	Brake chopper (integrated) N = No B = Yes	Degree of protection IP	Size FS
		P (400 V, 50 Hz)		P (440 - 480 V, 60 Hz)					
		[kW]	[A] ¹⁾	[HP]	[A] ¹⁾				
Mains supply voltage: 3 AC 400 V, 50 Hz / 480 V, 60 Hz									
Motor connection voltage: 3 AC 400 V, 50 Hz / 440 - 480 V, 60 Hz									
DC1-342D2...	2.2	0.75	1.9	1	2.1	N, F	N	IP20, IP66	FS1
DC1-344D1xN...	4.1	1.5	3.6	2	3.4	N, F	N	IP20, IP66	FS1
DC1-344D1xB...	4.1	1.5	3.6	2	3.4	N, F	B	IP20, IP66	FS2
DC1-345D8...	5.8	2.2	5	3	4.8	N, F	B	IP20, IP66	FS2
DC1-349D5...	9.5	4	8.5	5	7.6	N, F	B	IP20, IP66	FS2
DC1-34014...	14	5.5	11.3	7.5	11	N, F	B	IP20, IP66	FS3
DC1-34018...	18	7.5	15.2	10	14	N, F	B	IP20, IP66	FS3
DC1-34024...	24	11	21.7	15	21	N, F	B	IP20	FS3

1) The rated motor currents apply to normal internally and surface-cooled three-phase motors with

2) (1500 rpm at 50 Hz, 1800 rpm at 60 Hz).

11 Annex

11.2 General rated operational data

11.2 General rated operational data

Technical Data	Symbol	Unit	Value
General			
Standards			EMC: EN 61800-3:2004+A1-2012 Radio interference: EN 55011: 2010 Safety: EN 61800-5: 2007 Protection type: EN 60529: 1992
Certifications and manufacturer's declarations on conformity			CE, UL, cUL, c-Tick, UkrSEPRO, Gost-R
Production quality			RoHS, ISO 9001
Climatic proofing	ρ_w	%	< 95 %, average relative humidity (RH), non-condensing (EN 50178)
Ambient temperature			
Operation			
IP20 (NEMA 0)	ϑ	°C	-10 - +50 (frost-free and condensation-free) -10 - +45 for DC1-12011... and DC1-32011..., for UL compliance over a period of 24 hours
IP66 (NEMA 4X)	ϑ	°C	-10 - +40 (frost-free and condensation-free)
Storage	ϑ	°C	-40 - +60
MTBF (mean service life between failures)		Years	157
Electrostatic discharge (ESD, EN 61000-4-2:2009)	U	kV	±4, contact discharge ±8, air discharge
Fast transient burst (EFT/B, EN 61000-4-4: 2004)	U	kV	±1, at 5 kHz, control signal terminal ±2, at 5 kHz, motor connection terminals, single-phase mains connection terminals ±4, at 5 kHz, three-phase mains connection terminals
Overvoltage (surge, EN 61000-4-5: 2006)			
110 - 115 V, 200 - 240 V	U	kV	±1, phase to phase/neutral conductor ±2, phase/neutral conductor to earth
380 - 480 V	U	kV	±2, phase to phase ±4, phase to earth
Electric strength (flash, EN 61800-5-1: 2007)			
110 - 115 V, 200 - 240 V	U	kV	1.5
380 - 480 V	U	kV	2.5
Radio interference class (EMC)			
Category and maximum screened motor cable length with integrated radio interference suppression filter			
C1	l	m	1, only for DC1-122D3F... to DC1-12011F...(FS1, FS2)
C2	l	m	5
C3	l	m	25 (max. 200)
Mounting position			vertical
Altitude	h	m	0 - 1000 above sea level, > 1000 with 1% load current reduction every 100 m, maximum 2000 with UL approval, maximum 4000 (without UL)
Degree of protection			IP20 (NEMA 0) / IP66 (NEMA 4X)
Busbar tag shroud			BGV A3 (VBG4, finger- and back-of-hand proof)

Technical Data	Symbol	Unit	Value
Main circuit / power section			
Feeder unit			
Rated operating voltage			
DC1-1D...	U_e	V	1~ 110 (110 V - 10 % - 115 V +10 %, → $U_2 = 230$ V)
DC1-12...	U_e	V	1~ 230 (200 V -10 % - 240 V +10 %)
DC1-32...	U_e	V	3~ 230 (200 V -10 % - 240 V +10 %)
DC1-34...	U_e	V	3~ 400 (380 V -10 % - 480 V +10 %)
Mains frequency	f	Hz	50/60 (48 Hz - 62 Hz)
Power factor (PF)	$\cos \varphi$		> 0.98
Phase Imbalance		%	max. 3
Maximum short-circuit current (supply voltage)	SCCR	kA	5 (100 with recommended fuse)
Mains switch-on frequency			Maximum of one time every 30 seconds
Mains network configuration (AC power supply network)			TN and TT earthing systems with directly earthed neutral point. IT earthing systems with PCM insulation monitoring relays only. Operation on phase-earthed networks is only permissible up to a maximum phase-earth voltage of 300 VAC.
Motor feeder			
Output voltage			
DC1-1D...	U_2	V	3~ 0 - 2 x U_e (voltage doubler)
DC1-12..., DC1-32..., DC1-34...	U_2	V	3~ 0 - U_e
Assigned motor output			
at 230 V, 50 Hz	P	kW	0.37 - 4
at 400 V, 50 Hz	P	kW	0.75 - 11
Output frequency			
Range, parameterizable	f_2	Hz	0 - 50/60 (max. 500 Hz)
Resolution		Hz	0.1
Rated operation current	I_e	A	IP20: 2.3- 24 IP66: 2.3 -18
Overload current for 60 s every 600 s	I_L	%	150
Starting current for 2 s every 20 s	I_L	%	175
Efficiency	η	%	95
Pulse frequency	f_{PWM}	kHz	max. 32
Operating mode			V/Hz control, slip compensation
Slip compensation, max. speed deviation		%	±20
DC braking			
Time before start	t	S	0 - 25, at stop, only with size FS1
Motor pick-up control function (for catching spinning motors)			only for sizes FS2 and FS3
Brake chopper			only for sizes FS2 and FS3
Braking current during continuous operation		%	100 (I_e)
Maximum braking current		%	150 for 60 s

11 Annex

11.2 General rated operational data

Technical Data	Symbol	Unit	Value
Control section			
Control voltage			
Output voltage (control signal terminal 1)	U_C	V DC	24
Load rating (control signal terminal 1)	I_1	mA	100
Reference voltage (control signal terminal 5)	U_S	V DC	10
Load rating (control signal terminal 5)	I_S	mA	10
Digital input (DI)			
Count			2 - 4
Logic (level)			Increase
Response time	t	ms	< 4
Input voltage range High (1)	U_C	V DC	8 - 30
Input voltage range Low (0)	U_C	V DC	0 - 4
Analog Input (AI)			
Count			0 - 2
Resolution			12-bits
Accuracy		%	< 1 to the final value
Response time	t	ms	< 4
Input voltage range	U_S	V	0 - 10, DC ($R_i \sim 72 \text{ k}\Omega$)
Input current range	I_S	mA	0/4 - 20 ($R_B \sim 500 \Omega$)
Relay output (K)			
Count			1 relay
relay contact			N/O
Switching capacity			
AC	I	A	6 (250 V AC)
DC current	I	A	5 (30 V AC)
Digital/analog output (DO/AO)			
Count			1 (digital/analog)
Output voltage			
TH	U_{out}	V DC	+24
AO	U_{out}	V DC	0 - 10
Current carrying capacity DO	I_{out}	mA	< 20
AO resolution			12-bits
Interface (RJ45)			OP bus, Modbus RTU, CANopen, (RS485)

11.3 Technical data

11.3.1 DC1-1D

	Symbol	Unit	DC1-1D2D3...	DC1-1D4D3...	DC1-1D5D3...
Main circuit					
Rated operating voltage	U_e	V	115 AC, single-phase		
Mains voltage (50/60Hz)	U_{LN}	V	110 (-10 %) - 115 (+10 %)		
Input current	I_{LN}	A	11	19	25
Mains frequency	f_{LN}	Hz	50/60		
Frequency range	f_{LN}	Hz	48 - 62		
Power section					
Overload current for 60 s every 600 s	I_L	A	3.45	6.45	8.7
Starting current for 2 s every 20 s	I_L	A	4.03	7.53	10.15
Output voltage at U_e	U_2	V	230 AC, 3-phase		
Output frequency	f_2	Hz	0 - 50 (max. 500 Hz)		
Pulse frequency	f_{PWM}	kHz	16 (adjustable 4 – 32)		
Frequency resolution (setpoint value)	Δf	Hz	0.1		
Rated operational current ¹⁾	I_e	A	2.3	4.3	5.8
Heat dissipation at rated operational current			18.5	37.5	44
Efficiency	η	%	95	95	95
Maximum leakage current to earth (PE)	I_{PE}	mA	< 1	< 1	< 1
Fan, built-in			–	✓ ¹⁾	✓ ¹⁾
Size			FS1	FS1	FS2
Motor feeder					
Assigned motor output					
at 230 V, 50 Hz	P	kW	0.37	0.75	1.1
at 220 - 240 V, 60 Hz	P	HP	0.5	1	1.5
Apparent power					
Apparent power at rated operation 230 V	S	kVA	0.92	1.71	2.31
Apparent power at rated operation 240 V	S	kVA	0.96	1.79	2.41

1) Not with IP66 degree of protection.

11 Annex
11.3 Technical data

	Symbol	Unit	DC1-1D2D3...	DC1-1D4D3...	DC1-1D5D3...
Braking function					
Standard braking torque			max. 30 % M_N	max. 30 % M_N	max. 30 % M_N
DC braking torque			Max. 100% of rated operational current I_e , adjustable		
Braking torque with external braking resistance			–	–	Max. 100% of rated operational current I_e with external braking resistance
Minimum external braking resistance	R_{min}	Ω	–	–	47
On threshold for brake transistor	U_{DC}	V	–	–	390 DC –
Control section					
Control voltage	U_c	V	24 V DC (max. 100 mA)		
Reference voltage	U_s	V	10 V DC (max. 10 mA)		

Note: With a pulse frequency of 4 kHz and an ambient temperature of +40 °C / +50 °C with IP20/NEMA 0

11.3.2 DC1-12

	Symbol	Unit	DC1-122D3...	DC1-124D3...	DC1-127D0...	DC1-127D0...	DC1-12011...	DC1-12015...
Main circuit								
Feeder unit								
Rated operating voltage	U_e	V AC	230, single-phase					
Mains voltage (50/60Hz)	U_{LN}	V	200 (-10 %) - 240 (+10 %)					
Input current	I_{LN}	A	5	8.5	13.9	13.9	19.5	30.5
Mains frequency	f_{LN}	Hz	50/60					
Frequency range	f_{LN}	Hz	48 - 62					
Power section								
Overload current for 60 s every 600 s	I_L	A	3.45	6.45	10.5	10.5	15.75	22.5
Starting current for 2 s every 20 s	I_L	A	4.03	7.53	12.25	12.25	18.38	26.25
Output voltage at U_e	U_2	V AC	230, 3-phase					
Output frequency	f_2	Hz	0 - 50 (max. 500)					
Pulse frequency	f_{PWM}	kHz	16 (adjustable 4 – 32)					
Frequency resolution (setpoint value)	Δf	Hz	0.1	0.1	0.1	0.1	0.1	0.1
Rated operational current ¹⁾	I_e	A	2.3	4.3	7	7	10.5	15
Heat dissipation								
Heat dissipation of rated operational current	P_V	W	18.5	45.75	63	63	103.4	160
Efficiency	η	%	95	93.9	95.8	95.8	95.3	96
Maximum leakage current to earth (PE) without motor	I_{PE}	mA	2.49	2.49	2.49	2.49	2.49	< 1
Fan, built-in			–	✓	✓	✓	✓	✓
Size			FS1	FS1	FS1	FS2	FS2	FS3
Motor feeder								
Assigned motor output								
at 230 V, 50 Hz	P	kW	0.37	0.75	1.5	1.5	2.2	4
at 220 - 240 V, 60 Hz	P	HP	0.5	1	2	2	3	5
Apparent power								
Apparent power at rated operation 230 V	S	kVA	0.92	1.71	2.79	2.79	4.18	5.98
Apparent power at rated operation 240 V	S	kVA	0.96	1.79	2.91	2.91	4.36	6.24

11 Annex

11.3 Technical data

	Symbol	Unit	DC1-122D3...	DC1-124D3...	DC1-127D0...	DC1-127D0...	DC1-12011...	DC1-12015...
Braking function								
Standard braking torque			max. 30 % M_N					
DC braking torque			Max. 100% of rated operational current I_e , variable					
Braking torque with external braking resistance			–	–	max. 100% rated operational current I_e , with external braking resistance			
Minimum external braking resistance	R_{min}	Ω				47	47	47
Switch-on threshold for the braking transistor	U_{DC}	V DC				390	390	390
Control section								
External control voltage	U_c	V DC	24 (max. 100 mA)					
Reference voltage	U_s	V DC	10 (max. 10 mA)					

Note: With a pulse frequency of 4 kHz and an ambient temperature of +40 °C / +50 °C with IP20/NEMA 0

11.3.3 DC1-32

	Symbol	Unit	DC1-322D3...	DC1-324D3...	DC1-327D0...	DC1-327D0...	DC1-32011...	DC1-32018...	
Main circuit									
Feeder unit									
Rated operating voltage	U_e	V AC	230, 3-phase						
Mains voltage (50/60Hz)	U_{LN}	V	200 (-10 %) - 240 (+10 %)						
Input current	I_{LN}	A	3	4.5	7.3	7.3	11	18.8	
Mains frequency	f_{LN}	Hz	50/60						
Frequency range	f_{LN}	Hz	48 - 62						
Power section									
Overload current for 60 s every 600 s	I_L	A	3.45	6.45	10.5	10.5	15.75	27	
Starting current for 2 s every 20 s	I_L	A	4.03	7.53	12.25	12.25	18.38	31.5	
Output voltage at U_e	U_2	V AC	230, 3-phase						
Output frequency	f_2	Hz	0 - 50 (max. 500)						
Pulse frequency	f_{PWM}	kHz	16 (adjustable 4 – 32)						8 (adjustable 4 - 24)
Frequency resolution (setpoint value)	Δf	Hz	0.1						
Rated operational current ¹⁾	I_e	A	2.3	4.3	7	7	10.5	18	
Heat dissipation									
Heat dissipation of rated operational current	P_V	CO	14.8	39.75	61.5	61.5	90.2	160	
Efficiency	η	%	96	94.7	95.9	95.9	95.9	96	
Maximum leakage current to earth (PE) without motor	I_{PE}	mA	< 1	< 1	< 1	< 1	< 1	< 1	
Fan, built-in			–	✓	✓	✓	✓	✓	
Size			FS1	FS1	FS1	FS2	FS2	FS3	
Motor feeder									
Assigned motor output									
at 230 V, 50 Hz	P	kW	0.37	0.75	1.5	1.5	2.2	4	
at 220 - 240 V, 60 Hz	P	HP	0.5	1	2	2	3	5	
Apparent power									
Apparent power at rated operation 230 V	S	kVA	0.92	1.71	2.79	2.79	4.18	7.17	
Apparent power at rated operation 240 V	S	kVA	0.96	1.79	2.91	2.91	4.36	7.48	

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11.3 Technical data

	Symbol	Unit	DC1-322D3...	DC1-324D3...	DC1-327D0...	DC1-327D0...	DC1-32011...	DC1-32018...
Braking function								
Standard braking torque			max. 30% M_N					
DC braking torque			Max. 100% of rated operational current I_e , variable					
Braking torque with external braking resistance			max. 100% rated operational current I_e , with external braking resistance					
Minimum external braking resistance	R_{min}	Ω				47	47	47
On threshold for brake transistor	U_{DC}	V DC				390	390	390
Control section								
External control voltage	U_c	V DC	24 (max. 100 mA)					
Reference voltage	U_s	V DC	10 (max. 10 mA)					

Note: With a pulse frequency of 4 kHz and an ambient temperature of +40 °C / +50 °C with IP20/NEMA 0

11.3.4 DC1-34

	Symbol	Unit	DC1-342D2...	DC1-344D1...	DC1-344D1...	DC1-345D8...	DC1-349D5...
Main circuit							
Feeder unit							
Rated operating voltage	U_e	V AC	400, 3-phase				
Mains voltage (50/60Hz)	U_{LN}	V	380 (-10 %) - 480 (+10 %)				
Input current	I_{LN}	A	2.4	4.3	4.3	6.1	9.8
Mains frequency	f_{LN}	Hz	50/60				
Frequency range	f_{LN}	Hz	48 - 62				
Power section							
Overload current for 60 s every 600 s	I_L	A	3.3	6.15	6.15	8.7	14.25
Starting current for 2 s every 20 s	I_L	A	3.85	7.18	7.18	10.15	16.63
Output voltage at U_e	U_2	V AC	400, 3-phase				
Output frequency	f_2	Hz	0 - 50 Hz (max. 500)				
Pulse frequency	f_{PWM}	kHz	16 (adjustable 4 – 32)				
Frequency resolution (setpoint value)	Δf	Hz	0.1				
Rated operational current ¹⁾	I_e	A	2.2	4.1	4.1	5.8	9.5
Heat dissipation							
Heat dissipation of rated operational current	P_V	CO	63.75	76.5	76.5	101.2	136
Efficiency	η	%	91.5	94.9	94.9	95.4	96.6
Maximum leakage current to earth (PE) without motor	I_{PE}	mA	< 1	< 1	< 1	< 1	< 1
Fan, built-in			✓	✓	✓	✓	✓
Size			Size FS1	FS1	FS2	FS2	FS2
Motor feeder							
Assigned motor output							
at 400 V, 50 Hz	P	kW	0.75	1.5	1.5	2.2	4
at 440 - 480 V, 60 Hz	P	HP	1	2	2	3	5
Apparent power							
Apparent power at rated operation 400 V	S	kVA	1.52	2.84	2.84	4.02	6.58
Apparent power at rated operation 480 V	S	kVA	1.83	3.41	3.41	4.82	7.9

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11.3 Technical data

	Symbol	Unit	DC1-342D2...	DC1-344D1...	DC1-344D1...	DC1-345D8...	DC1-349D5...
Braking function							
Standard braking torque			max. 30 % M_N				
DC braking torque			Max. 100% of rated operational current I_e , variable				
Braking torque with external braking resistance			Max. 100% of rated operational current I_e with external braking resistance				
Minimum external braking resistance	R_{min}	Ω			100	100	100
On threshold for brake transistor	U_{DC}	V DC			780	780	780
Control section							
External control voltage	U_c	V DC	24 (max. 100 mA)				
Reference voltage	U_s	V DC	10 (max. 10 mA)				

Note: With a pulse frequency of 4 kHz and an ambient temperature of +40 °C / +50 °C with IP20/NEMA 0

11.3.5 DC1-34

	Symbol	Unit	DC1-34014...	DC1-34018...	DC1-34024...
Main circuit					
Feeder unit					
Rated operating voltage	U_e	V AC	400, 3-phase		
Mains voltage (50/60Hz)	U_{LN}	V	380 (-10 %) - 480 (+10 %)		
Input current	I_{LN}	A	14.6	18.1	24.7
Mains frequency	f_{LN}	Hz	50/60	50/60	50/60
Frequency range	f_{LN}	Hz	48 - 62	48 - 62	48 - 62
Power section					
Overload current for 60 s every 600 s	I_L	A	21	27	36
Starting current for 2 s every 20 s	I_L	A	24.5	31.5	42
Output voltage at U_e	U_2	V AC	400, 3-phase	400, 3-phase	400, 3-phase
Output frequency	f_2	Hz	0 - 50 (max. 500)	0 - 50 (max. 500)	0 - 50 (max. 500)
Pulse frequency	f_{PWM}	kHz	8 (adjustable 4 – 24)		
Frequency resolution (setpoint value)	Δf	Hz	0.1		
Rated operational current ¹⁾	I_e	A	14	18	24
Heat dissipation					
Heat dissipation of rated operational current	P_V	CO	209	30	297
Efficiency	η	%	96.2	99.6	97.3
Maximum leakage current to earth (PE) without motor	I_{PE}	mA	< 1	< 1	2.49
Fan, built-in			✓	✓	✓ ¹⁾
Size			FS3	FS3	FS3
Motor feeder					
Assigned motor output					
at 400 V, 50 Hz	P	kW	5.5	7.5	11
at 440 - 480 V, 60 Hz	P	HP	7.5	10	15
Apparent power					
Apparent power at rated operation 400 V	S	kVA	9.67	12.47	16.63
Apparent power at rated operation 480 V	S	kVA	11.64	14.96	19.95

1) Not with IP66 degree of protection.

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11.3 Technical data

			DC1-34014...	DC1-34018...	DC1-34024...
	Symbol	Unit			
Braking function					
Standard braking torque			max. 30% M_N		
DC braking torque			Max. 100% of rated operational current I_e , variable		
Braking torque with external braking resistance			Max. 100% of rated operational current I_e with external braking resistance		
Minimum external braking resistance	R_{min}	Ω	47	47	47
On threshold for brake transistor	U_{DC}	V DC	780	780	780
Control section					
External control voltage	U_c	V DC	24 (max. 100 mA)		
Reference voltage	U_s	V DC	10 (max. 10 mA)		

Note: With a pulse frequency of 4 kHz and an ambient temperature of +40 °C / +50 °C with IP20/NEMA 0

11.4 Dimensions and frame size

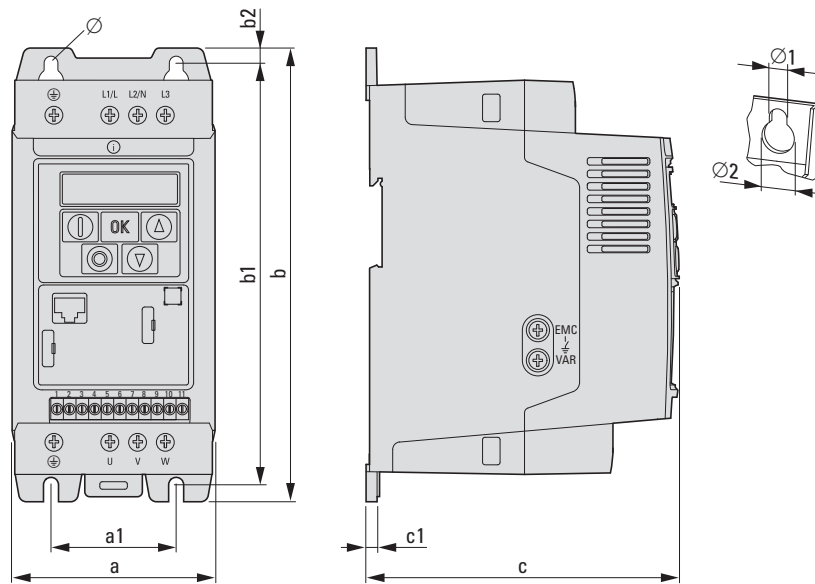


Figure 92: Dimensions for DC1 with IP20 degree of protection

Table 22: Dimensions, weights, and sizes for IP20

Frame size	a [mm] (in)	a1 [mm] (in)	b [mm] (in)	b1 [mm] (in)	b2 [mm] (in)	c [mm] (in)	c1 [mm] (in)	Ø1 [mm] (in)	Ø2 [mm] (in)	m [kg]
FS1	81 (3.19)	50.0 (1.97)	184 (7.24)	170 (6.69)	7 (0.28)	124 (4.88)	4 (0.16)	6 (0.25)	12 (0.47)	1.1
Size FS2	107 (4.21)	75 (2.95)	231 (9.09)	215 (8.46)	8 (0.31)	152 (5.98)	5 (0.2)	6 (0.25)	12 (0.47)	2.6
FS3	131 (5.16)	100 (3.94)	273 (10.75)	255 (10.04)	8.5 (0.33)	175 (6.89)	5 (0.2)	6 (0.25)	12 (0.47)	4

1 in = 1" = 25.4 mm, 1 mm = 0.0394 in

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11.4 Dimensions and frame size

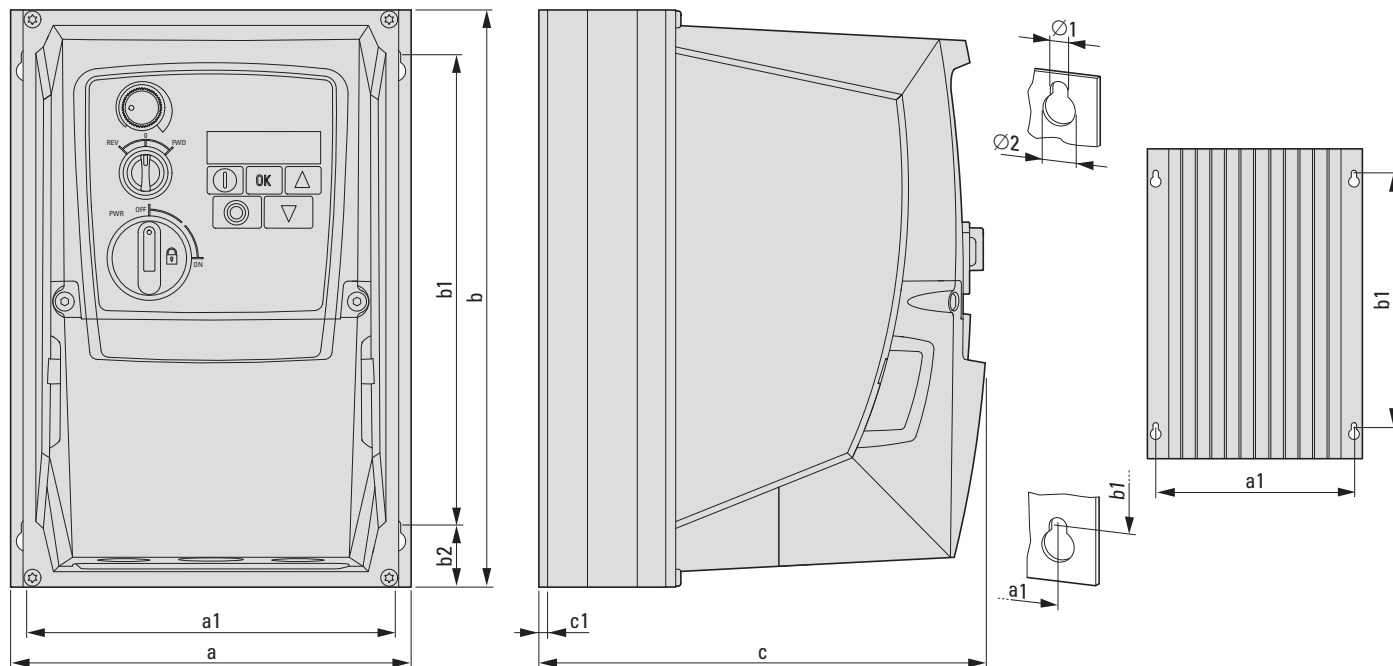


Figure 93: Dimensions for DC1 with IP66 degree of protection

Table 23: Dimensions, weights, and sizes for IP66

Frame size	a [mm] (in)	a1 [mm] (in)	b [mm] (in)	b1 [mm] (in)	b2 [mm] (in)	c [mm] (in)	c1 [mm] (in)	Ø1 [mm] (in)	Ø2 [mm] (in)	m [kg]
FS1	161 (6.34)	148.5 (5.85)	232 (9.13)	189 (7.44)	25 (0.98)	184 (7.24)	3.5 (0.14)	4 (0.15)	8 (0.31)	2.8 (6.17)
FS2	188 (7.4)	176 (6.93)	257 (10.12)	200 (7.87)	28 (1.1)	192 (7.56)	3.5 (0.14)	4.2 (0.16)	8.5 (0.33)	5 (11.02)
FS3	210 (8.27)	197.5 (7.78)	310 (12.2)	252 (9.92)	33 (1.3)	234 (9.21)	3.5 (0.14)	4.2 (0.16)	8.5 (0.33)	8.2 (18.08)

1 in = 1" = 25.4 mm, 1 mm = 0.0394 in

11.5 Variable frequency drives for single-phase AC motors

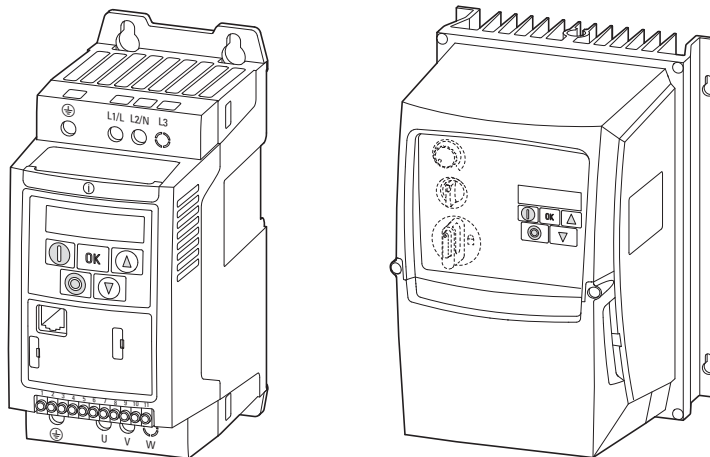


Figure 94: DC1-S...

Starting the motor properly requires a special method. The variable frequency drive will start the motor directly with the motor's rated operational frequency (P-32), while the voltage, starting from the boost start voltage (P-11), will be increased to the motor's rated operational voltage (P-07) within the boost time (P-33) period.

After the boost start process, the variable frequency drive will start adjusting the motor's speed by changing the output frequency.

The curves in figure 95 below show how this function works.

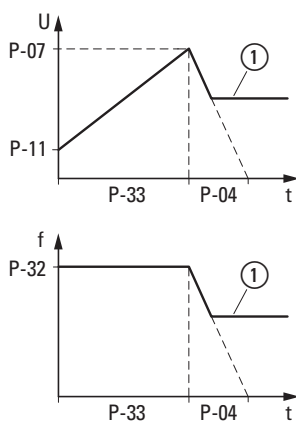


Figure 95: Startup behavior

① Setpoint value

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11.5 Variable frequency drives for single-phase AC motors

Follow the steps below in order to obtain a reliable start:

- ▶1. Connect the motor to the variable frequency drive correctly.
- ▶2. Set the motor's rated operational voltage (P-07) and the rated motor current (P-08) correctly (see the information on the nameplate).
- ▶3. Open the extended parameter set with P-14 = 101.
- ▶4. Set boost time P-33 to its maximum value of 150 s.
- ▶5. Start the variable frequency drive and have the display show the motor current (to do this, press the OK button until "A x.x" is shown).
- ▶6. About 3 to 5 seconds after the unit starts, compare the motor current with the rated motor current. Then follow the scenario that applies:

a) The motor current is less than 80% of the rated motor current:

- Stop the variable frequency drive
- Increase the value in P-11
- Repeat, starting from step 5

b) The motor current is more than 90% of the rated motor current:

- Stop the variable frequency drive
 - Reduce the value in P-11
 - Repeat, starting from step 5
- ▶ Check to make sure that once the boost start voltage is set correctly, the current falls between 80% and 90% of the rated motor current about 3 to 5 seconds after the unit starts.
 - ▶ Now reduce boost time P-33 in the direction of the value required for the motor start. The ideal boost time will be a few seconds longer than the time for the motor start.



For more information and technical data on DC1-S-... variable frequency drives, please refer to instructional leaflets IL04020014Z and IL040001ZU.

11.6 DX-SPL-RJ45-2SL1PL

This splitter was specifically designed for networking multiple variable frequency drives. The RJ45 ports are connected in parallel so as to make it possible to connect multiple variable frequency drives or up to two external keypads with a simple RJ45 cable.

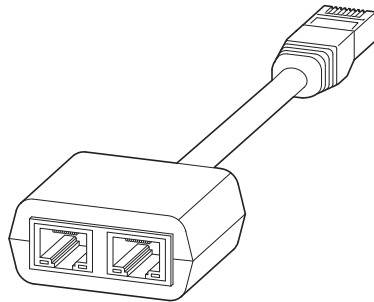


Figure 96: DX-SPL-RJ45-2SL1PL

The RJ45 connector needs to be plugged into the front of the DC1 variable frequency drive. The sockets can be used to connect another variable frequency drive, an external keypad, or a head-end controller (via a field bus).

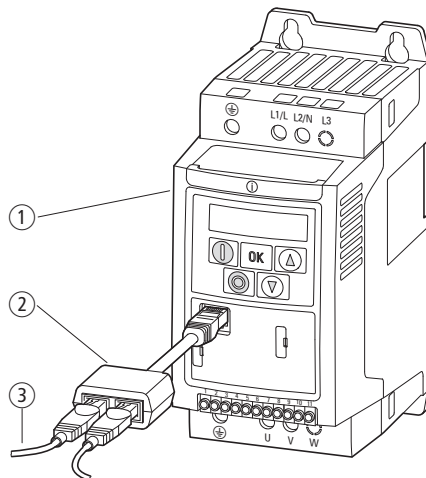


Figure 97: Connection

- ① variable frequency drives
- ② Splitter DX-SPL-RJ45-2SL1PL
- ③ RJ45 Cables

11.7 External keypad

11.7.1 DX-KEY-...

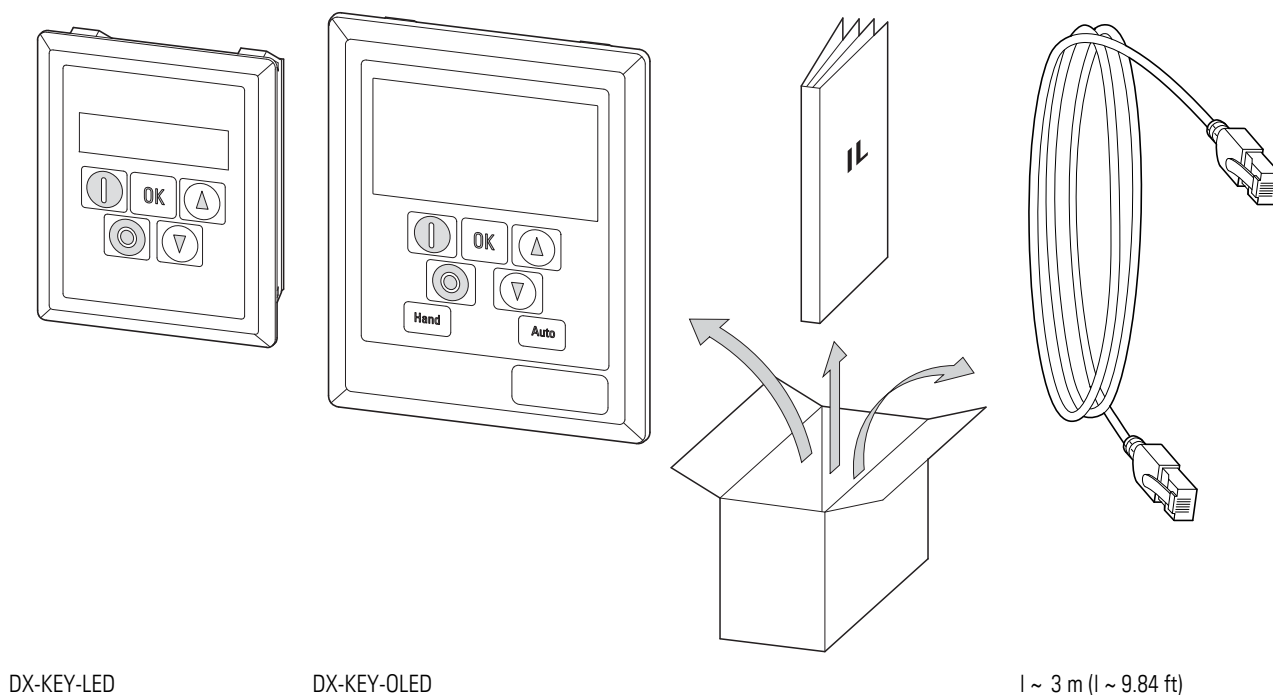


Figure 98: Equipment supplied with DX-KEY-...
DX-KEY-LED or DX-KEY-OLED external keypad
Instructional leaflet
RJ45 cable (3 m)



The equipment supplied with the DC1 variable frequency drive does not include an external DX-KEY-... keypad.

DX-KEY-... keypads can be used to externally control the variable frequency drive from a distance of up to 100 m. They are designed for installation on a control panel door, meaning that an IP54 degree of protection can be achieved when they are installed.

A network with 63 DC1 variable frequency drives can be controlled by a maximum of two keypads.

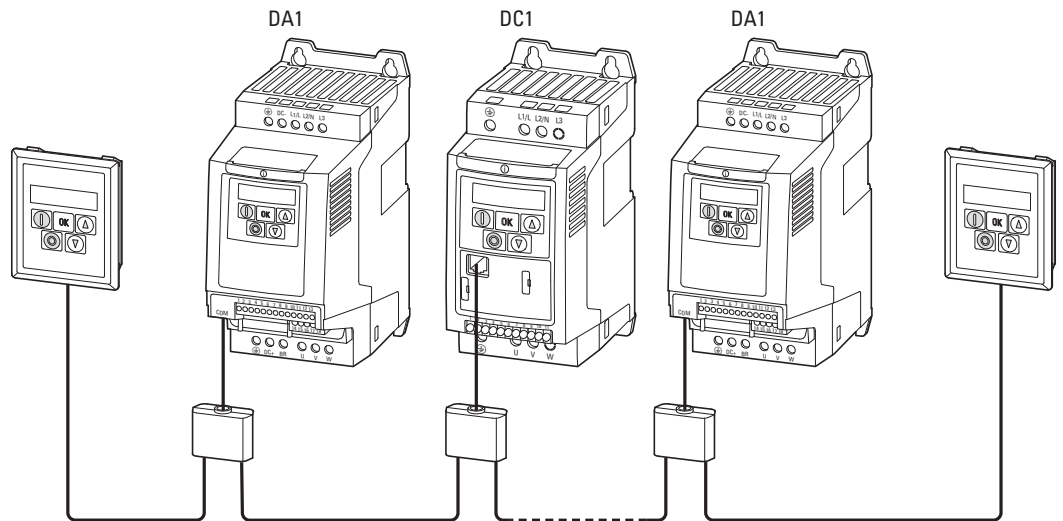


Figure 99: Variable frequency drive network with two keypads

The external keypad can be connected without any tools. One end of the RJ45 cable is simply plugged into the front of the variable frequency drive. The other end is plugged into the bottom of DX-KEY-LED external keypads and into the back of DX-KEY-OLED keypads.

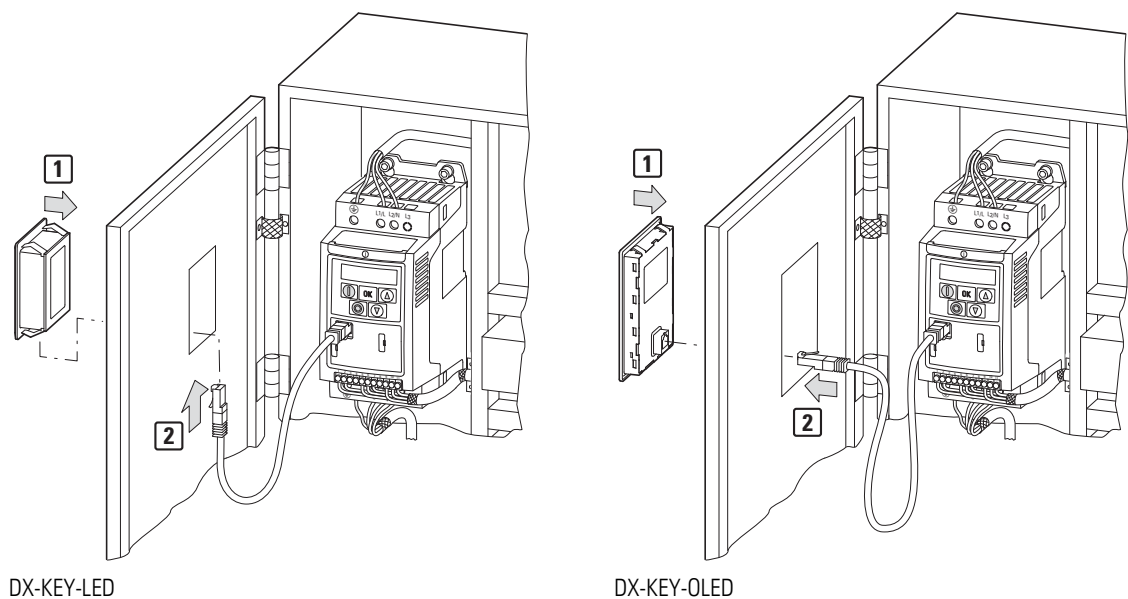


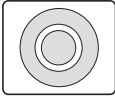


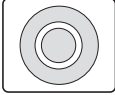
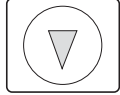
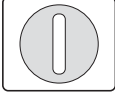
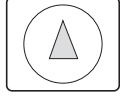
Figure 100: Installing the external keypad



For detailed instructions on how to install the external keypad, please refer to instructional leaflet IL04012020Z.

In order to connect two external keypads, you will have to change the port address on one of the keypads to 2 (WE = 1). To control a DC1 variable frequency drive with the keypads, you will need to set the variable frequency drive address defined in parameter P-36.

Button combinations for external keypads

Function	Key combination
Keypad Port	  
Variable frequency drive address	 
Language ¹⁾	 

1) On DX-KEY-OLED keypads only

11.7.2 DX-KEY-LED

The external DX-KEY-LED 7-segment LED keypad has the same functions as the internal keypad.

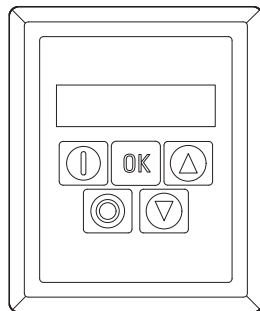


Figure 101: DX-KEY-LED

Setting the keypad port

To set the keypad port, use the **OK + Stop + ▼** button combination. After you use the combination, the display will show "Port-1."

Use the arrow keys to set the port you want (*Port-1* or *Port-2*). Pressing the **OK + Stop + ▼** button combination again will save the keypad port setting you just configured.

Setting the variable frequency drive address

To set the variable frequency drive address, use the **Stop + ▼** button combination. After you use the combination, the display will show "Adr-01."

Use the arrow keys to set the variable frequency drive address you want (Adr-01, Adr-02 to Adr-63). Pressing the **Stop + ▼** button combination again will save the address and load the data from the variable frequency drive.

11.7.3 DX-KEY-OLED

The DX-KEY-OLED external keypad with an organic LED display has a display that shows plaintext messages in a variety of languages. DX-KEY-OLED external keypads have two additional buttons: **Hand** and **Auto**. These buttons do not serve any purpose when used with DC1 variable frequency drives.

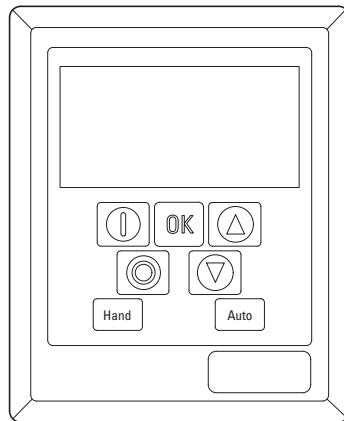


Figure 102: DX-KEY-OLED

Setting the keypad port

To set the keypad port, use the **OK + Stop + ▼** button combination. After you use the combination, the display will show "01."

Use the arrow keys to set the port you want (01 or 02).

Pressing the **Stop** button again will save the port setting you just configured.

Setting the variable frequency drive address

To set the variable frequency drive address, use the **Stop + ▼** button combination. After you use the combination, the display will show "01."

Use the arrow keys to set the variable frequency drive address you want (01, 02 to 63).

Pressing the **Stop** button will save the address.

Setting a language

To set a display language, use the **Start + ▲** button combination. After you use the combination, the display will show "**Select Language**." Use the arrow keys to switch to the language you want. Pressing the **OK** button will save the language setting you select.

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11.7 External keypad

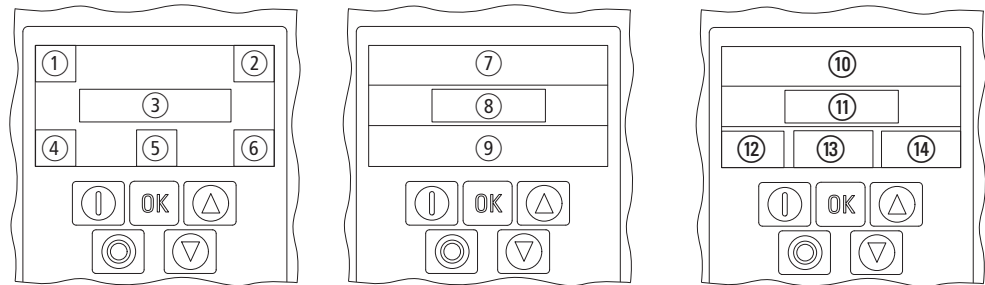


Figure 103: Designations for the elements that make up the OLED keypad

- ① Variable frequency drive part no.
- ② Variable frequency drive address
- ③ Status Message
- ④ Rated power
- ⑤ Rated operating voltage
- ⑥ Size (FS1, FS2, FS3)

After pressing the OK button and holding it down for two seconds

- ⑦ Parameter name
- ⑧ Parameter number
- ⑨ Parameter value

After pressing the OK button again

- ⑩ Parameter name
- ⑪ Parameter value
- ⑫ Parameter number
- ⑬ Maximum value
- ⑭ Minimum value

11.8 DX-NET-SWD3

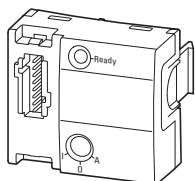


Figure 104: DX-NET-SWD3

The DX-NET-SWD3 expansion module can be used to connect a DC1 variable frequency drive to SmartWire-DT. Together with a SmartWire-DT gateway, this makes it possible to communicate directly via, for example, PROFIBUS DP or PROFINET with the corresponding PROFIdrive profile.

The SmartWire-DT module needs to be plugged into the front of the DC1 variable frequency drive and then connected to an SWD4-...LF8-... ribbon cable using an SWD4-8F2-5 external device plug.

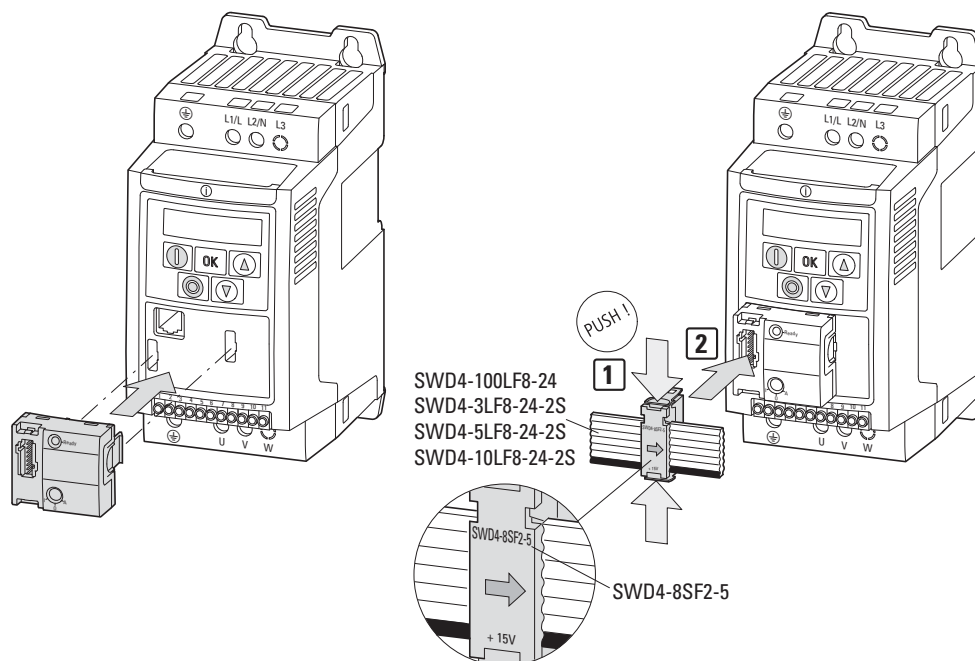


Figure 105: SmartWire-DT Connection



For detailed instructions on how to install the module, please refer to instructional leaflet IL040009ZU.



For detailed instructions on how to use the DX-NET-SWD3 module, please refer to manual MN04012009Z-EN.

11.9 PC-Interface cards

11.9.1 DX-COM-STICK

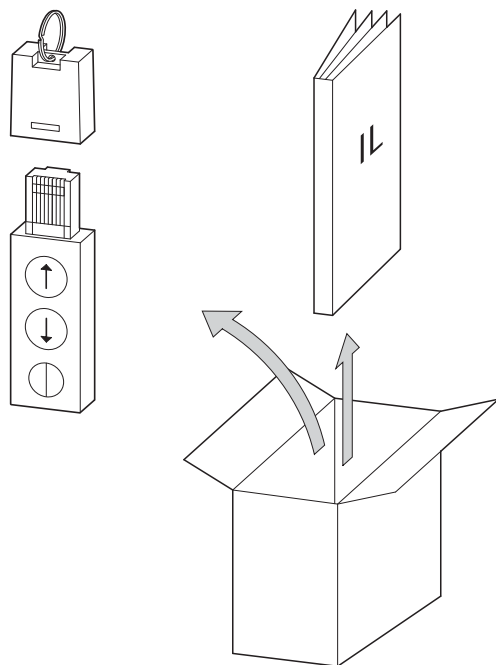


Figure 106: Equipment supplied DX-COM-STICK

- DX-COM-STICK Bluetooth communication stick
- Instructional leaflet



The equipment supplied with the DC1 variable frequency drive does not include a DX-COM-STICK Bluetooth communication stick.

The DX-COM-STICK Bluetooth communication stick comes with a parameter copying function and can be used to establish a Bluetooth connection to a computer.

The arrow keys can be used to copy parameters to the DC1 variable frequency drive or to the DX-COM-STICK Bluetooth communication stick:



Copies the parameters from the DX-COM-STICK device to the variable frequency drive.



Copies the parameters from the variable frequency drive to the DX-COM-STICK Bluetooth communication stick.

➔ For more information on the DX-COM-STICK Bluetooth communication stick, please refer to manual MN040003EN, "drivesConnect · Parameter Configuration Software for PowerXL™ Variable Frequency Drives."

11.9.2 DX-COM-PCKIT

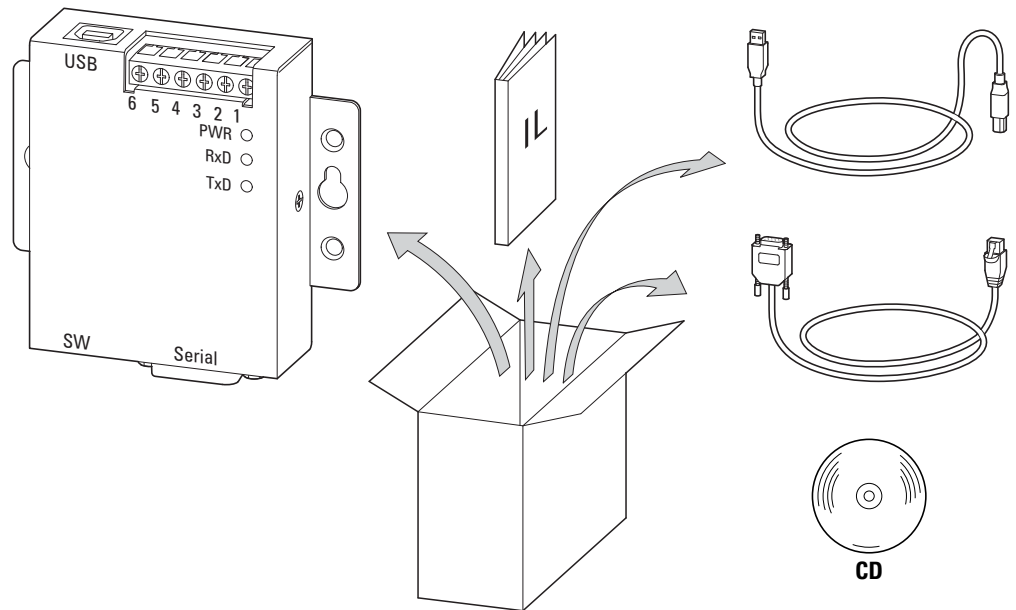


Figure 107: Equipment supplied with DX-COM-PCKIT
Instructional leaflet
Driver software
Cables

➔ The equipment supplied with the DC1 variable frequency drive does not include a DX-COM-PCKIT computer interface.

The DX-COM-PCKIT computer interface can be used to establish wired communications between a DC1 variable frequency drive and a computer running a Windows operating system (point-to-point connection).

➔ For more information on the DX-COM-PCKIT connection cable, please refer to manual MN040003EN, "drivesConnect · Parameter Configuration Software for PowerXL™ Variable Frequency Drives."

11.9.3 DX-CBL-PC1M5

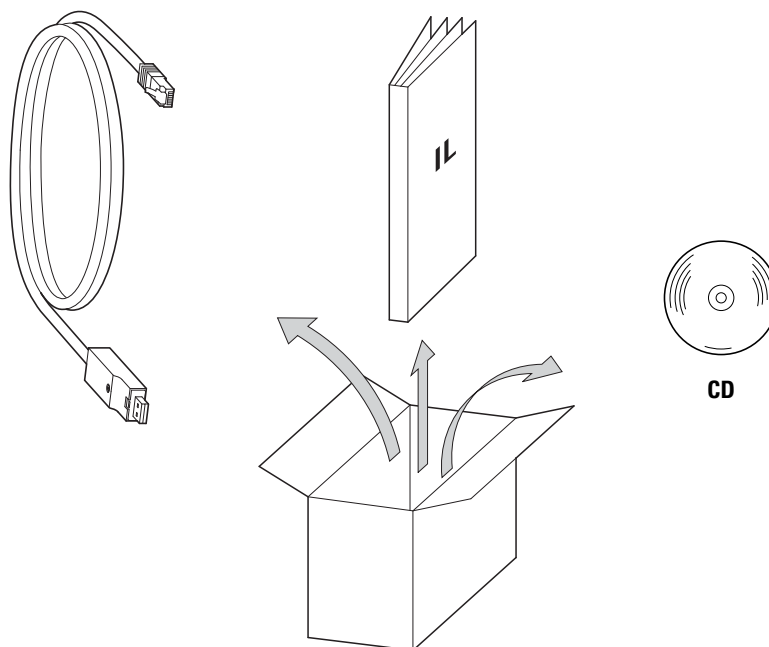


Figure 108: Equipment supplied with DX-CBL-PC-1M5
Instructional leaflet
Driver software
Cable

➔ The equipment supplied with the DC1 variable frequency drive does not include a DX-CBL-PC-1M5 computer interface.

The DX-CBL-PC-1M5 computer interface can be used to establish wired communications between a DC1 variable frequency drive and a computer running a Windows operating system (point-to-point connection).

➔ For more information on the DX-CBL-PC1M5 connection cable, please refer to manual MN040003EN, "drivesConnect · Parameter Configuration Software for PowerXL™ Variable Frequency Drives."

11.9.4 drivesConnect

The drivesConnect parameter configuration program can be used with a computer in order to quickly configure a DC1 variable frequency drive's parameters, as well as to control, diagnose, document (by printing and saving the corresponding parameter lists), and transfer data from and to the variable frequency drive.

The drivesConnect program is found in the CD enclosed with the variable frequency drive and can also be downloaded for free on the Internet.

To be able to use the function block editor's full functionality, you will need a license for it. A DX-COM-SOFT dongle is required for this purpose.

In order to establish a connection to the computer, you will need a DX-COM-STICK or the connection cable included with the DX-COM-PC-KIT or DX-CBL-PC-1M5.



For more information on drivesConnect and the various computer connection options, please refer to manual MN040003EN, "drivesConnect · Parameter Configuration Software for PowerXL™ Variable Frequency Drives."

11.10 Expansion modules

11.10.1 DXC-EXT-IO110, DXC-EXT-IO230

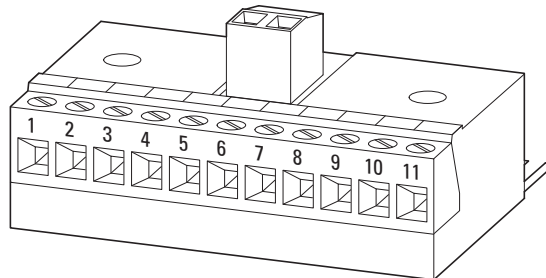


Figure 109: DXC-EXT-IO110 and DXC-EXT-IO230

The DXC-EXT-IO110 and DXC-EXT-IO230 expansion modules can be used to integrate the digital inputs on DC1 variable frequency drives directly into circuits with 110 VAC / 230 VAC. These inputs are galvanically isolated from the variable frequency drive.

11.10.1.1 Technical Data

Technical Data	Symbol	Unit	Value
Input voltage			
DXC-EXT-IO110	U	V	100 - 10 % - 120 + 10 %, 50/60 Hz (90 - 132 ± 0 %, 48 - 62 Hz ± 0 Hz)
DXC-EXT-IO230	U	V	200 - 10 % - 240 + 10 %, 50/60 Hz (180 - 264 ± 0 %, 48 - 62 Hz ± 0 Hz)
High signal			
DXC-EXT-IO110		%	80 - 250 , $R_i \approx 68 \text{ k}\Omega$
DXC-EXT-IO230			80 - 250 , $R_i \approx 68 \text{ k}\Omega$
Operation temperature		°C	0 - +50
Storage temperature		°C	-40 - +60
Degree of protection			IP00

11.10.1.2 mounting



For detailed instructions on how to install the expansion modules, please refer to instructional leaflet IL04012016Z.

NOTICE

Internal relay K1 is looped with the expansion module, meaning it can conduct a lower current ($\leq 1 \text{ A}$).



DANGER

Dangerous voltage!

Expansion modules DXC-EXT-IO110 and DXC-EXT-IO230 must not be placed into operation until all mounting and installation work has been completed. Any other use will be considered to be an inappropriate use.



The control signal terminals on the DC1 variable frequency drive are plug-in terminals. They can be screwed onto the expansion module in order to cover the pins (protection against contact).

11.10.1.3 Block diagram

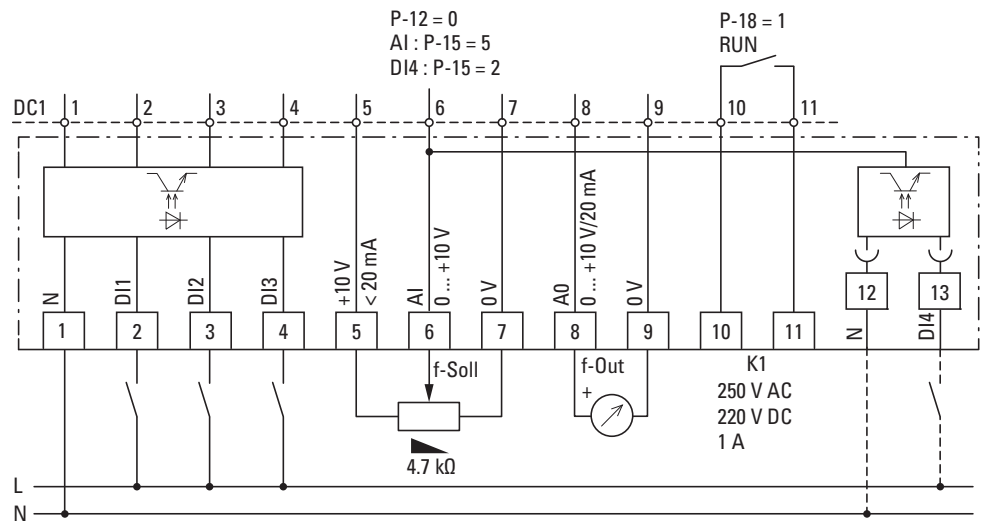


Figure 110: Block diagram DXC-EXT-IO110 and DXC-EXT-IO230

11.10.1.4 Parameter definition

- P-12 = 0 Terminal mode (WE)
- P-15 = 5 WE = The analog value on terminal 6 will be used as the frequency reference value (AI)
- P-15 = 2 Terminal 12 and 13 digital input active (DI4)
- P-18 = 0 RUN (WE)

11.10.2 DXC-EXT-2RO

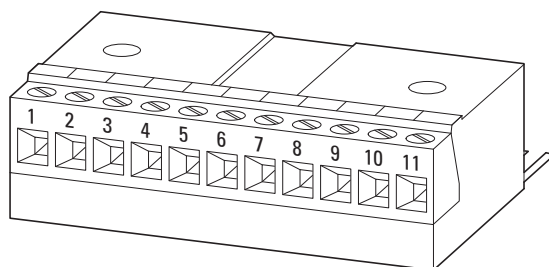


Figure 111: DXC-EXT-2RO

The DXC-EXT-2RO expansion module transforms the DC1 variable frequency drive's DO1 digital output into a K2 relay output. This provides the variable frequency drive with two potential-free relay contacts and enables it to switch mains voltages of up to 250 VAC and 220 VDC.

11.10.2.1 Technical Data

Technical Data	Symbol	Unit	Value
Input voltage, maximum		V DC	±50
Relay switching voltage			
K1		V	250 AC / 220 DC
K2		V	250 AC / 220 DC
Relay switching current			
K1		A	≅ 1
K2		A	≅ 1
Operation temperature		°C	-10 - +50
Degree of protection			IP00

11.10.2.2 mounting



For detailed instructions on how to install the module, please refer to instructional leaflet IL04012015Z.

NOTICE

Internal relay K1 is looped with the expansion module, meaning it can conduct a lower current (≅ 1 A).



DANGER

Dangerous voltage!

Expansion module DXC-EXT-2RO must not be placed into operation until all mounting and installation work has been completed. Any other use will be considered to be an inappropriate use.



The control signal terminals on the DC1 variable frequency drive are plug-in terminals. They can be screwed onto the expansion module in order to cover the pins (protection against contact).

11.10.2.3 Block diagram

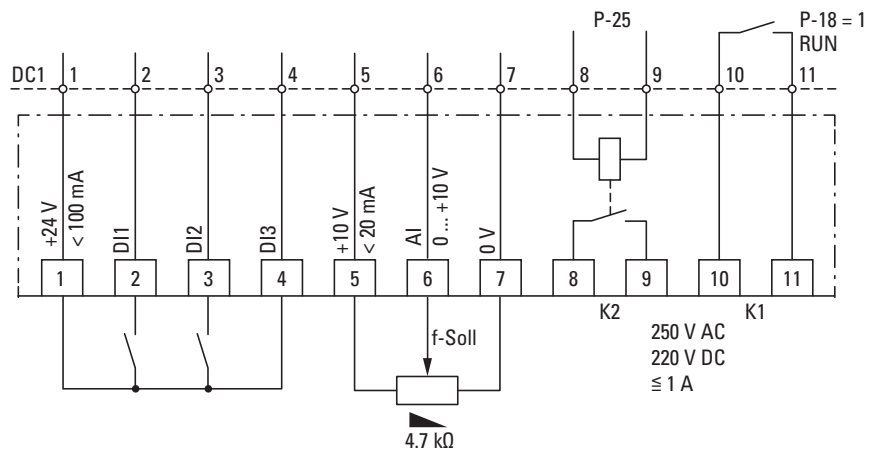


Figure 112: Block diagram DXC-EXT-2RO

11.10.2.4 Parameter definition

The K1 relay output's function can be configured using parameter P-18. Meanwhile, the new K2 relay output's function can be configured using parameter P-25.



For more information, please refer to application note AP040032.

NOTICE

Parameter P-25 must be set to a value between 0 and 7 and function as a digital output. If it is set to a value greater than 7, the K2 relay output will not work properly.

11.10.3 DXC-EXT-2R01AO

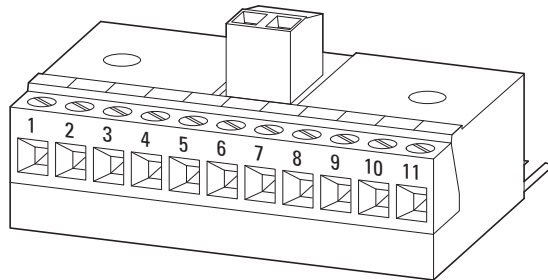


Figure 113: DXC-EXT-2R01AO

The DXC-EXT-2R01AO expansion module was developed for HVAC applications. It transforms the DC1 variable frequency drive's AO analog output into a K2 relay output. This provides the variable frequency drive with two potential-free relay contacts and enables it to switch mains voltages of up to 250 VAC and 220 VDC.. In addition, analog output AO will be retained and will output a voltage (0 - 10 V) that is proportional to the output frequency.

11.10.3.1 Technical Data

Technical Data	Unit	Value
Input voltage, maximum	V DC	±50
Output switching voltage		
K1	V	250 AC / 220 DC
K2	V	250 AC / 220 DC
AO	V	0 -10 DC
Relay switching current		
K1	A	≤ 1
K2	A	≤ 1
AO	mA	< 20
Operation temperature	°C	-10 - +50
Degree of protection		IP00

11.10.3.2 mounting



For detailed instructions on how to install the module, please refer to instructional leaflet IL04012014Z.

NOTICE

Internal relay K1 is looped with the expansion module, meaning it can conduct a lower current (≤ 1 A).



DANGER

Dangerous voltage!

Expansion module DXC-EXT-2RO1AO must not be placed into operation until all mounting and installation work has been completed. Any other use will be considered to be an inappropriate use.



The control signal terminals on the DC1 variable frequency drive are plug-in terminals. They can be screwed onto the expansion module in order to cover the pins (protection against contact).

11.10.3.3 Block diagram

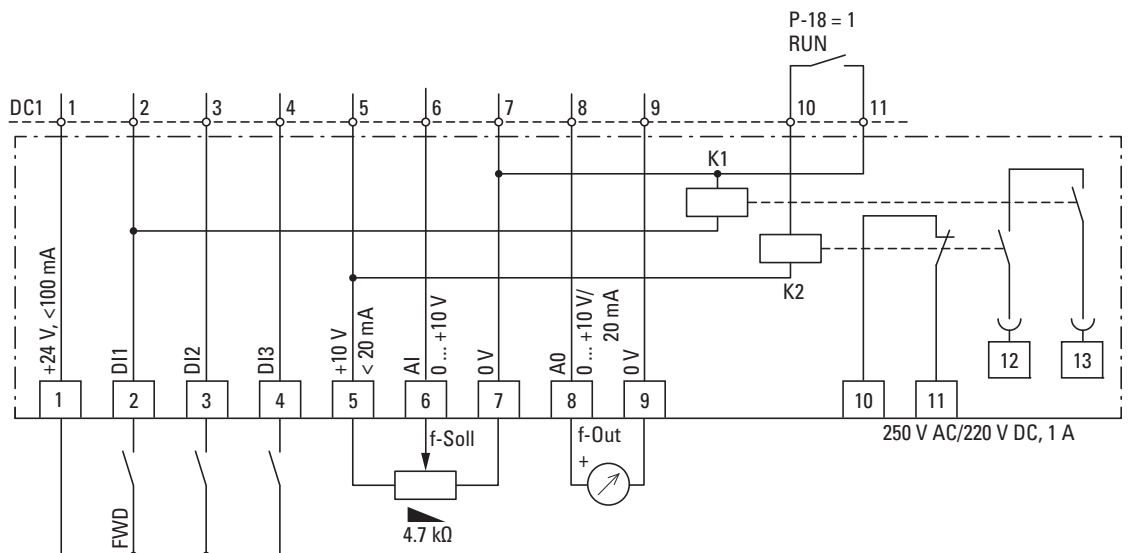


Figure 114: Block diagram DXC-EXT-2RO1AO

11.10.3.4 Parameter definition

NOTICE

Parameter P-25 must be set to a value between 0 and 7 and function as a digital output. If it is set to a value greater than 7, the K2 relay output will not work properly.

11.11 Cables and fuses

Select all the cross-sectional cable areas and cable protection fuses that you will be using in such a way as to comply with all applicable local standards.

For an installation in accordance with UL Standards, the fuses and copper cable that are UL-approved and have a heat-resistance of +60/75 °C are to be used.

Use power cables with insulation according to the specified mains voltages for the permanent installation. A screened cable is not required on the mains side. On the motor side however, a complete (360°), low-impedance, screened cable is necessary.

The length of the motor cable depends on the RFI class.

NOTICE

When selecting fuses and cables, make sure to always comply with all the regulations that apply at the installation site.

Table 24: Fusing and assigned cross-sectional areas

Device type	F1, Q1 =		L1/L, L2/N, L3		U, V, W		PE		DC+, DC-, BR	
	1~	3~	mm ²	AWG ¹⁾	mm ²	AWG ¹⁾	mm ²	AWG ¹⁾	mm ²	AWG ¹⁾
DC1-1D2D3...	16 15 ²⁾	–	2 x 1.5	2 x 14	3 x 1.5	3 x 14	1.5	14	1.5	14
DC1-1D4D3...	25	–	2 x 4	2 x 8	3 x 1.5	3 x 14	4	8	1.5	14
DC1-1D5D8...	32	–	2 x 4	2 x 10	3 x 1.5	3 x 14	4	10	1.5	14
DC1-122D3...	10	–	2 x 1.5	2 x 14	3 x 1.5	3 x 14	1.5	14	1.5	14
DC1-124D3...	16	–	2 x 1.5	2 x 14	3 x 1.5	3 x 14	1.5	14	1.5	14
DC1-127D0...	16	–	2 x 1.5	2 x 14	3 x 1.5	3 x 14	1.5	14	1.5	14
DC1-12011...	25	–	2 x 4	2 x 14	3 x 1.5	3 x 14	4	10	1.5	14
DC1-12015...	40	–	2 x 6	2 x 8	3 x 2.5	3 x 12	6	8	2.5	12
DC1-322D3...	–	6	3 x 1.5	3 x 14	3 x 1.5	3 x 14	1.5	14	1.5	14
DC1-324D3...	–	6	3 x 1.5	3 x 14	3 x 1.5	3 x 14	1.5	14	1.5	14
DC1-327D0...	–	10	3 x 1.5	3 x 14	3 x 1.5	3 x 14	1.5	14	2.5	12
DC1-32011...	–	16 15 ²⁾	3 x 2.5	3 x 12	3 x 1.5	3 x 14	2.5	12	4	10
DC1-32018...	–	20	3 x 2.5	3 x 12	3 x 2.5	3 x 12	2.5	12	4	10
DC1-342D2...	–	6	3 x 1.5	3 x 14	3 x 1.5	3 x 14	1.5	14	1.5	14
DC1-344D1...	–	6	3 x 1.5	3 x 14	3 x 1.5	3 x 14	1.5	14	1.5	14
DC1-345D8...	–	10	3 x 1.5	3 x 14	3 x 1.5	3 x 14	1.5	14	2.5	12
DC1-349D5...	–	16 15 ²⁾	3 x 1.5	3 x 14	3 x 1.5	3 x 14	1.5	14	2.5	12
DC1-34014...	–	20	3 x 2.5	3 x 12	3 x 2.5	3 x 12	2.5	12	2.5	12
DC1-34018...	–	25	3 x 4	3 x 10	3 x 2.5	3 x 12	4	10	4	10
DC1-34024...	–	32	3 x 6	3 x 8	3 x 6	3 x 8	6	8	6	8





1) AWG = American Wire Gauge

2) UL fuse with AWG

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11.11 Cables and fuses

Table 25: Specified fuses

Device type	Maximum permitted mains supply voltage U_{LN} [V]			 2)	 3)
		VDE [A]	UL ¹⁾ [A]	Part no. Eaton (VDE)	
DC1-1D2D3...	1 AC 115 V +10 %	16	15	FAZ-B16/1N	—
DC1-1D4D3...	1 AC 115 V +10 %	25	25	FAZ-B25/1N	—
DC1-1D5D8...	1 AC 115 V +10 %	32	35	FAZ-B32/1N	—
DC1-122D3...	1 AC 240 V +10 %	10	10	FAZ-B10/1N	—
DC1-124D3...	1 AC 240 V +10 %	10	10	FAZ-B10/1N	—
DC1-127D0...	1 AC 240 V +10 %	16	16	FAZ-B16/1N	—
DC1-12011...	1 AC 240 V +10 %	25	25	FAZ-B25/1N	—
DC1-12015...	1 AC 240 V +10 %	40	40	FAZ-B40/1N	—
DC1-322D3...	3 AC 240 V +10 %	6	6	FAZ-B6/3	PKM0-6,3
DC1-324D3...	3 AC 240 V +10 %	6	6	FAZ-B6/3	PKM0-6,3
DC1-327D0...	3 AC 240 V +10 %	10	10	FAZ-B10/3	PKM0-10
DC1-32011...	3 AC 240 V +10 %	16	15	FAZ-B16/3	PKM0-16
DC1-32018...	3 AC 240 V +10 %	20	20	FAZ-B20/3	PKM0-20
DC1-342D2...	3 AC 480 V +10 %	6	6	FAZ-B6/3	PKM0-6.3
DC1-344D1...	3 AC 480 V +10 %	6	6	FAZ-B6/3	PKM0-6.3
DC1-345D8...	3 AC 480 V +10 %	10	10	FAZ-B10/3	PKM0-10
DC1-349D5...	3 AC 480 V +10 %	16	15	FAZ-B16/3	PKM0-16
DC1-34014...	3 AC 480 V +10 %	20	20	FAZ-B20/3	PKM0-20
DC1-34018...	3 AC 480 V +10 %	25	25	FAZ-B25/3	PKM0-25
DC1-34024...	3 AC 480 V +10 %	32	35	FAZ-B32/3	PKM0-32

1) Fuse UL-rated, class T

2) $I_{cn} = 10$ kA

3) $I_{cn} = 50$ kA

11.12 Mains contactors



The mains contactors shown here allow for the input-side rated operating current ILN of the variable frequency drive without a mains choke.

The selection is based on the free air thermal current $\rightarrow I_{th} = I_e$ (AC-1) at the specified ambient temperature.

NOTICE

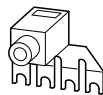
The inching operation is not permissible via the mains contactor (Pause time ≥ 30 s between switching off and on).



Technical data on the mains contactors can be found in the main catalog HPL, Contactors DILEM and DILM 7.

DILM12-XP1

P1DILEM



DILM

DILEM



DILM12-XP1

P1DILEM

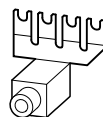


Figure 115: Mains contactor at single-phase connection

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11.12 Mains contactors

Table 26: Assigned mains contactors

Device type	Rated operating voltage		Rated input current I_{LN} [A]	Related mains contactor		
	(50 Hz)	(60 Hz)		Part no.	Thermal current AC-1	
	U_{LN}	U_{LN}			+50 °C I_N [A]	+40 °C I_N [A]
DC1-1D2D3...	1 AC 110 V	1 AC 120 V	11	DILEM-10 + DILM12-XP1	20	22
DC1-1D4D3...	1 AC 110 V	1 AC 120 V	19	DILEM-10 + DILM12-XP1	20	22
DC1-1D5D8...	1 AC 110 V	1 AC 120 V	25	DILEM-10 + DILM12-XP1	20	22
DC1-122D3...	1 AC 230 V	1 AC 240 V	5	DILEM-10 + DILM12-XP1 DILM7 ²⁾	20 21	22
DC1-124D3...	1 AC 230 V	1 AC 240 V	8.5	DILM7	21	22
DC1-127D0FN...	1 AC 230 V	1 AC 240 V	13.9	DILM7	21	22
DC1-127D0FB...	1 AC 230 V	1 AC 240 V	13.9	DILM7	21	22
DC1-12011...	1 AC 230 V	1 AC 240 V	19.5	DILM17	38	40
DC1-12015...	1 AC 230 V	1 AC 240 V	30.5	DILM17	38	40
DC1-322D3...	3 AC 230 V	3 AC 240 V	3.0	DILEM-10	20	22
DC1-324D3...	3 AC 230 V	3 AC 240 V	4.5	DILEM-10	20	22
DC1-327D0FN...	3 AC 230 V	3 AC 240 V	7.3	DILEM-10	20	22
DC1-327D0FB...	3 AC 230 V	3 AC 240 V	7.3	DILEM-10	20	22
DC1-32011...	3 AC 230 V	3 AC 240 V	11.0	DILM7	21	22
DC1-32018...	3 AC 230 V	3 AC 240 V	18.8	DILM7 DILM17 ¹⁾	21 38	22 40
DC1-342D2...	3 AC 400 V	3 AC 480 V	2.4	DILEM-10	20	22
DC1-344D1FN...	3 AC 400 V	3 AC 480 V	4.3	DILEM-10	20	22
DC1-344D1FB...	3 AC 400 V	3 AC 480 V	4.3	DILEM-10	20	22
DC1-345D8...	3 AC 400 V	3 AC 480 V	6.1	DILEM-10	20	22
DC1-349D5...	3 AC 400 V	3 AC 480 V	9.8	DILEM-10	20	22
DC1-34014...	3 AC 400 V	3 AC 480 V	14.6	DILM7	21	22
DC1-34018...	3 AC 400 V	3 AC 480 V	18.1	DILM7	21	22
DC1-34024...	3 AC 400 V	3 AC 480 V	24.7	DILM17	38	40

1) For UL® installation observe note → Page 208

2) Maximum operating temperature +40 °C



For UL®-compliant installation and operation, the switchgear on the mains side must allow for an input current that is 1.25 times higher. The switchgear listed here meets this requirement.

11.13 EMC cable brackets

DX-EMC-MNT-... cable brackets can be used to route and secure cables in a DC1 variable frequency drive's connection area. These cable brackets are mounted on the variable frequency drive's mains connection and motor sides and are then connected to the drive's ground connection.

The cable brackets' integrated hole pattern (M4 screw tread) makes it possible to secure the cables being connected and relieve any strain on them by using the corresponding gland plates. It also makes it possible to have a 360° EMC connection (PES) in the case of screened cables.

These cable brackets are made of galvanized sheet steel.

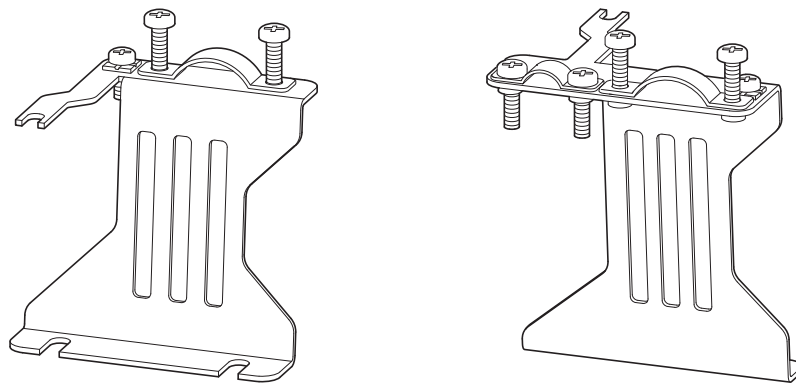


Figure 116: DX-EMC-MNT-1N (left) and DX-EMC-MNT-1M (right) cable brackets



For more information and technical data on DX-EMC-MNT-... EMC cable brackets, please refer to instructional leaflet IL040010ZU.



DX-EMC-MNT-... EMC cable brackets are sold as individual units. There are different brackets for each DC1 variable frequency drive size (FS1, FS2, and FS3). The gland plates and their fixing screws are included in the equipment supplied with the cable brackets.

Cable bracket	Size DC1	Gland plates
		Quantity / Designation
DX-EMC-MNT-1N	FS1	1 x / mains connection
DX-EMC-MNT-1M	FS1	2 x / control cables, motor connection
DX-EMC-MNT-2N	FS2	1 x / mains connection
DX-EMC-MNT-2M	FS2	3 x / control cables, motor connection, external braking resistance
DX-EMC-MNT-3N	FS3	1 x / mains connection
DX-EMC-MNT-3M	FS3	3 x / control cables, motor connection, external braking resistance

11.14 Radio interference suppression filter

The DX-EMC1... and DX-EMC3... external radio interference suppression filters can be used to further limit emitted interference (EMC) in the relevant environment. The ability to stay within the permissible limits (category C1, C2, C3) in the 1st environment (public grid) or 2nd environment (industrial supply network) will depend on the motor cable length and on switching frequency f_{PWM} of the inverter in the DC1 variable frequency drive.

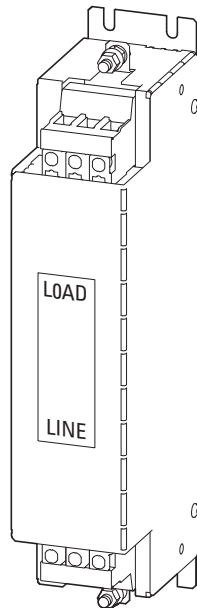


Figure 117: Radio interference suppression filter



The DX-EMC1... and DX-EMC3... radio interference suppression filters must only be used together with the recommended DC1-...N... variable frequency drives (which do not have an integrated radio interference suppression filter). In the case of variable frequency drives with an internal radio interference suppression filter, the EMC screw must be used instead.

The radio interference suppression filters can be mounted side by side with the variable frequency drives without any lateral clearance between them. The connection must be made on the mains side (LINE) using screw terminals L and N in DX-EMC12-... devices and terminals L1, L2, L3 in DX-EMC34-... devices. The variable frequency drives need to be connected to the screw terminals labeled LOAD.

The PE connection needs to be made using the stud marked with a grounding symbol. The radio interference suppression filters have low leakage currents. The rated value at 50 Hz with mains voltage fluctuations of $\pm 10\%$ is < 3.00 mA for DX-EMC1... devices and < 0.40 mA for DX-EMC3... devices.



For more information and technical data on the DX-EMC1... and DX-EMC3... radio interference suppression filters, please refer to instructional leaflet IL04012017ZU.

Table 27: Motor cable lengths and pulse frequencies with external Radio interference suppression filter¹⁾

Device type DC1...	Recommended radio interference suppression filter	Mains connection				EMC category (maximum permissible motor cable length)					
		Stages Count	U _{LN} [V]	I _e [A]	I _{PE} [mA]	C1		C2		C3	
						l [m]	f _{PWM} [kHz]	l [m]	f _{PWM} [kHz]	l [m]	f _{PWM} [kHz]
DC1-122D3N...	DX-EMC12-008	1	230	8							
DC1-S24D3N...	DX-EMC12-008	1	230	8							
DC1-1D2D3N...	DX-EMC12-012	1	115	12							
DC1-S27D0N...	DX-EMC12-012	1	115	12							
DC1-S24D3N...	DX-EMC12-012	1	230	12							
DC1-S27D0N...	DX-EMC12-012	1	230	12							
DC1-S1011N...	DX-EMC12-016	1	115	16							
DC1-127D0N...	DX-EMC12-016	1	230	16							
DC1-S2011N...	DX-EMC12-016	1	230	16							
DC1-1D4D3N...	DX-EMC12-020	1	115	20							
DC1-12011N...	DX-EMC12-020	1	230	20							
DC1-1D5D8N...	DX-EMC12-030	1	115	30							
DC1-12015N...	DX-EMC12-030	1	230	30							
DC1-322D3N...	DX-EMC34-008	3	230	8							
DC1-324D3N...	DX-EMC34-008	3	230	8							
DC1-327D0N...	DX-EMC34-008	3	230	8	< 6	50	16	100	16	125	16
DC1-342D2N...	DX-EMC34-008	3	400	8							
DC1-344D1N...	DX-EMC34-008	3	400	8	<6	5	16	20	8	50	4
DC1-345D8N...	DX-EMC34-008	3	400	8							
DC1-349D5N...	DX-EMC34-012	3	400	12	< 6	25	4	50	4	60	4
DC1-32011N...	DX-EMC34-016	3	230	16	< 6	20	4	75	4	100	4
DC1-34014N...	DX-EMC34-016	3	400	16							
DC1-32018N...	DX-EMC34-030	3	230	30							
DC1-34018N...	DX-EMC34-030	3	400	30	< 6.5	60	16	125	16	125	16
DC1-34024N...	DX-EMC34-030	3	400	30	< 6.5	20	4	35	16	50	16

1) DX-EMC... external radio interference suppression filters have low leakage currents (I_{PE}).

11.15 Braking resistances

Braking resistances convert the mechanical braking energy produced during extended periods of dynamic operation or when braking large moments of inertia into heat.

Braking resistances can be connected to terminals BR and DC+ on DC1 variable frequency drives with a size of FS2 or FS3.

11.15.1 DX-BR3-100

Braking resistance DX-BR-100 can be installed directly inside the heat sink in FS2 and FS3 DC1 variable frequency drives.

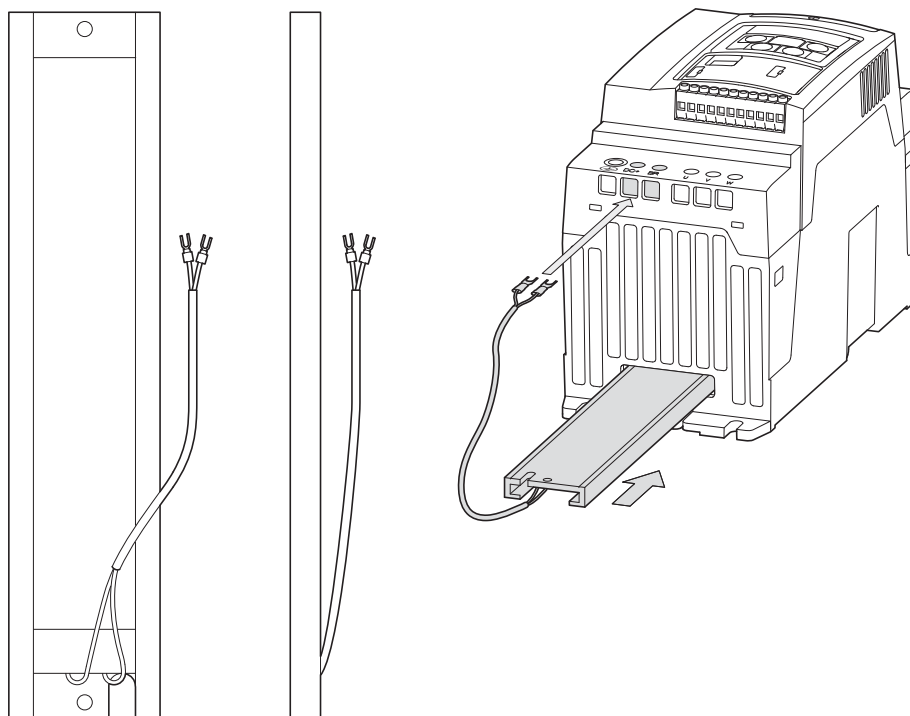


Figure 118: Braking resistance DX-BR3-100



For detailed instructions on how to install the braking resistance, please refer to instructional leaflet IL0412024ZU.

NOTICE

Do not install braking resistance DX-BR-100 unless the system is de-energized first!

Table 28: Technical data DX-BR3-100

Technical Data	Formula sign	Unit	Value
Rated operating voltage	U	V DC	900
Resistor	R	Ω	100 \pm 10
Continuous rating	P _{DB}	CO	200
Peak power	P _{Peak}	kW	12 for 1.25 s
Duty factor	ED	%	5

Table 29: Rating and short-time rating

Part no.	R _B [Ω]	P _{DB} [W]	P _{max} [W]	PDB (UL®) [W]	P _{max} (UL®) [W]
DX-BR050-0K4	50	400	3236	400	3236
DX-BR100-0K8	100	800	6084	800	6084
DX-BR047-3K1	47	3100	12945	3100	12945
DX-BR050-0K8	50	800	3236	800	3236
DX-BR100-1K6	100	1600	6084	1600	6084
DX-BR047-5K1	47	5100	12945	5100	12945
DX-BR100-6K2	100	6200	6084	6200	6084
DX-BR047-9K2	47	9200	12945	9200	12945

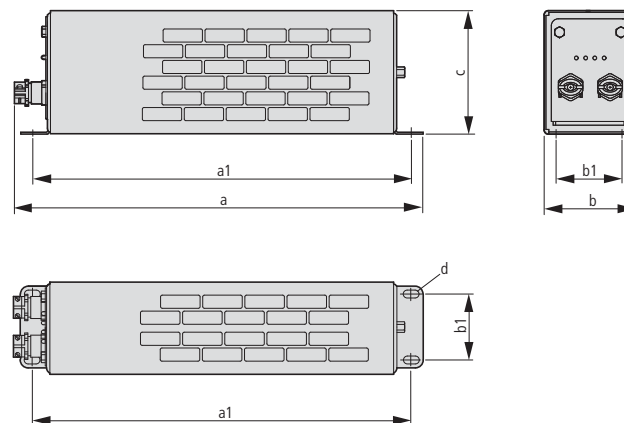


Figure 119: Dimensions

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11.15 Braking resistances

Table 30: Braking resistance dimensions and weights

Part no.	a [mm]	a1 [mm]	B [mm]	b1 [mm]	c [mm]	d [mm]	m [kg]
DX-BR050-0K4	445	425	95	70	95	6 x 12	2.1
DX-BR100-0K8	445	425	140	120	120	6 x 12	4.0
DX-BR047-3K1	485	380	326	300	301	9	12.0
DX-BR050-0K8	445	425	140	120	120	6 x 12	4.0
DX-BR100-1K6	445	425	280	120	120	6 x 12	8.0
DX-BR047-5K1	485	380	426	380	301	9	15.5
DX-BR100-6K2	485	380	526	500	301	9	18.0
DX-BR047-9K2	485	380	626	600	301	9	20.5

Table 31: Recommended braking resistances

Part no.	DC1-127D0	DC1-12011	DC1-12015	DC1-327D0	DC1-32011	DC1-32018	DC1-344D1	DC1-345D8	DC1-349D5	DC1-34014	DC1-34018	DC1-34024
Permissible R_{min}	47 Ω	47 Ω	47 Ω	47 Ω	47 Ω	47 Ω	47 Ω	47 Ω	47 Ω	47 Ω	47 Ω	47
Duty factor	ED [%]	ED [%]	ED [%]	ED [%]	ED [%]	ED [%]	ED [%]	ED [%]	ED [%]	ED [%]	ED [%]	
DX-BR050-0K4	10	10	10	10	10	10	–	–	–	–	–	–
DX-BR100-0K8	–	–	–	–	–	–	10	10	10	–	–	–
DX-BR047-3K1	40	40	40	40	40	40	–	–	–	10	10	10
DX-BR050-0K8	20	20	20	20	20	20	–	–	–	–	–	–
DX-BR100-1K6	–	–	–	–	–	–	20	20	20	–	–	–
DX-BR047-5K1	–	–	–	–	–	–	–	–	–	20	20	20
DX-BR100-6K2	–	–	–	–	–	–	40	40	40	–	–	–
DX-BR047-9K2	–	–	–	–	–	–	–	–	–	40	40	40

11.16 Mains chokes

Allocating the mains chokes is done according to the rated input currents of the variable frequency drive (without upstream main choke).

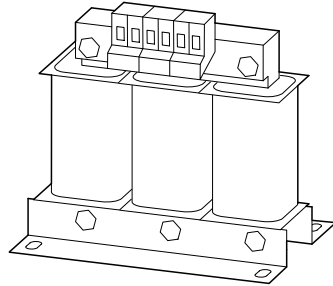


Figure 120: main chokes DEX-LN...



When the variable frequency drive is running at its rated current limit, the mains choke with a u_K value of around 4% will cause the variable frequency drive's maximum possible output voltage (U_2) to be reduced to about 96% of the mains voltage (U_{LN}).



Mains chokes reduce the magnitude of the current harmonics up to about 30 % and increase the lifespan of variable frequency drives and upstream-connected switching devices.

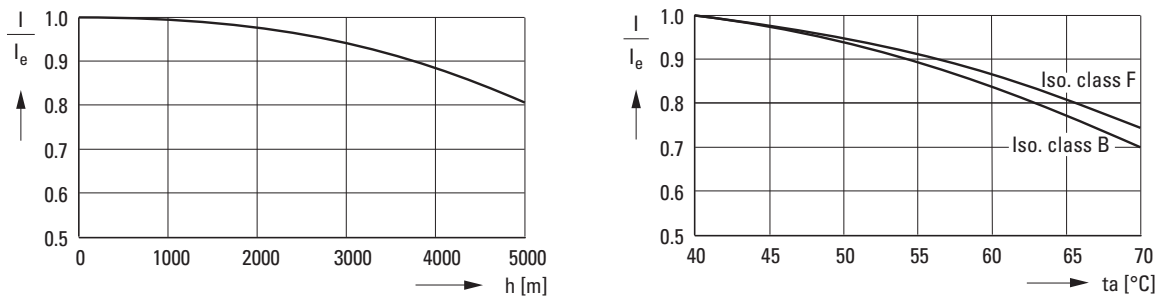


Figure 121: Derating values for deviating installation altitudes and ambient air temperatures



Further information and technical data on the mains chokes of the DX-LN... series is provided in instructional leaflet IL00906003Z.

11 Annex

11.16 Mains chokes

Table 32: Compatible DX-LN1... single-phase main chokes

Device type	Rated input current	Assigned motor choke			
	I_{LN} [A]	Part no.	Rated operational current I_e [A]	frequency f [Hz]	Voltage U_{LNmax} [V]
DC1-122D3...	5	DX-LN1-006	5.8	50/60 ±10 %	260 +0 %
DC1-124D3...	8.5		8.6		
DC1-1D2D3...	11	DX-LN1-013	13	50/60 ±10 %	260 +0 %
DC1-127D0...	13.9	DX-LN1-018	18	50/60 ±10 %	260 +0 %
DC1-1D4D3...	19	DX-LN1-024	24	50/60 ±10 %	260 +0 %
DC1-12011...	19.5				
DC1-1D5D8...	25	DX-LN1-032	32	50/60 ±10 %	260 +0 %
DC1-12015...	30.5				

Table 33: Compatible DX-LN3... three-phase main chokes

Device type	Rated input current	Assigned motor choke			
	I_{LN} [A]	Part no.	Rated operational current I_e [A]	frequency f [Hz]	Voltage U_{LNmax} [V]
DC1-322D3...	3	DX-LN3-004	4	50/60 ±10 %	550 +0 %
DC1-432D2...	2.4				
DC1-324D3...	4.5	DX-LN3-006	6	50/60 ±10 %	550 +0 %
DC1-324D1...	4.3				
DC1-345D8...	6.1				
DC1-327D0...	7.3	DX-LN3-010	10	50/60 ±10 %	550 +0 %
DC1-349D5...	9.8				
DC1-32011...	11	DX-LN3-016	16	50/60 ±10 %	550 +0 %
DC1-34014...	14.6				
DC1-32018...	18.8	DX-LN3-025	25	50/60 ±10 %	550 +0 %
DC1-34018...	18.1				
DC1-34024...	24.7				

11.17 Motor chokes

A motor choke is in the output of the variable frequency drive. Its rated operational current must always be greater than/equal to the rated operational current of variable frequency drive.

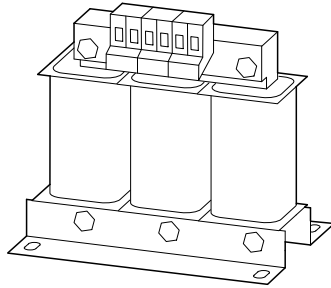
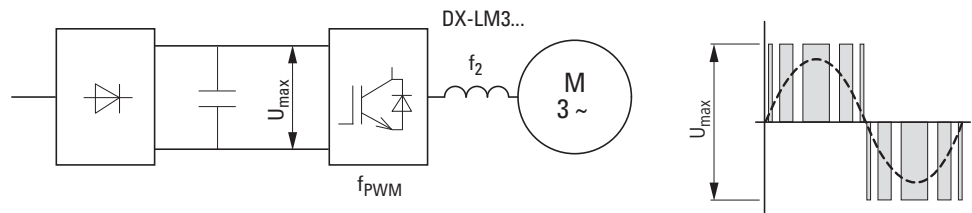


Figure 122: Motor choke DX-LM3...



When multiple motors are connected in parallel in the motor choke, the rated operational current of the motor choke must be greater than the total current of all motors.

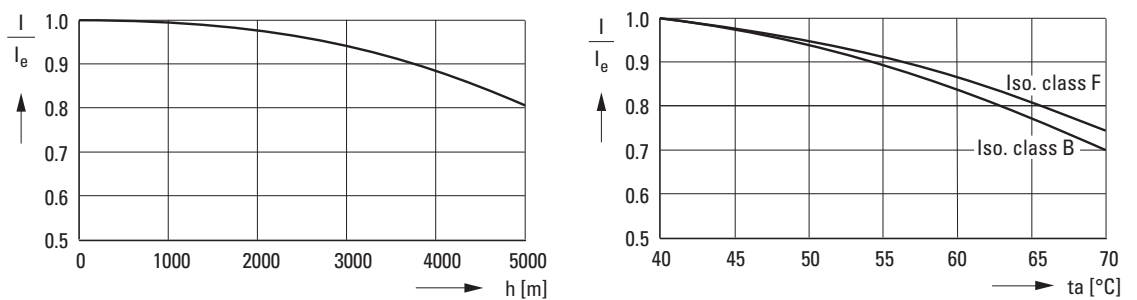


Figure 123: Derating values for deviating installation altitudes and ambient air temperatures



Further information and technical data on the motor chokes of the DX-LM3... series is provided in instructional leaflet IL00906003Z.

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11.17 Motor chokes

Table 34: Allocation of the motor chokes for variable frequency drives of the 230-V class

Device type	Rated operational current I_e [A]	Assigned motor choke		Assigned motor output			
		at ambient temperature to +50 °C	Rated operational current I_e [A]	(230 V, 50 Hz)		(220 - 240 V, 60 Hz)	
				P [kW]	I_e [A]	P [HP]	I_e [A]
DC1-122D3...	2.3	DX-LM3-005	5	0.37	2	0.5	2.2
DC1-124D3...	4.3	DX-LM3-005	5	0.75	3.2	1	4.2
DC1-127D0...	7	DX-LM3-008	8	1.5	6.3	2	6.8
DC1-12011...	10.5	DX-LM3-011	11	2.2	8.7	3	9.6
DC1-12015...	15	DX-LM3-016	16	4	14.8	5	15
DC1-1D2D3...	2.3	DX-LM3-005	5	0.37	2	0.5	2.2
DC1-1D4D3...	4.3	DX-LM3-005	5	0.75	3.2	1	4.2
DC1-1D5D8...	5.8	DX-LM3-008	8	1.1	4.6	1.5	5.8
DC1-322D3...	2.3	DX-LM3-005	5	0.37	2	0.5	2.2
DC1-324D3...	4.3	DX-LM3-005	5	0.75	3.2	1	4.2
DC1-327D3...	7	DX-LM3-008	8	1.5	6.3	2	6.8
DC1-32011...	10.5	DX-LM3-008	8	2.2	8.7	3	9.6
DC1-32018...	18	DX-LM3-035	35	4	14.8	5	15.2

Notes:

- Max. power supply (U_{max}): 750 V \pm 0 %
- Maximum permissible frequency: 200 Hz
- Maximum permissible pulse frequency (f_{PWM}): 12 kHz

Table 35: Compatible motor chokes for 400-V class variable frequency drives

Device type	Rated operational current I_e [A]	Assigned motor choke		Assigned motor output			
		at ambient temperature to +50 °C	Rated operational current I_e [A]	(400 V, 50 Hz)		(440 - 480 V, 60 Hz)	
				P [kW]	I_e [A]	P [HP]	I_e [A]
DC1-342D2...	2.2	DX-LM3-005	5	0.75	1.9	1	2.1
DC1-344D1...	4.1	DX-LM3-005	5	1.5	3.6	2	3.4
DC1-345D8...	5.8	DX-LM3-008	8	2.2	5	3	4.8
DC1-349D5...	9.5	DX-LM3-011	11	4	8.5	5	7.6
DC1-34014...	14	DX-LM3-016	16	5.5	11.3	7.5	11
DC1-34018...	18	DX-LM3-035	35	7.5	15.2	10	14
DC1-34024...	24	DX-LM3-035	35	11	21.7	15	21

Notes:

- Max. power supply (U_{max}): 750 V \pm 0 %
- Maximum permissible frequency: 200 Hz
- Maximum permissible pulse frequency (f_{PWM}): 12 kHz

11.18 Sine filter

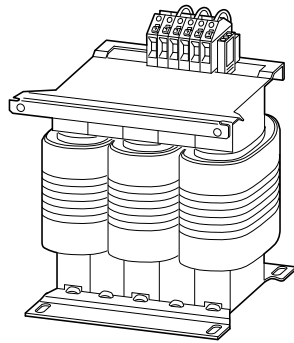


Figure 124: Sine filter DX-SIN3...

The DX-SIN3... sine filter removes high-frequency components from the variable frequency drive's output voltage (U_2). This reduces the conducted and radiated emission. The sine filter's output voltage has a sine wave shape with a small superimposed ripple voltage. The sinusoidal voltage's total harmonic distortion is typically 5 to 10%. This reduces noise and losses in the motor.

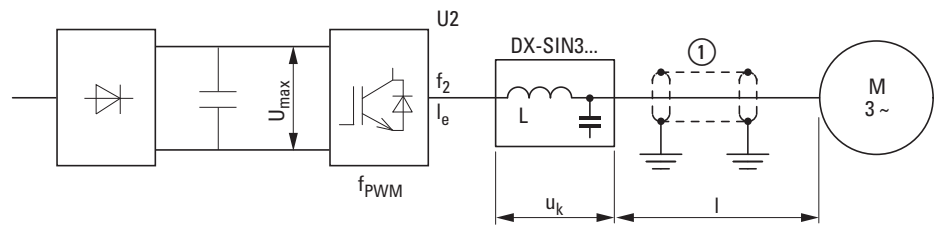


Figure 125: Maximum permissible motor cable lengths

- ① **Screened motor cable:** $U_2 \leq 230 \text{ V} \rightarrow \leq 200 \text{ m (656.17 ft)}$; $U_2 \leq 500 \text{ V} \rightarrow \leq 150 \text{ m (492.13 ft)}$
Unscreened motor cable: $U_2 \leq 230 \text{ V} \rightarrow \leq 300 \text{ m (924.25 ft)}$; $U_2 \leq 500 \text{ V} \rightarrow \leq 200 \text{ m (656.17 ft)}$

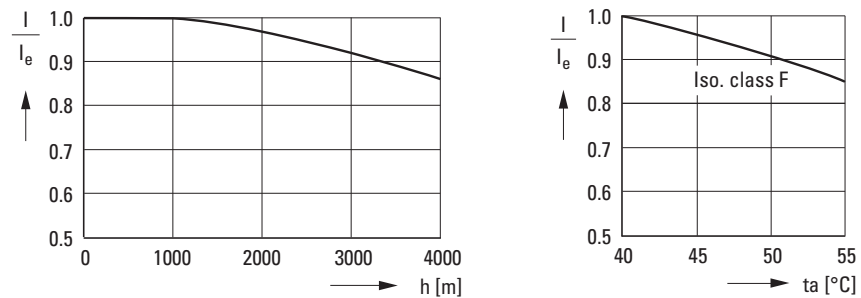


Figure 126: Derating values for deviating installation altitudes and ambient air temperatures



For more information and technical data regarding DX-SIN3... series sine filters, please consult instructional leaflet IL00906001Z.

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11.18 Sine filter

Table 36: Assignment of sine filters

Device type	Rated operational current I_e [A]	Assigned sine filter Part no.	I_e [A]	f_2 [Hz]	U_k [%]	U_{e1} [V]	f_{PWM1} [kHz]	U_{e2} [V]	f_{PWM2} [kHz]								
DC1-122D3...	2.3	DX-SIN3-004	4	0 - 150	7.5	0 - 440	3 - 8	0 - 520	4 - 8								
DC1-1D2D3...	2.3																
DC1-322D3...	2.3																
DC1-432D2...	2.2																
DC1-124D3...	4.3	DX-SIN3-010	10	0 - 150	7	0 - 440	3 - 8	0 - 520	4 - 8								
DC1-1D4D3...	4.3																
DC1-324D3...	4.3																
DC1-324D1...	4.1																
DC1-127D0...	7																
DC1-1D5D8...	5.8																
DC1-327D0...	7																
DC1-345D8...	5.8																
DC1-349D5...	9.5																
DC1-12011...	10.5									DX-SIN3-016	16.5	0 - 150	7.5	0 - 440	3 - 8	0 - 520	4 - 8
DC1-32011...	10.5																
DC1-12015...	15																
DC1-32018...	18	DX-SIN3-023	23.5	0 - 150	8	0 - 440	3 - 8	0 - 520	4 - 8								
DC1-34018...	18																
DC1-34024...	24	DX-SIN3-032	32	0 - 150	8.7	0 - 440	3 - 8	0 - 520	4 - 8								

Note:

Sine filter DX-SIN3... should only be operated with fixed pulse frequencies:

- Range f_{PWM1} at rated operating voltage U_{e1}
- Range f_{PWM2} at rated operating voltage U_{e2}

11.19 List of parameters

Table 37: List of parameters

PNU	ID	Access right		Value	Description	DS	Page / Application note
		RUN	ro/rw				
P-01	129	✓	rw	0 - 250 Hz (max. 500 Hz)	Maximum frequency / maximum speed	50.0	114, 114
P-02	130	✓	rw	0 - 250 Hz (max. 500 Hz)	Minimum frequency / minimum speed	0.0	114
P-03	131	✓	rw	0.1 - 600 s	Acceleration time (acc1)	5.0	114; AP040016
P-04	132	✓	rw	0.1 - 600 s	Deceleration time (dec1)	5.0	114, 107; AP040016
P-05	133	✓	rw		Stop Function	1	118; AP040018
				0	Ramp, deceleration = dynamic braking.		
				1	Free coasting		
				2	Ramp, quick stop = dynamic braking		
P-06	134	✓	rw		Energy optimization	0	AP040040
				0	Deactivated		
				1	Activated		
P-07	135	–	rw	0.20 - 230/500 V	Nominal motor voltage	230 ¹⁾	38, 114, 114; AP040014
P-08	136	✓	rw	Depending on device	Rated motor current	4.8 ¹⁾	38, 109; AP040014
P-09	137	–	rw	25 - 500 Hz	Rated motor frequency	50.0 ¹⁾	38, 114, 114; AP040014
P-10	138	✓	rw	0 - 30000 rpm (min ⁻¹)	Nominal speed of the motor	0	38, 110; AP040022, AP040014
P-11	139	✓	rw	0.00 - 20.0 %	Voltage amplification	3.0	114; AP040036

1) Depends on the variable frequency drive's rated power

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11.19 List of parameters

PNU	ID	Access right		Value	Description	DS	Page / Application note
		RUN	ro/rw				
P-12	140	–	rw		Control level	0	98, 100, 105, 138, 153
				0	Control signal terminals		
				1	Keypad (FWD)		
				2	Keypad (FWD/REV)		
				3	Modbus (internal ramp times)		
				4	Modbus (bus ramp times)		
				5	PI controller with external actual value		
				6	PI controller with external actual value and totalized value of AI1		
				7	CANopen (internal ramp times)		
				8	CANopen (CANopen ramp times)		
				9	SmartWire-DT (SWD control command and setpoint value)		
				10	SmartWire-DT (SWD control command; internal setpoint value)		
				11	SmartWire-DT (SWD setpoint value; internal control command)		
				12	SmartWire-DT (control will depend on the configuration in the event of a loss of communications; automatic switch to local control)		
13	SmartWire-DT (SWD control command and setpoint value; in addition, an enable signal via DI1 and an enable setpoint via DI2)						
P-13	141	–	ro	P-DEF	Fault log history	–	163
P-14	142	✓	rw	0 - 9999	Access code (P-15 to P-53 → 101)	0	97; AP040020
Extended parameter range (access: P-14 = 101)							
P-15	143	–	rw	0 - 12	Function of digital inputs	5	98, 100
P-16	144	✓	rw		Analog input 1 (AI1), signal range	V0-10	AP040024
				0 = U0 - 10	0 - 10-V signal (FWD)		
				1 = b - 10 - 10	0 - 10-V signal (FWD/REV)		
				2 = RU - 20	0 - 20 mA signal		
				3 = t 4 - 20	4 - 20 mA signal		
				4 = r 4 - 20	4 - 20 mA signal		
				5 = t 20 - 4	20 - 4 mA signal		
6 = r 20 - 4	20 - 4 mA signal						
P-17	145	✓	rw	8, 12, 16, 24, 32	Pulse frequency	16 ¹⁾	

1) Depends on the variable frequency drive's rated power

PNU	ID	Access right		Value	Description	DS	Page / Application note
		RUN	ro/rw				
P-18	146	✓	rw		K1 signal (Relay Output 1)	0	118; 130; AP040030
				0	RUN, enable (FWD, REV)		
				1	READY, variable frequency drive ready for operation		
				2	Output frequency = frequency reference value		
				3	Error message (variable frequency drive not ready)		
				4	Output frequency \geq limit value (P-19)		
				5	Output current \geq limit value (P-19)		
				6	Output frequency < limit value (P-19)		
				7	Output current < limit value (P-19)		
P-19	147	✓	rw	0 - 200.0 %	K1-Limit value (relay)	100.0	118, 131; AP040030
P-20	148	✓	rw	0 - 50 Hz	Fixed frequency FF1 / speed 1	15.0	124; AP040038
P-21	149	✓	rw	0 - 50 Hz	Fixed frequency FF2 / speed 2	0.0	124; AP040038
P-22	150	✓	rw	0 - 50 Hz	Fixed frequency FF3 / speed 3	0.0	124; AP040038
P-23	151	✓	rw	0 - 50 Hz	Fixed frequency FF4 / speed 4	0.0	124; AP040038
P-24	152	✓	rw	0.1 - 25.0 s	Second deceleration time (dec2)	0.0	107; AP040016
P-25	153	✓	rw		AO1 signal (Analog Output) Switch to digital output	8	119, 131
					DO1 (digital output 1) → +24 VDC (values 0 - 7)		
				0	RUN (variable frequency drive enabled and running – FWD, REV)		
				1	READY, variable frequency drive ready for operation / no faults		
				2	Output frequency = frequency reference value		
				3	Error message (variable frequency drive is not ready)		
				4	Output frequency \geq limit value (P-19)		
				5	Output current \geq limit value (P-19)		
				6	Output frequency < limit value (P-19)		
				7	Output current < limit value (P-19)		
		Analog output → 0 - 10 V DC (value 8, 9)					
8	Output frequency f-Out → 0 - 100 % f_{max} (P-01)						
9	Output current → 0 - 200 % I_e (P-08)						
P-26	154	✓	rw	0.00 - 50.00 Hz	Frequency skip 1, bandwidth (hysteresis range)	0	126; AP040026
P-27	155	✓	rw	0.00 - 50.00 Hz	Frequency skip 1, center	0	126; AP040026
P-28	156	–	rw	0.00 - P-07 V	V/Hz characteristic curve modification voltage	0	114; AP040036
P-29	157	–	rw	0.00 - P-09 Hz	V/Hz characteristic curve modification frequency	0	114; AP040036

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11.19 List of parameters

PNU	ID	Access right		Value	Description	DS	Page / Application note	
		RUN	ro/rw					
P-30	158	✓	rw		REAF, Start function with automatic restart, control signal terminals	E d 9 E - r	132; AP040028	
				0 = E d 9 E - r	Disabled			
				1 = R U E o - 0	Automatic start			
				2 = R U E o - 1	Automatic start: once			
				3 = R U E o - 2	Automatic start: two times			
				4 = R U E o - 3	Automatic start: three times			
				5 = R U E o - 4	Automatic start: four times			
P-31	159	✓	rw		Start function with automatic restart, operating unit.	1	129; AP040028	
				0	Minimum frequency/speed; keypad			
				1	Previous speed, keypad			
				2	Minimum frequency/speed; terminal			
P-32	160	✓	rw	0 - 25 s	DC current braking	0	119	
P-33	161	✓	rw		Motor pick-up control function (to catch spinning motors) (in sizes FS2 and FS3) / DC braking, braking time at start (in size FS1)	0	119	
				0	Deactivated			
				1	Activated			
P-34	162	✓	rw		Brake chopper activation (in sizes FS2 and FS3)	0	119; AP040024	
				0	Locked			
				1	Enabled with overload protection braking resistance			
P-35	163	✓	rw	0 - 500 %	Analog input 1 scaling	100	122	
P-36	164	-	rw		Serial communication configuration		138, 153	
				1 - 63	Variable frequency drive slave address	1		
					Modbus RTU baud rate	6		
				2	9.6 kBit/s			
				3	19.2 Kbit/s			
				4	38.4 kBit/s			
				5	57.6 kBit/s			
				6	115.2 kBit/s			
					TimedOut	3000		138, 154
				0	0			
1	t 30 ms							
2	t 100 ms							

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11.19 List of parameters

PNU	ID	Access right		Value	Description	DS	Page / Application note
		RUN	ro/rw				
				3	t 1000 ms		
				4	t 3000 ms		
				5	r 30 ms		
				6	r 100 ms		
				7	r 1000 ms		
				8	r 3000 ms		
P-37	165	✓	rw	0 - 9999	Access code definition	101	97; AP040020
P-38	166	✓	rw		Parameter access lock	0	97; AP040020
				0	Deactivated		
				1	Activated		
P-39	167	✓	rw	-500.0 - +500.0 %	Offset for analog input 1	0.0	AP040024
P-40	168	✓	rw	0.00 - 6,000	Speed display scaling factor	0.00	AP040034
P-41	169	✓	rw	0.0 - 30.0	PI controller, proportional gain	1.0	
P-42	170	✓	rw	0.0 - 30.0 s	PI controller, integral time	1.0	
P-43	171	✓	rw		PI controller, operating mode	0	
				0	direct operation		
				1	Reverse action		
P-44	172	✓	rw		PI controller, reference value/setpoint value	0	
				0	Digital, preset setpoint value (P-45)		
				1	Analog input 1		
P-45	173	✓	rw	0.0 - 100.0 %	PI digital setpoint value	0.0	
P-46	174	✓	rw		PI controller, feedback	0	
				0	Analog input 2		
				1	Analog input 1		
				2	Motor current		
P-47	175	✓	rw		Analog input 2 (AI2), signal range	t 4-20	121; AP040024
				0 = U 0 - 10	0 - 10 V signal		
				1 = A 0 - 20	0 - 20 mA		
				2 = t 4 - 20	4 - 20 mA (≤ 3 mA \rightarrow error message: 4-20F)		
				3 = r 4 - 20	4 - 20 mA (≤ 3 mA \rightarrow delay time 1)		
				4 = t 20 - 4	20 - 4 mA (≤ 3 mA \rightarrow error message: 4-20F)		
				5 = r 20 - 4	20 - 4 mA (≤ 3 mA \rightarrow delay time 1)		
P-48	176	✓	rw	0.1 - 25.0 s	Standby-time	20	
				0	Deactivated		
P-49	177	✓	rw	0.0 - 100.0 %	PI controller, feedback wakeup level	0	

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11.19 List of parameters

PNU	ID	Access right		Value	Description	DS	Page / Application note
		RUN	ro/rw				
P-50	178	✓	rw		CANopen Baud rate	2	154
				0	125 kbit/s		
				1	250 kBit/s		
				2	500 kBit/s		
				3	1000 kBit/s		
P-51	179	✓	rw		Motor overload protection	0	
				0	Thermal map is lost after the device is switched off		
				1	Thermal map is retained after the device is switched off		
P-52	180	✓	rw		Parameter access	0	→ Manual MN04012009Z
				0	Keypad / field bus		
				1	SmartWire-DT		
P-53	181	✓	rw		Reaction to the communication fault	0	→ Manual MN04012009Z
				0	No response: device keeps running		
				1	Sets warning bit, Device keeps running		
				2	Sets error bit: stop with ramp		
				3	Sets error bit: stop with second ramp		
				4	Sets error bit: switches power off		

PNU	ID	Access right ro/rw	Unit	Value	Description	Page / Appli- cation note
P00-...-Display values						
P00-01	20	ro	%	0 - 100	Analog input 1	103
P00-02	21	ro	%	0 - 100	Analog Input 2	
P00-03	23	ro	Hz/rpm		Reference frequency/reference speed	
P00-04	11	ro		DI1 - DI4 status	Digital inputs 1 - 4	
					State of the variable frequency drive's digital input	
P00-05		ro		0	Reserved	
P00-06		ro		0	Reserved	
P00-07		ro	V		Motor voltage	
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