PowerXL™

DC1
Frequency Inverter

E·T·N

Powering Business Worldwide

Danger!
Dangerous electrical voltage!

Before commencing the installation

- Disconnect the power supply of the device.

- Ensure that devices cannot be accidentally restarted.

- Verify isolation from the supply.

- Earth and short circuit the device.

- Cover or enclose any adjacent live components.

- Follow the engineering instructions (AWA/IL) for 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, PES) must be connected to the protective earth (PE) or the potential equalisation. The system installer is responsible for implementing this connection.

- Connecting cables and signal lines should be installed so that inductive or capacitive interference does 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 interface so that an open circuit on the signal side does not result in undefined states in the automation devices.

- Ensure a reliable electrical isolation of the extra-low voltage of the 24 V supply. Only use power supply units complying with IEC 60364-4-41 (VDE 0100 Part 410) or HD384.4.41 S2.

- Deviations of the mains voltage from the rated value must not exceed the tolerance limits given in the specifications, 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-stop devices must not cause a restart.

- Devices that are designed for mounting in housings or control cabinets must only be operated and controlled after they have been installed and with the housing closed. Desktop or portable units must only be operated and controlled in enclosed housings.

- 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-stop devices should be implemented.

- Wherever faults in the automation system may cause injury or material damage, 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.).

- Depending on their degree of protection, frequency inverters may contain live bright metal parts, moving or rotating components or hot surfaces during and immediately after operation.

- Removal of the required covers, improper installation or incorrect operation of motor or frequency inverter may cause the failure of the device and may lead to serious injury or damage.

- The applicable national accident prevention and safety regulations apply to all work carried on live frequency inverters.

- The electrical installation must be carried out in accordance with the relevant regulations (e. g. with regard to cable cross sections, fuses, PE).

- Transport, installation, commissioning and maintenance work must be carried out only by qualified personnel (IEC 60364, HD 384 and national occupational safety regulations).

- Installations containing frequency inverters must be provided with additional monitoring and protective devices in accordance with the applicable safety regulations. Modifications to the frequency inverters using the operating software are permitted.

- All covers and doors must be kept closed during operation.

- To reduce the hazards for people or equipment, the user must include in the machine design measures that restrict the consequences of a malfunction or failure of the drive (increased motor speed or sudden standstill of motor). These measures include:

  - Other independent devices for monitoring safety-related variables (speed, travel, end positions etc.).
  - Electrical or non-electrical system-wide measures (electrical or mechanical interlocks).
  - Never touch live parts or cable connections of the frequency inverter after it has been disconnected from the power supply. Due to the charge in the capacitors, these parts may still be live after disconnection. Fit appropriate warning signs.

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Table of contents

0 About this manual

This manual contains special information required for the correct selection and connection a DC1 frequency inverter and its configuration to your specific requirements using the parameters. The details apply to the indicated hardware and software versions. The manual describes all sizes of the DC1 device series. The differences and special characteristics of each rating level and size are listed accordingly.

0.1 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.

0.2 Writing conventions

Symbols used in this manual have the following meanings:

▶ Indicates instructions to be followed.

→ Indicates useful tips.

> *NOTICE*
> Warns about the possibility of material damage.

> ⚠ **CAUTION**
> Warns of the possibility of hazardous situations that may possibly cause slight injury.

> ⚠ **DANGER**
> Warns of hazardous situations that result in serious injury or death.

For greater clarity, the name of the current chapter and the name of the current section are shown in the page header.

➔ In order to make it easier to understand some of the figures included in this manual, the housing of the frequency inverter, as well as other safety-relevant parts, have been left out. However, it is important to note that the frequency inverter must always be operated with its housing placed properly, 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:

http://www.eaton.com/moeller ➔ **Support**

0.3 Abbreviations

The following abbreviations are used in this manual.

dec	Decimal (base-10 numeral system)
DS	Default settings
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
LCD	Liquid Crystal Display
LSB	Least significant bit
MSB	Most significant bit
PDS	Power Drive System (magnet system)
PE	Protective earth ⏚
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)
UL	Underwriters Laboratories

0.4 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 frequency inverter'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 connection voltages for the DC1 series are listed in the Technical Specifications section in the appendix.

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

0.5 Units

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

0 About this manual

0.5 Units

1 DC1 device series

1.1 Introduction

DC1 series frequency inverters are ideally suited to applications involving the simple frequency control of three-phase motors within an output range of 0.37 kW (at 230 V) to 11 kW (at 400 V) and AC motors within an output range of 0.37 to 1.1 kW (at 230 V).

DC1 series devices feature a compact and rugged design and are available in three sizes (FS1, FS2, FS3), as well as with protection types IP20 and IP66. For protection type IP66, there is also a model with a mains switch and controls for local control available.

Due to their ease of use and handling, the innovative technology behind them, and a high level of reliability, DC1 frequency inverters are particularly suitable for use in general applications. 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.

The computer-supported parameter configuration software 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.

1.2 System overview
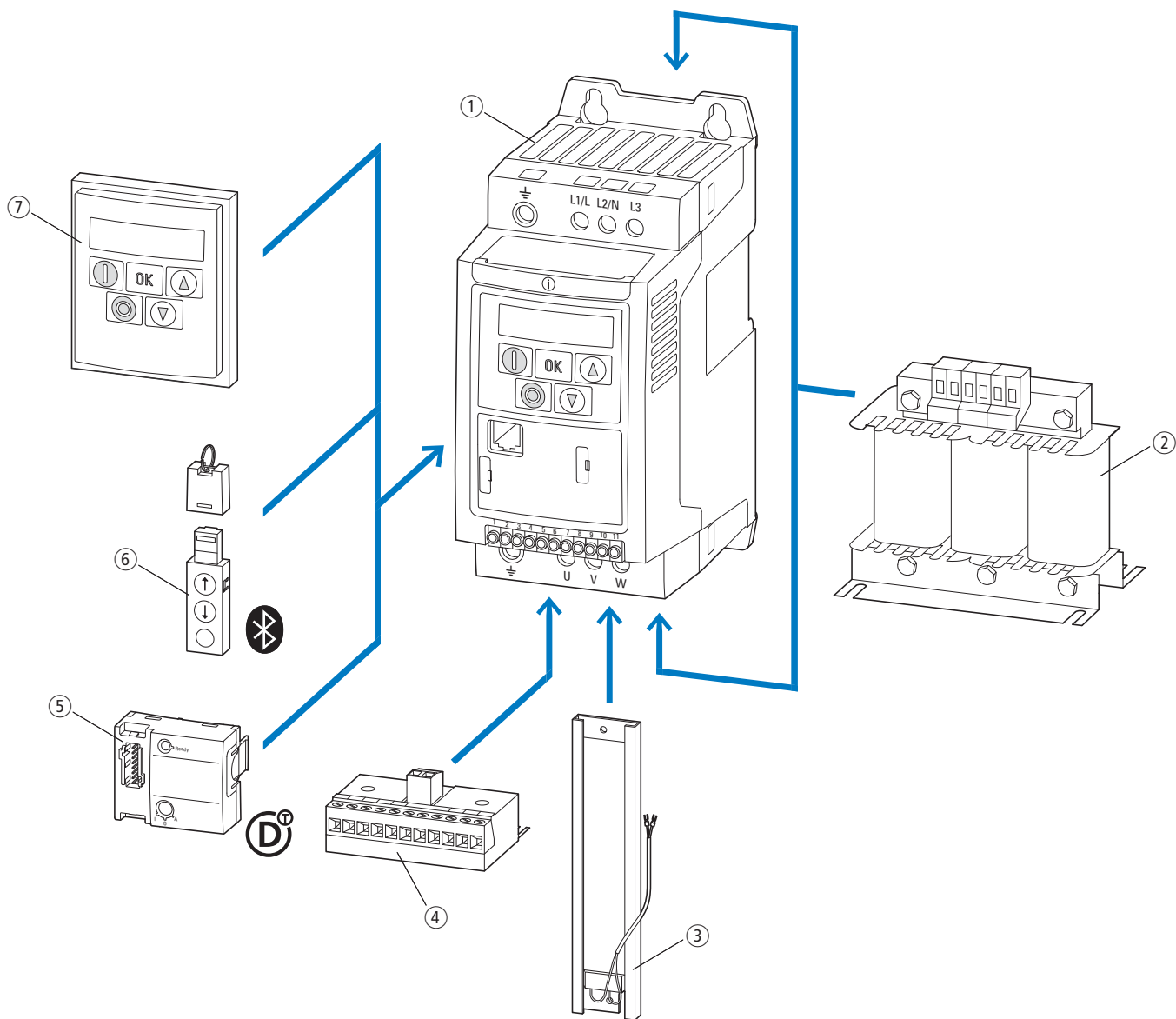
Figure 1: DC1 frequency inverters system overview

① DC1-… frequency inverters
② DX-LN-… main chokes, DX-LM3-… motor reactors, DX-SIN3-… sinusoidal filters
③ DX-BR… braking resistance
④ DXC-EXT-… expansion module
⑤ DXC-NET-… fieldbus connection
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 label on it to make sure that you received the correct frequency inverter.
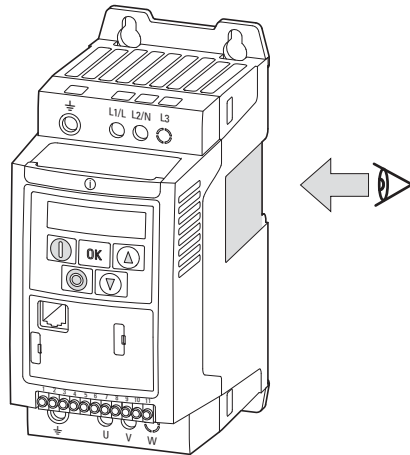
Figure 2: Location of nameplate on DC1 frequency inverter

The DC1 series frequency inverters 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.

The packaging must contain the following parts:

- DC1 series frequency inverter,
- an instructional leaflet
    - IL04020009Z,
    - IL04020013Z for devices with protection type IP66
    - IL04020014Z for DC1-S2… series frequency inverters for single-phase AC motors
- A data carrier (CD-ROM) containing documentation for DC1 series frequency inverters
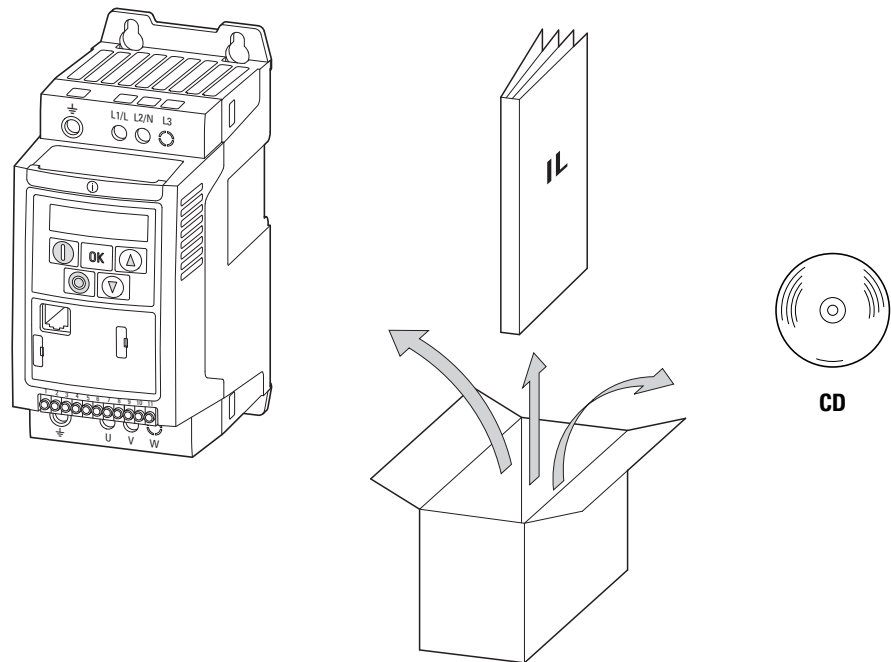
Figure 3:   Equipment supplied with DC1 frequency inverter

1.4 Rated data

Voltage categories

DC1 frequency inverters are divided into following voltage categories:

- 110 V: DC1-1**D**…
- 230 V: DC1-1**2**…, DC1-S**2**…, DC1-3**2**…
- 400 V: DC1-3**4**…

1.4.1 Rating data on the nameplate

The device-specific rated operational data for the DC1 frequency inverter 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 frequency inverter 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 radio interference suppression filter B = Integrated brake chopper A = LED display (7-segment text display) 20 = IP20 protection type N = Standard basic device
Input	Power connection rating: Three-phase AC voltage (U_e 3~ AC), 380 - 480 V voltage, 50/60 Hz frequency, input phase current (5.1 A).
Output	Load side (motor) rating: 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
→ [i]	Frequency inverter is an electrical apparatus. Read the manual (in this case MN04020003Z-EN) before making any electrical connections and commissioning.
IP20/Open type	Protection type of the housing: IP 20, UL (cUL) Open type
25072012	Manufacturing date: 25.07.2012

1.4.2 Key to part numbers

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

Series – Power section – Model – Version

The following figure shows it in greater detail:

```
D  C  1  -  1  2  4  D  1  F  N  -  A  2  0  N          Explanation
```

Type
N = Standard basic device

Protection type
20 = IP20 / NEMA 0
66 = IP66 / NEMA 4X
6S = IP66 with switch / NEMA 4X, switched

Display unit (display)
A = LED display
B = OLED display

Brake Chopper
N = No internal brake chopper
B = Brake chopper

EMC (radio interference suppression filter)
N = No internal RFI filter
F = Internal RFI filter

Rated operational current (examples)
2D2 = 2.2 A
4D1 = 4.1 A
024 = 24 A

Mains voltage category
1 = 110 V (110 - 115 V ±10 %)
2 = 230 V (200 - 240 V ±10 %)
4 = 400 V (380 - 480 V ±10 %)
D = 110 V input / 230 V output (voltage doubler)

Connection in power section
1 = Single-phase mains connection / three-phase motor connec-
3 = Three-phase mains connection / three-phase motor connec-
S = Single-phase mains connection / single-phase motor

Device series
DC1 = Frequency inverter, compact, Series 1
(D = Drives, C = Compact, 1 = Series)

Figure 4:   Key to part numbers of the DC1 frequency inverters

Catalog number examples

Inscription	Meaning
DC1-124D1FN-A20N	DC1 = DC1 series frequency inverter 1 = Single-phase mains connection / three-phase motor connection 2 = 230 V mains voltage category (200 - 240 V ±10 %) 4D1 = 4.1 A rated operational current (output current) F = Internal radio interference suppression filter (RFI, EMC measure) N = No internal brake chopper A = LED display (7-segment) on operating unit 20 = Protection type IP20 / NEMA 0 N = Standard basic device[1]
DC1-S27D0FB-A20N	DC1 = DC1 series frequency inverter S = Single-phase mains connection / single-phase motor connection for AC motors 2 = 230 V mains voltage category (200 - 240 V ±10 %) 7D0 = 7 A rated operational current (output current) F = Internal radio interference suppression filter (RFI, EMC measure) B = Internal brake chopper. An external braking resistor (optional) is required for this function. A = LED display (7-segment) on operating unit 20 = Protection type IP20 / NEMA 0 N = Standard basic device[1]
DC1-34024NB-A20N	DC1 = DC1 series frequency inverter 3 = Three-phase mains connection / three-phase motor connection 4 = 400 V mains voltage category (380 - 480 V ±10 %) 024 = 24 A rated operational current (output current) N = No internal radio interference suppression filter (RFI)[2] B = Internal brake chopper. An external braking resistor (optional) is required for this function. A = LED display (7-segment) on operating unit 20 = Protection type IP20 / NEMA 0 N = Standard basic device[1]
DC1-342D2FN-A6SN	DC1 = DC1 series frequency inverter 3 = Three-phase mains connection / three-phase motor connection 4 = 400 V mains voltage category (380 - 480 V ±10 %) 2D2 = 2.2 A rated operational current (output current) F = Internal radio interference suppression filter (RFI, EMC measure) N = No internal brake chopper A = LED display (7-segment) on operating unit 6S = Protection type IP66 / NEMA 4X with switches (mains switch, enable/phase sequence, potentiometer) for local control N = Standard basic device[1]

1) Standard version = with Modbus
2) For frequency inverters without an internal EMC filter, external measures for complying with the relevant limits concerning electromagnetic compatibility (EMC) must be taken for operation as per IEC/EN 61800-3 (e.g., external radio interference suppression filter).

➜ An external radio interference suppression filter is required for DC1… N… for operation as per IEC/EN 61800-3.

1.4.3 General rated operational data

Technical Data	Formula sign	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
Production quality			RoHS, ISO 9001
Climatic proofing	ρ_w	%	< 95 %, average relative humidity (RH), non-condensing (EN 50178)
Ambient air 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	-10 - +60
Electrostatic discharge (ESD, EN 61000-4-2:2009	V	kV	±4, contact discharge ±8, air discharge
Fast transient burst (EFT/B, EN 61000-4-4: 2004)	V	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	V	kV	±1, phase to phase/neutral conductor ±2, phase/neutral conductor to earth
380 - 480 V	V	kV	±2, phase to phase ±4, phase to earth
Dielectric strength (flash, EN 61800-5-1: 2007)			
110 - 115 V, 200 - 240 V	V	kV	1.5
380 - 480 V	V	kV	2.5
Radio interference class (EMC)			
Category and maximum screened motor cable length			
C1	l	m	1, only with sizes FS1 and FS2 for single-phase mains voltages (110 - 115 V, 200 - 240 V)
C2	l	m	5
C3	l	m	25
Mounting position			Vertical, max. ±30 °
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	Formula sign	Unit	Value
Main circuit / power section			
Power supply system			
Rated operational voltage			
DC1-1D…	U_e	V	1~ 110 (110 V - 0 % - 115 V +10 %, → U_2 = 230 V)
DC1-S2…, 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	p.f.		> 98
Phase Imbalance		%	max. 3
Maximum short-circuit current (supply voltage)	I_q	kA	5
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 monitors 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-S2…	U_2	V	1~ 0 - U_e (for single-phase AC motor)
DC1-12…, DC1-32…, DC1-34…	U_2	V	3~ 0 - U_e
Output Frequency			
Range, parameterizable	f_2	Hz	0 - 50/60 (max. 500 Hz)
Resolution		Hz	0.1
Overload current			
for 60 s		%	150
for 2 s		%	175
Pulse frequency			
FS1	f_{PWM}	kHz	16 (max. 32)
FS2, FS3	f_{PWM}	kHz	8 (max. 32)
Operating mode			V/Hz control, slip compensation
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

Technical Data	Formula sign	Unit	Value
Control section			
Control Voltage			
Output voltage (control terminal 1)	U_C	V	24, DC
Load rating (control terminal 1)	I_1	mA	100
Reference voltage (control terminal 5)	U_S	V	10, DC
Load rating (control terminal 5)	I_5	mA	20
Digital input (DI)			
Count			3 (4)
Logic (level)			Increase
Response time	t	ms	< 4
Input voltage range High (1)	U_C	V	8 - 30, DC
Input voltage range Low (0)	U_C	V	0 - 4, DC
Analog Input (AI)			
Count			1 (2)
Resolution			12-bit
Accuracy		%	< 1 to the final value
Response time	t	ms	< 4
Input voltage range	U_S	V	0 - 10, DC (R_i ~ 72 kΩ)
Input current range	I_S	mA	0/4 - 20 (R_B ~ 500 Ω)
Digital Output (DO)			
Count			1 (analog/digital) / 1 relay
Output voltage	U_{out}	V	0 - 10, DC
Output current	I_{out}	mA	0/4 - 20
Relays			N/O contact, 6 A (250 V AC) / 5 A (30 V DC)
Interface (RJ45)			RS485, Modbus RTU
Control level			Control signal terminal/operating unit/interface

1.4.4 Features

Part no.	Rated current I_e [A]	Assigned motor power				EMV filter (integrated) N = No F = Yes	Brake chopper (integrated) N = No B = Yes	Degree of protection IP	Size FS
		P (230 V, 50 Hz) [kW]	[A][1]	P (220 - 240 V, 60 Hz) [HP]	[A][1]				
Mains supply voltage: 1 AC 230 V **Motor connection voltage: 1 AC 230 V, 50/60 Hz (AC motor)**									
DC1-S24D3…	4.3	0.37	3	1/2	4.9	N, F	N	IP20, IP66	FS1
DC1-S27D0…	7	0.75	5	1	8	N, F	N	IP20, IP66	FS1
DC1-S2011…	11	1.1	7.5	1-1/2	10	N, F	N, B	IP20, IP66	FS2
Mains supply voltage: 1 AC 115 V, 50/60 Hz (voltage doubler), EMC: no internal 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**									
DC1-1D2D3N…	2.3	0.37	2	1/2	2.2	N	N	IP20, IP66	FS1
DC1-1D4D3N…	4.3	0.75	3.2	1	4.2	N	N	IP20, IP66	FS1
DC1-1D5D8N…	5.8	1.1	4.6	1-1/2[2]	6[2]	N	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	N, B	IP20, IP66	FS2
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, F	N	IP20, IP66	FS1
DC1-324D3…	4.3	0.75	3.2	1	4.2	N, F	N	IP20, IP66	FS1
DC1-327D0xN…	7	1.5	6.3	2	6.8	N, F	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	N, B	IP20, IP66	FS2
DC1-32018…	18	4	14.8	5	15.2	N, F	N, B	IP20, IP66	FS3

1) The rated motor currents apply to normal internally and surface-cooled three-phase asynchronous motor
(1500 rpm at 50 Hz, 1800 rpm at 60 Hz).

2) Take motor data into account (6 A = normalized rated value as per UL 580 C)
Operation may be limited to a reduced motor load.

1 DC1 device series
1.4 Rated data

Part no.	Rated current I_e [A]	Assigned motor power P (400 V, 50 Hz) [kW]	[A][1]	P (440 - 480 V, 60 Hz) [HP]	[A][1]	EMC filter (integrated) N = No F = Yes	Brake chopper (integrated) N = No B = Yes	Degree of protection IP	Size FS
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	N, B	IP20, IP66	FS2
DC1-349D5…	9.5	4	8.5	5	7.6	N, F	N, B	IP20, IP66	FS2
DC1-34014…	14	5.5	11.3	7-1/2	11	N, F	N, B	IP20, IP66	FS3
DC1-34018…	18	7.5	15.2	10	14	N, F	N, B	IP20, IP66	FS3
DC1-34024…	24	11	21.7	15	21	N, F	N, B	IP20, IP66	FS3

1) The rated motor currents apply to normal internally and surface-cooled three-phase asynchronous motor
(1500 rpm at 50 Hz, 1800 rpm at 60 Hz).

1.5 DC1 layout

The following drawing shows examples of named elements of the DC1 frequency inverters in different frame sizes.
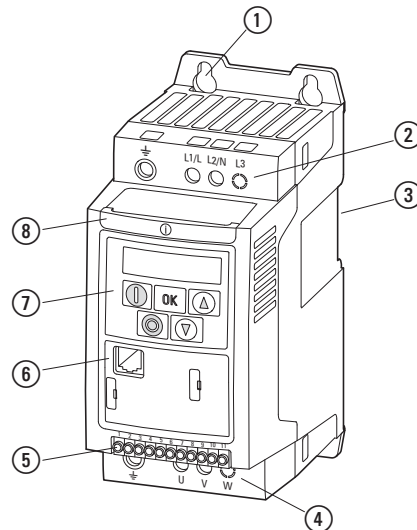

Figure 5:   DC1 frequency inverter layout, sizes FS1, FS2, and FS3

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 terminals (plug-in)
⑥ Communication interface (RJ45)
⑦ Operating unit with 5 control buttons and LED display
⑧ Info card

1.6 Features

DC1 series frequency inverters 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.
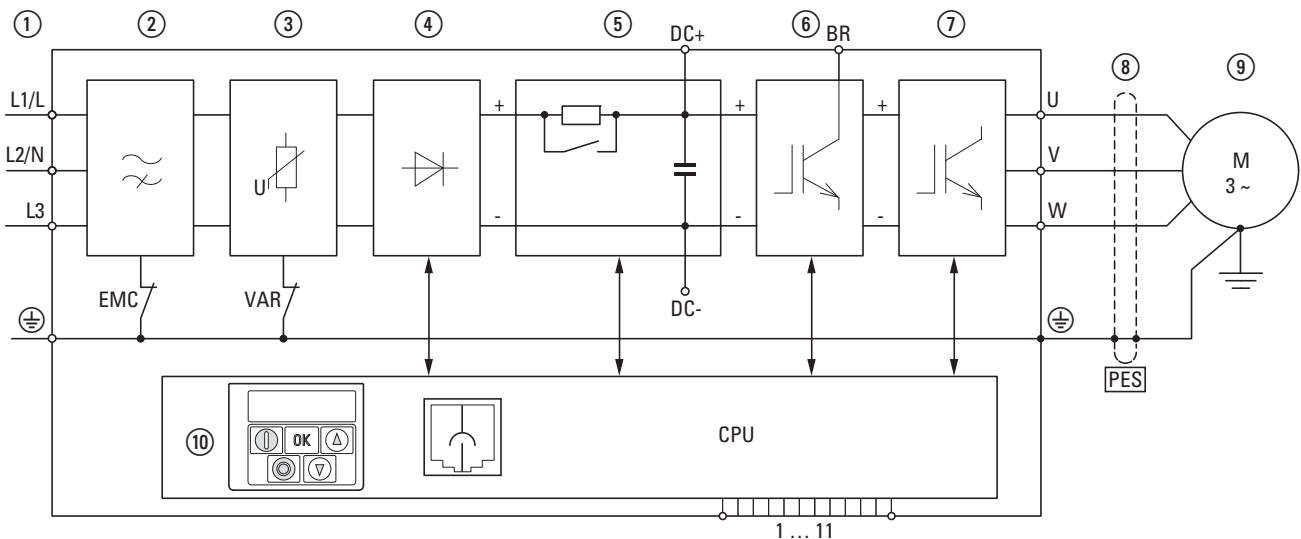
Figure 6: Block diagram; components in a DC1 frequency inverter

① L1/L, L2/N, L3, PE supply; mains supply voltage $U_{LN} = U_e$ at 50/60 Hz:
  DC1-S2… (1 AC 230 V) for AC motors
  DC1-1D…: single-phase mains connection (1 AC 115 V), with voltage doubler
  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 DC link with charging resistor, capacitor and switched-mode power supply unit (SMPS = Switching-Mode Power Supply).
⑥ Brake chopper for external braking resistor (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 the 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-S2…: 4.3 - 11 A
DC1-1D…: 2.3 - 5.8 A
DC1-12…: 2.3 - 10.5 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
Variable speed control of motors for assigned motor shaft powers (P_2):
DC1-1D…: 0.37 - 1.1 kW (230 V, 50 Hz) or 0.5 - 1 HP (230 V, 60 Hz)
DC1-12…: 0.37 - 2.2 kW (230 V, 50 Hz) or 0.5 - 3 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)
AC motor for assigned motor shaft powers (P_2):
DC1-S2…: 0.37 - 1.1 kW (230 V, 50 Hz) or 0.5 - 1.5 HP (230 V, 60 Hz)

⑩ Control section with operating unit and control buttons, 7-digital display assembly, control voltage, plug-in control signal terminals, relays, and RJ-45 port for computer and fieldbus connection

1.7 Selection criteria

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

The rated output current I_e of the frequency inverter must be greater than or equal to the rated motor current.
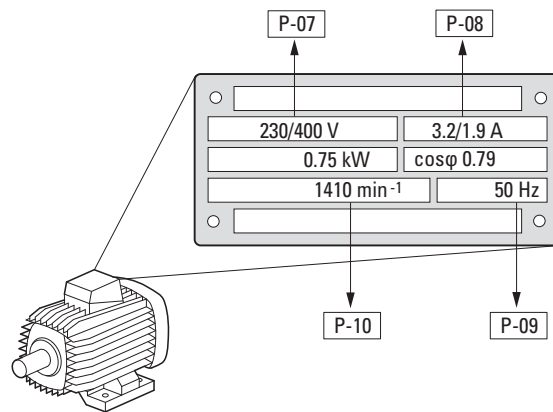
Figure 7:   Selection criteria

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

- Type of motor (three-phase asynchronous 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).

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

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

1.8 Proper use

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

The DC1 frequency inverters 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

After installation in a machine, the frequency inverters must not be taken into operation until the associated machine has been confirmed to comply with the safety requirements of Machinery Safety Directive (MSD) 89/392/EEC (meets the requirements of 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 the DC1 frequency inverter confirm that, when used in a typical drive configuration, the apparatus complies with the European Low Voltage Directive (LVD) and the EMC Directives (Directive 73/23/EEC, as amended by 93/68/EEC and Directive 89/336/EEC, as amended by 93/68/EEC).

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

A connection of a DC1 frequency inverter 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 frequency inverter you must not:
>
> - connect a voltage or capacitive loads (e.g. phase compensation capacitors),
> - connect multiple frequency inverters in parallel,
> - make a direct connection to the input (bypass).

Observe the technical data and connection requirements.
For additional information, refer to the equipment nameplate or label of the frequency inverter and the documentation. Any other usage constitutes improper use.

1.9 Maintenance and inspection

DC1 series frequency inverters will be maintenance-free as long as the general rated operational data (➔ Section 1.4.3, „General rated operational data", page16) is adhered to and the specific technical data (see appendix) for the corresponding ratings is taken into account. Please note, however, that external influences may affect the operation and lifespan of a DC1 frequency inverter.

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 frequency inverters

Maintenance measures	Maintenance interval
Clean cooling vents (cooling slits)	Please enquire
Check the fan function	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 1.11, „Charging the internal DC link capacitors")

There are no plans for replacing or repairing individual components of DC1 frequency inverters.

If the DC1 frequency inverter 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.

1.10 Storage

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

- Storage temperature: -40 - +70 °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 1.11, „Charging the internal DC link capacitors").

1.11 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 frequency inverter 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 frequency inverter 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} ~ 1.41 x U_e) and applied for one hour at least (regeneration time).

- DC1-S2…, 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, the capacitors in DC1-1D…frequency inverters cannot be regenerated using the connection terminals!
Please contact your local sales office.

1.12 Service and warranty

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

When you call, have the following data ready:

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

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

2 Engineering

2.1 Introduction

This chapter describes the most important features in the energy circuit of a magnet system (PDS = Power Drive System), which you should take into consideration in your project planning.
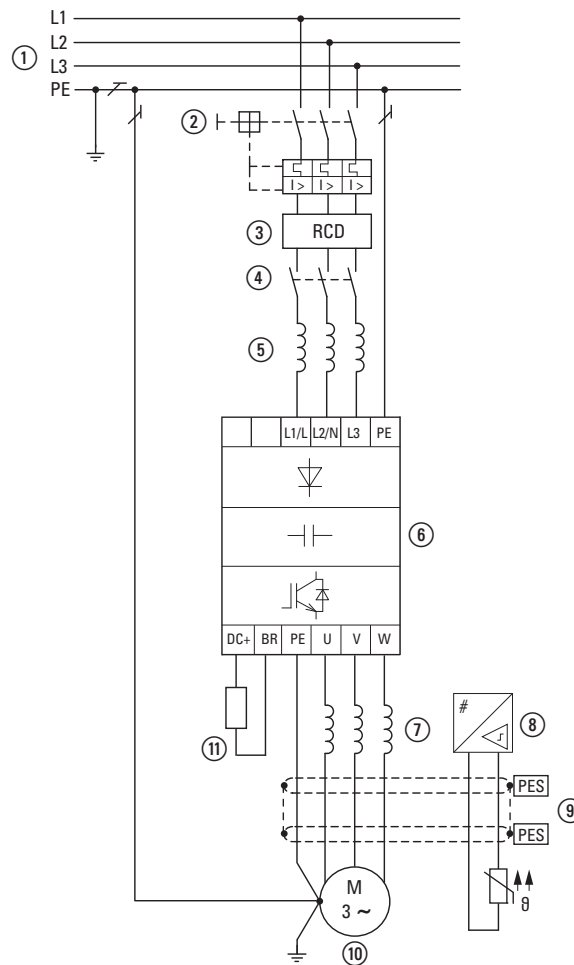
Figure 8:   Example of a magnet system with a three-phase feeder unit for a three-phase motor

① Network configuration, mains voltage, mains frequency, interaction with p.f. correction systems
② Fuses and cable cross-sections, cable protection
③ Protection of persons and domestic animals with residual current protective devices
④ Mains contactor
⑤ Main choke, radio interference filter, line filter
⑥ Frequency inverter: mounting, installation; power connection; EMC compliance; circuit examples
⑦ Motor reactor, dV/dt filter, sinusoidal filter
⑧ Motor protection; Thermistor overload relay for machine protection
⑨ Cable lengths, motor cables, shielding (EMC)
⑩ Motor and application, parallel operation of multiple motors on a frequency inverter, bypass circuit; DC braking
⑪ Braking resistance; dynamic braking

2.2 Electrical power network

2.2.1 Mains connection and configuration

The frequency inverters of the DC1 series can be connected and operated with all control-point grounded AC supply systems (see IEC 60364 for more information in this regard).
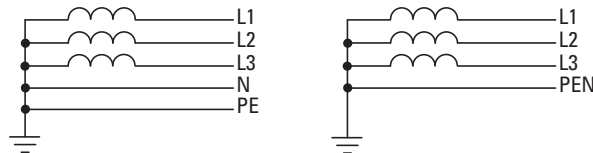
Figure 9:   AC power networks with earthed center point (TN-/TT networks)

➜ While planning the project, consider a symmetrical distribution to the three main poles, if multiple frequency inverters 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 frequency inverters 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 main pole, the maximum phase-earth voltage must not exceed 300 V AC.

If DC1 series frequency inverters are connected to an asymmetrically earthed network or to an IT network (non-earthed, insulated), the internal radio interference suppression filter must be disconnected (by unscrewing the screw marked EMC).

Figure 10:   EMC screw location

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 regulations.

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.
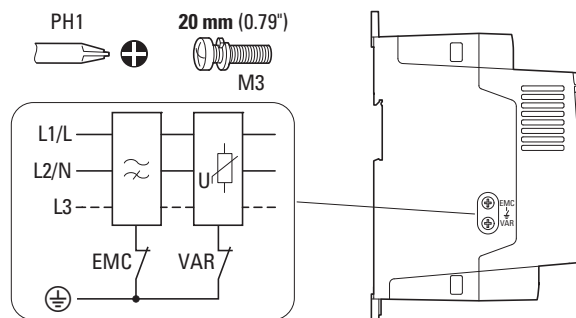
2.2.2 Mains voltage and frequency

The standardized rated operating voltages (IEC 60038, VDE 017-1) of power utilities guarantee the following conditions at the connection point:

- Deviation from the rated value of voltage:
  maximum ±10 %
- Deviation in voltage phase balance:
  maximum ±3 %
- Deviation from rated value of the frequency:
  maximum ±4 %

The broad tolerance band of the DC1 frequency inverter considers the rated value for European as (EU: U_{LN} = 230 V/400 V, 50 Hz) and American as (USA: U_{LN} = 240 V/480 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 (EU) and 240 V, 60 Hz (USA) at DC1-12…, DC1-32…, DC1-S2…
  200 V - 10 % - 240 V + 10 % (190 V - 0 % - 264 V + 0 %)
- 400 V, 50 Hz (EU) and 480 V, 60 Hz (USA) at DC1-34…
  380 V - 10 % - 480 V + 10 % (370 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

Because of the uneven loading on the conductor and with the direct connection of greater power ratings, deviations from the ideal voltage form and asymmetrical voltages can be caused in three-phase AC power networks. These asymmetric divergences in the mains voltage can lead to different loading of the diodes in mains rectifiers with three-phase supplied frequency inverters and as a result, to an advance failure of this diode.

→ In the project planning for the connection of three-phase sup-
plied frequency inverters (DC1-3…), consider only AC supply
systems that handle permitted asymmetric divergences in the
mains voltage ≦ +3 %.

If this condition is not fulfilled, or symmetry at the connection location is not
known, the use of an assigned main choke is recommended (see „Appen-
dix", section "Mains chokes", Page 180).

2.2.4 Total Harmonic Distortion (THD)

Non-linear consumers (loads) in an AC supply system produce harmonic volt-
ages that again result in harmonic currents. These harmonic currents at the
inductive and capacitive reactances of a mains supply system produce addi-
tional voltage drops with different values which are then overlaid on the sinu-
soidal 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.

Non-linear consumers (harmonics producers) include for example:

- Induction and arc furnaces, welding devices,
- Current converters, rectifiers and inverters, soft starters, frequency
  inverters,
- Switched-mode power supply units (computers, monitors, lighting),
  uninterruptible power supplies (UPS).

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.
For example, the THD for a current is:

$$THD = \frac{\sqrt{\sum_{n=2}^{\infty} I_n^2}}{I_1}$$

Where I_1 is the rms value of the fundamental frequency current and n is the
order of a harmonic with its own frequency, which is an integer multiple of
the fundamental frequency (Fourier analysis).

Example: 5th harmonic of a mains frequency of 50 Hz : 5 x 50 Hz = 250 Hz.

The THD value of the harmonic distortion is stated in relation to the rms
value of the total signal as a percentage. On a frequency inverter, the total
harmonic distortion is around 120 %. A mains choke (such as 4 % u_k) on the
supply side of a frequency inverter enables the THD value with a single-phase
supply (B2 diode rectifier bridge) to be reduced to around 80 % and with a
three-phase supply (B6 diode rectifier bridge) to around 50 %.
The supply quality is thus improved and the mains supply distortion is
reduced. The power factor is also improved.

2.2.5 Idle power compensation devices

Compensation on the power supply side is not required for the frequency inverters of the DC1 series. From the AC power supply network they only take on very little reactive power of the fundamental harmonics (cos φ ~ 0.98).

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

In the project planning for the connection of frequency inverters 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.

These reduce the total harmonic distortion, the mains feedback and improve the power factor. The apparent current on the mains side is then reduced by around 30 %.

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

→ For the operation of the DC1 frequency inverter, 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 frequency inverter for decoupling.

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

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

The main chokes assigned to the DC1 frequency inverter are listed in the appendix (→ Table 25 and → Table 26).

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 frequency inverter (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 frequency inverters are listed in Page 176 the appendix.

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 ⏚ and the metallic enclosure (IP66) must be connected to the earth-current circuit.

The leakage currents to earth (as per EN 50178) are greater than 3.5 mA. They are listed for the individual ratings in the appendix, under the specific technical data on Page 167.

➡ As per the requirements in standard EN 50178, a protective earth (PE) must be connected. The cable cross-section must be at least 10 mm^2 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 lines (U, V, W).

2.3.2 Residual current device (RCD)

Residual current devices (RCD) are also known as ground fault circuit interrupters (GFCI) orresidual-current circuit breakers (RCCB).

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.

> Residual current devices must be suitable for:
>
> - the protection of installations with DC current component in case of fault scenario (RCD, type B),
> - high leakage currents (300 mA),
> - Briefly diverting surge currents

> ⚠ **CAUTION**
>
> Only AC/DC sensitive residual current devices (RCD, type B) may be used with frequency inverters (EN 50178, IEC 755).

Marking on the residual current device		
AC/DC sensitive (RCD, part no. B)	⊟	∿

> Frequency inverters work internally with rectified AC currents. If an error occurs, the DC currents can block an RCD safety device of type A from triggering and therefore disable the protective functionality.

> *NOTICE*
>
> Residual current devices (RCD) are only to be installed between the AC power supply network and the frequency inverter.

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

Leakage currents to earth are mainly caused by foreign capacities with frequency inverters: 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 frequency inverter and switching off in case of a fault.

The mains contactor is designed based on the mains-side input current I_{LN} of the frequency inverter for utilization category AC-1 (IEC 60947) and the ambient air temperature at the location of use. Mains contactors and their assignment to the frequency inverters belonging to the DC1 series are listed in the appendix on Page 178.

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

The maximum permissible mains voltage switch-on frequency for the DC1 frequency inverter 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 8, page 29. 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 (→ Figure 11). He must also utilize means to increase the interference immunity of the devices of the system.

With their high interference immunity up to category C3, DC1 frequency inverters 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 58) and the observance of the permissible motor cable lengths and the maximum switching frequency (f_{PWM}) of the inverter.

In the case of frequency inverters 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.
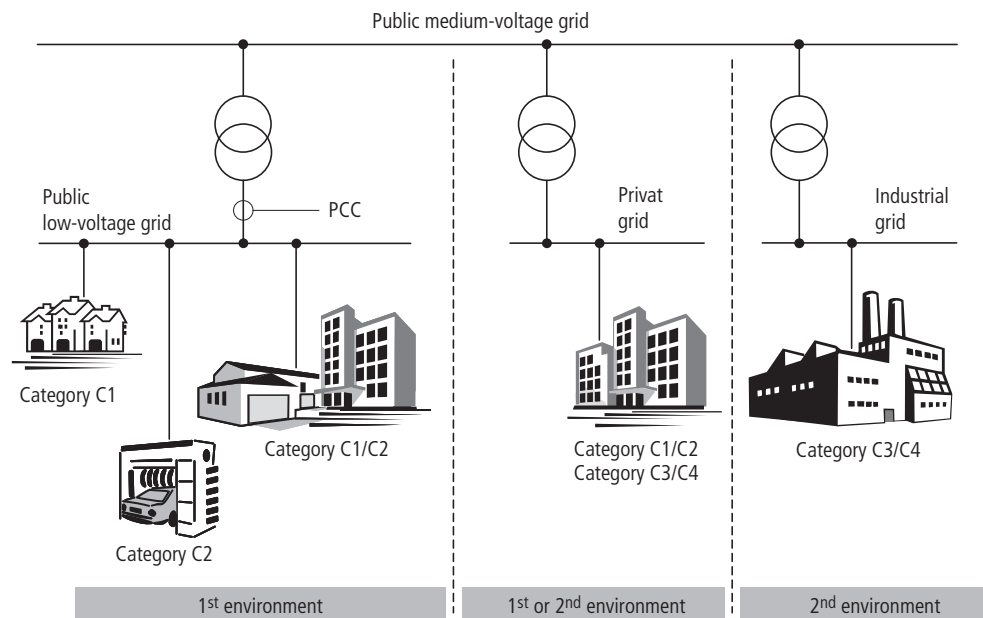

Figure 11:   EMC environment and categories

2.5 Motor and Application

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 frequency inverter, but normally require additional engineering in consultation with the motor's manufacturer.
- Using single-phase AC motors (shaded-pole motors, permanent-split capacitor motors) requires a DC1-S… frequency inverter.
- 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 frequency inverter, 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

The DC1 frequency inverters allow parallel operation of several motors in "V/f control mode":

- With multiple motors with the same or different rated operational data: The total of the motor currents must be less than the rated operational current of the frequency inverter.
- Connecting and disconnecting individual motors: The total of the motor currents in operation, plus the motor's inrush current, must be less than the rated operational current of the frequency inverter.

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 frequency inverter 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.

To reduce the current distortion, you should use motor reactors (see ① in Figure 12) in the output of the frequency inverter (➜ Section 9.8, „Motor reactors", page 182).
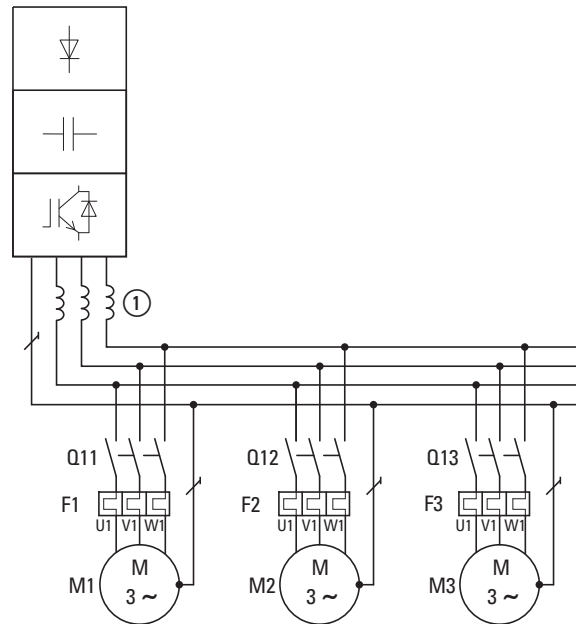
Figure 12:   Parallel connection of several motors to one frequency inverter

> **NOTICE**
>
> If multiple motors are connected in parallel to a single frequency inverter, make sure to dimension the individual motors' contactors for utilization category AC-3. The motor contactor must be selected according to the rated operational current of the motor that will be connected.

→   The current consumption of all motors connected in parallel must not exceed the frequency inverter's rated output current I_{2N}.

→   When operating multiple motors in parallel, you cannot use the frequency inverter's electronic motor protection. You will have to protect each motor individually with thermistors and/or a current transformer-operated overload relay.

→   The use of motor-protective circuit-breakers at the output of frequency inverters can result in motors being disconnected in an undefined manner and is only possible in select applications.

→   When operating multiple single-phase AC motors in parallel (only permissible with DC1-S… inverters), it is not permitted to connect individual motors during operation!

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.
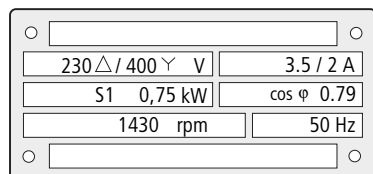

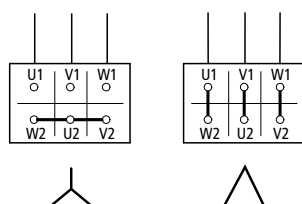Figure 13:   Example of a motor rating plate

Figure 14:   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 13 can be operated with either a start 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 13 with a delta circuit on a 400-V network at 87 Hz. To enable this, the frequency inverter must deliver the higher current for delta circuits (3.5 A) and the motor frequency (V/Hz key point) must be set to 87 Hz on the frequency inverter.

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 one size smaller (and therefore more affordable) 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 and to only use motors with aninsulation class of F at the very least.

→ 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).
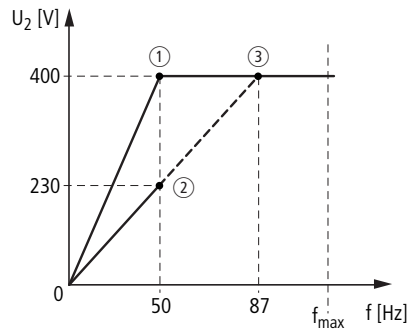

Figure 15:   V/Hz characteristic curve
for the rating plate of the motor from → Figure 13

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

The following Tabelle 3 shows the allocation of possible frequency inverters depending on the mains voltage and the type of circuit.

Table 3:   Assignments between frequency inverters and V/Hz characteristic curve (→ Figure 15)

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
V/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)
Motor current	3.5A	3.5A	2.0A	3.5A
Motor voltage	3 AC 0 - 230 V	3 AC 0 - 230 V	3 AC 0 - 400 V	3 AC 0 - 400 V
Motor speed	1430 min^{-1}	1430 min^{-1}	1430 min^{-1}	2474 min^{-1} [1]
Motor frequency	50 Hz	50 Hz	50 Hz	87 Hz[1]

1)   Note the permitted limit values of the motor!

2.5.5 Bypass operation

When it is necessary to be able to power the motor directly with mains voltage independently from the frequency inverter (bypass operation), the branches must be mechanically interlocked.

> *NOTICE*
>
> The system may only switch (S1) between the frequency inverter (T1) and mains voltage (see Figure 16) while in a de-energized state.

> ⚠ **CAUTION**
>
> The frequency inverter's outputs (U, V, W) must not be connected to the mains voltage (destruction risk, fire hazard).

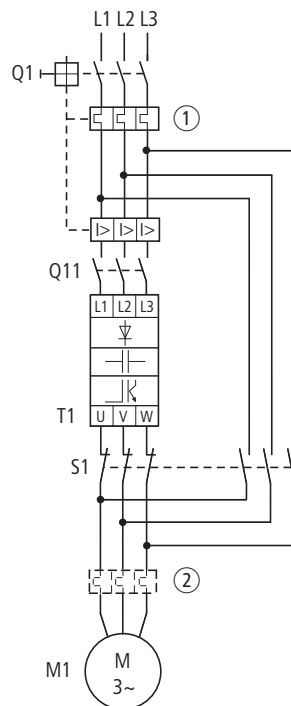Figure 16:   Bypass motor control (example)

→ When running the motor directly with mains voltage, protective measures (circuit-breaker with thermal overload protection ① or overload relay ②) against overload must be in place.

→ Contactors and switches (S1) in the frequency inverter output and for the direct start must be designed based on utilization category AC-3 for the rated operational current of the motor.

2.5.6 Connecting EX motors

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

- The frequency inverter must be installed outside the EX area.
- 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 frequency inverter – e.g., whether motor reactors (dV/dt limiting) or sinusoidal filters are required – must be taken into account.
- Temperature monitors in the motor windings (thermistor, Thermo-Click) must not be connected directly to the frequency inverter, but instead must be connected through a relay approved for the hazardous location (e.g. EMT6).

2.5.7 Sinusoidal filter

Sinusoidal filters are connected in the output of a frequency inverter.

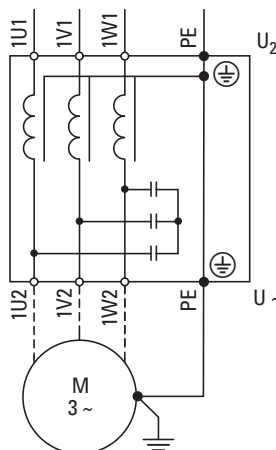Figure 17:   Circuit Diagram of a sinusoidal filter

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

① Without sinusoidal filter
② With sinusoidal filter
f: Rotating field frequency
n: Order of harmonics
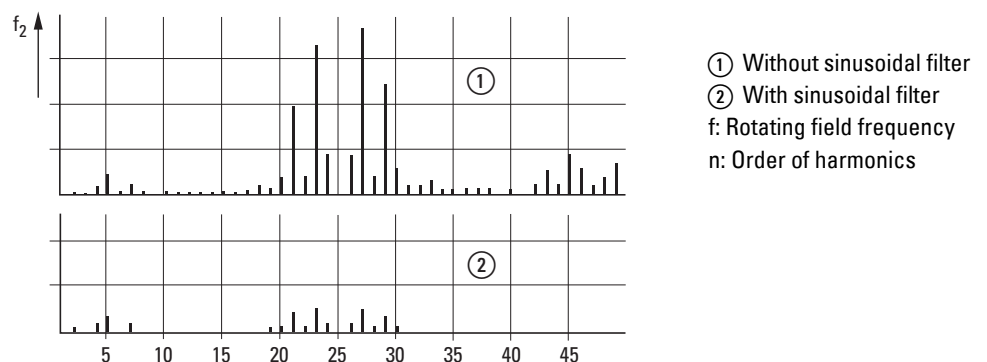
Figure 18:   High frequency components of the output voltage

The output voltage of the sinusoidal filter (U~) achieves a sinusoidal shape with a slight superimposed ripple voltage.

The THD factor of the sinusoidal voltage is normally 5 to 10 %.
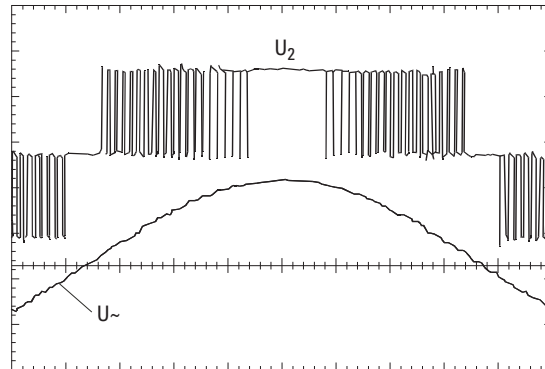
Figure 19:   Output voltage to motor
                U_2: Frequency inverter output voltage
                U~: Sinusoidal voltage to be simulated

Advantages of sinusoidal filters:

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

Disadvantages of sinusoidal 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*
> Sinusoidal filters must only be used with permanently set pulse frequencies.

2.5.8 Single-phase AC motors

The frequency inverters in the DC1-S2… series are specifically designed for the speed control of single-phase AC motors (230 V).

These single-phase AC motors, which are listed further below, have the following characteristics:

- Asynchronous operational behavior with elliptical rotating field
- A small starting torque
- Applications run with a reduced starting torque (approximately 50 to 100 % of the motor's rated torque).
  Application examples: pumps and fans.

DC1-S2… series frequency inverters can be used to control the following motor types:

- Shaded-pole motor:
  Shaded-pole motors have a laminated core stator with pronounced poles that are separated from the main pole (shaded poles). These auxiliary poles have shading coils in which a flux that is lagging behind the main field is generated by self-induction.
  The resulting elliptical rotating field moves the rotor with it. The mechanical arrangement of the shaded poles makes it impossible for the rotating field to change direction in this type of motor.
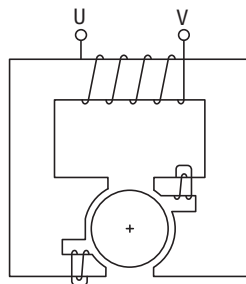

Figure 20: Schematic diagram of a shaded-pole motor

- Permanent-split capacitor motor, PSC motor:
  In permanent-split capacitor motors, a winding (secondary winding) is connected in series with a capacitor in order to generate the rotating field (90° phase shift, elliptical rotating field). The direction of the rotating field can be changed by changing the secondary winding connection.
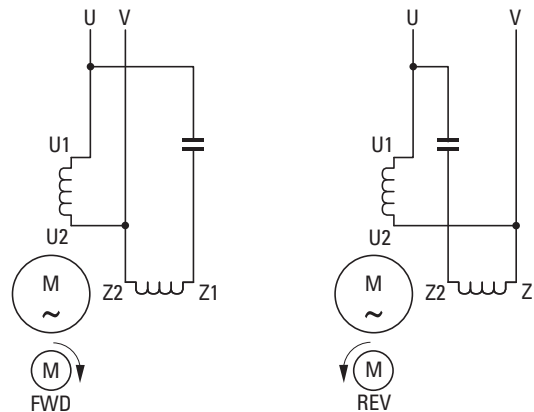
Figure 21:   Permanent-split capacitor motor (connection
example) Clockwise rotating field (FWD),
counterclockwise rotating field (REV)

• Three-phase motor with Steinmetz connection:
  Using a Steinmetz connection makes it possible to operate three-phase
  asynchronous motors on a single-phase AC supply system. To do this, a
  stator winding is connected in series with a capacitor. This creates a split
  phase with a phase shift of less than 90° (instead of 120°). Only an ellip-
  tical rotating field is generated in this case as well. A star or delta con-
  nection (preferred) can be used as per the winding voltages. The direc-
  tion of the rotating field can be changed by changing the capacitor's
  connection (phase).
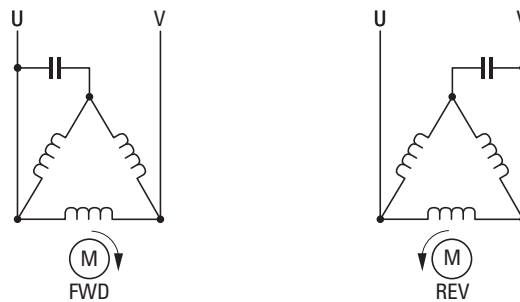
Figure 22:   Three-phase motor with Steinmetz connection:
Clockwise rotating field (FWD), counterclockwise
rotating field (REV)

➜   Operating motors with an additional start capacitor is not per-
     missible.
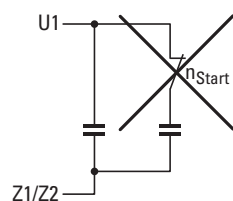
2.5.9 Mode of operation of DC1-S2… frequency inverter

The special start method used by the DC1-S2… frequency inverter ensures a safe motor start. The output voltage and the corresponding frequency are first regulated to the motor's rated operational data and are then automatically set at the required operating point (setpoint).
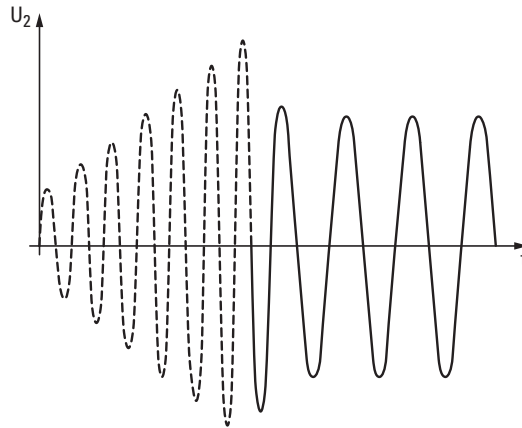
Figure 23:   Start phase and required operating point

➡️ DC1-S2… frequency inverters feature a specific parameter set that cannot be transferred to other DC1 frequency inverter models.

3 Installation

3.1 Introduction

This chapter provides a description of the installation and the electrical connections for the frequency inverter DC1 series.

→ While mounting and/or assembling the frequency inverter, 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 protection type 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 frequency inverter in order to allow for proper air circulation. The air should come in from below the frequency inverter 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.

3.2.1 Mounting position

DC1 series frequency inverters are designed to be mounted vertically. The maximum permissible inclination is 30°.
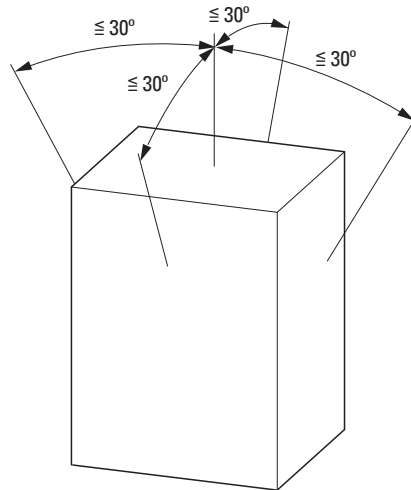
Figure 24:   Mounting position

3.2.2 Cooling measures

In order to guarantee sufficient air circulation, enough thermal clearance must be ensured according to the frame size (rating) of the frequency inverter.
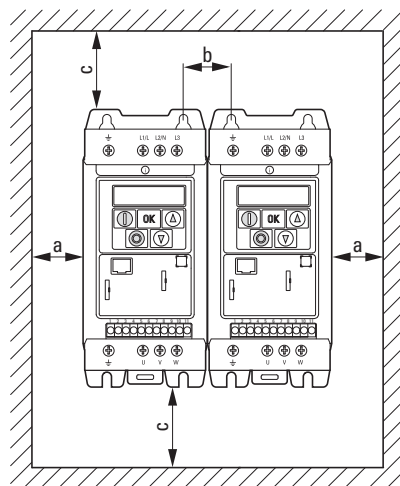
Figure 25:   Space for air-cooling

→   DC1 series frequency inverters can be mounted side by side without any lateral clearance between them.

Table 4: Minimum clearance and required cooling air

Size	a		b		c		Air through-put	
	[mm]	[in]	[mm]	[in]	[mm]	[in]	[m³/h]	[ft³/min]
FS1	50	1.97	33	1.3	50	1.97	18.69	11
FS2	50	1.97	46	1.81	75	2.95	18.69	11
FS3[1]	50	1.97	52	2.05	100	3.94	44.1	26

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… frequency inverters.

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.
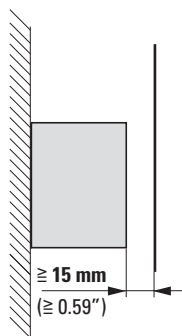
Figure 26: Minimum required clearance in front of the frequency inverter

➞ Please note that the mounting makes it possible to open and close the control signal terminal covers without any problems.

When frequency inverters 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).
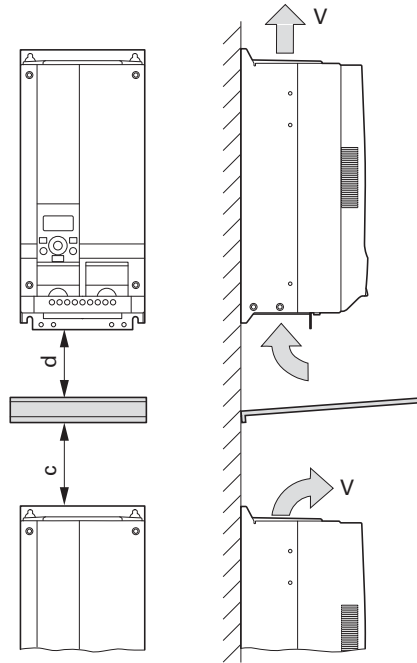
Figure 27:   Air baffle due to increased circulation with device fan

When devices are arranged vertically over each other, the clearance between every two devices must at least be equal to distance 2c (Table 4, page 51) ("active neighboring device").

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

3.2.3 Control panel installation
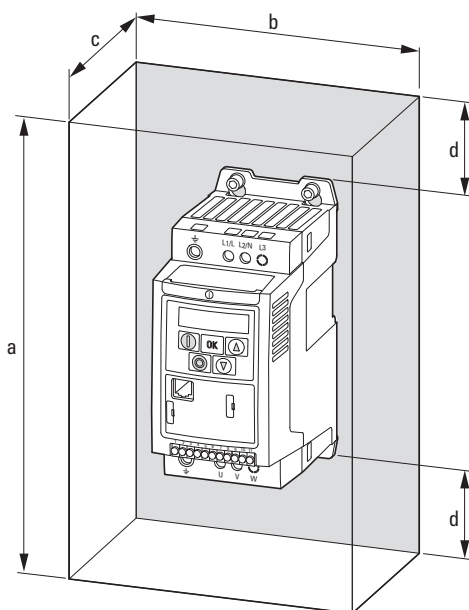
Figure 28:   Control panel dimensioning

Calculation of control panel surface:

$$A = \frac{P_V}{\Delta T \times K} \; [m^2]$$

A   =   Control panel surface [m^2] calculated according to IEC 890)

P_V =   Total heat dissipation [W] of all fitted devices

ΔT =   Temperature difference [K], (default value = 5.5 K)

K   =   Heat transfer coefficient [$W/(m^2 \times K)$]
(standard value = 5.5 for steel control panels)

When installing a DC1 frequency inverter with protection type IP20 in an enclosed installation enclosure (in order to get a higher protection type in the case of a "local installation", for example), the following minimum clearances are required:

Table 5: Clearances for a sealed metal enclosure without ventilation openings

Part no.	Size	a		b		c		d	
		[mm]	[in]	[mm]	[in]	[mm]	[in]	[mm]	[in]
DC1-1D2D3N… DC1-1D4D3N… DC1-122D3… DC1-124D3… DC1-322D3… DC1-324D3…	FS1	300	11.81	250	9.84	200	7.87	50	1.97
DC1-127D0xN… DC1-327D0xN… DC1-342D2…	FS1	400	15.75	300	11.81	250	9.84	75	2.95
DC1-1D5D8N… DC1-127D0xB… DC1-327D0xB… DC1-344D1xB… DC1-345D8…	FS2	400	15.75	300	11.81	300	11.81	60	2.36
DC1-127D0… DC1-32011… DC1-349D5…	FS2	600	23.62	450	17.72	300	11.81	100	3.94

Table 6: Clearances for a metal enclosure with ventilation openings

Size	a		b		c		d	
	[mm]	[in]	[mm]	[in]	[mm]	[in]	[mm]	[in]
FS1	400	15.75	300	11.81	150	5.91	75	2.95
FS2	600	23.62	400	15.75	250	9.84	100	3.94
FS3	800	31.5	600	23.62	300	11.81	150	5.91

Table 7: Clearances for a metal enclosure with forced ventilation

Size	a		b		c		d		Air through-put	
	[mm]	[in]	[mm]	[in]	[mm]	[in]	[mm]	[in]	[m³/h]	[ft³/min]
FS1	300	11.81	200	7.87	150	5.91	75	2.95	> 15	> 8.83
FS2	400	15.75	300	11.81	250	9.84	100	3.94	> 45	> 26.49
FS3	600	23.62	400	15.75	250	9.84	150	5.91	> 80	> 47.09

3.2.4 Fixing

The frequency inverters in frame sizes FS1, FS2 and FS3 can be screw fastened or fastened on a mounting rail.

→ Install the frequency inverter only on a nonflammable mounting base (e.g., on a metal plate).

→ Dimension and weight specifications for the DC1 frequency inverter can be found in the appendix (→ Page 167).

3.2.4.1 Fixing with screws

→ The number and the arrangement of the required fixing dimensions are found in → Section 9.2, "Dimensions and frame size", page 170.

→ Use screws with a washer and split washer with the permissible tightening torque in order to protect the enclosure and safely and reliably mount the device.
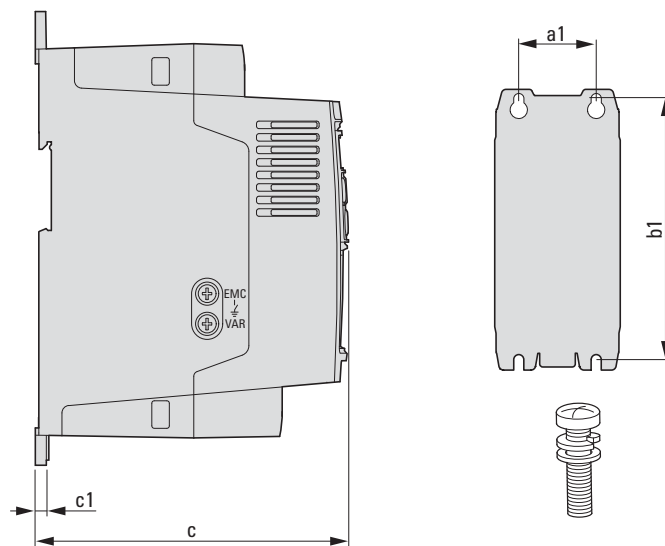
Figure 29:   Mounting dimensions
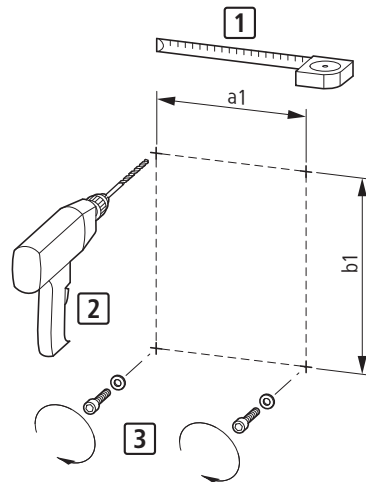
Figure 30:   Mounting preparation

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

➜   The permitted maximum tightening torque for the fixing screws
     is 1.3 Nm.

3.2.4.2 Fixing on mounting rails

As an alternative to screw fixing, DC1 frequency inverters with sizes FS1,
FS2, and FS3 can also be mounted on a mounting rail as per IEC/EN 60715.
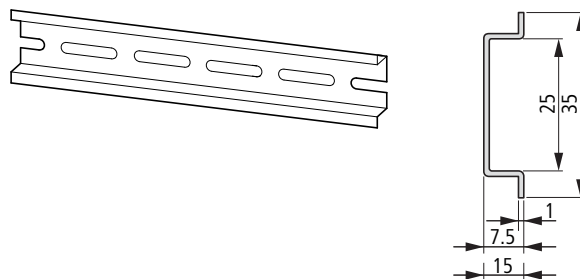
Figure 31:   Mounting rail conforming with IEC/EN 60715

▶   To do this, place the frequency inverter on the mounting rail from above
     [1] and press it down until it snaps into place [2].
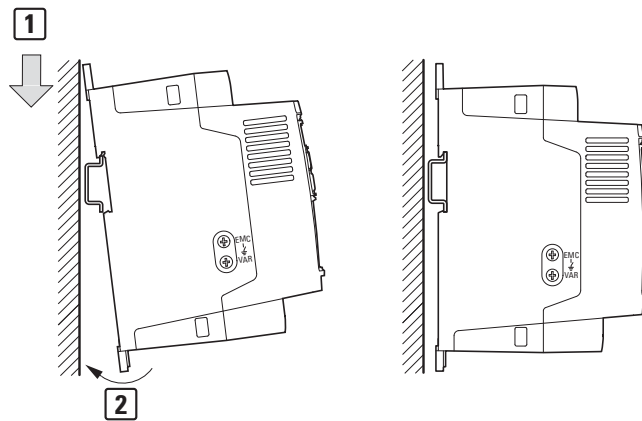
Figure 32:   Fixing to the mounting rail

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.
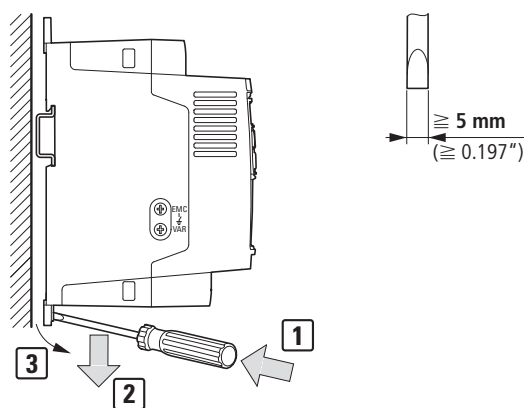
Figure 33:   Dismantling from mounting rails

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 (→ Figure 11, page 37). He must also utilize means to increase the interference immunity of the devices of the system.

In a magnet system (PDS) with frequency inverters, you should take measures for electromagnetic compatibility (EMC) while doing your engineering, since changes or improvements to the installation site, which are required in the installation or while mounting, are normally associated with additional higher costs as well.

The technology and system of a frequency inverter 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 $\geqq$ 10 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 frequency inverter 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

For the EMC-compatible installation, connect all metallic parts of the device and the control panel together over broad surfaces and so that high-frequencies will be conducted. Mounting plates and control panel doors should make good contact and be connected with short HF-drain wires. Avoid using painted surfaces (Anodized, chromized). An overview of all EMC measures is provided in Figure35 on Page 62.

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

→ 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.

3.3.2 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 frequency inverter 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 drive system's conductive components (frequency inverter, motor reactor, 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 frequency inverters in one control panel. Make sure that all metallic devices that are to be grounded have a broad area connection with the mounting plate.

3.3.2.1 Protective earth

This refers to the legally required protective earth for a frequency inverter. An earthing terminal on the frequency inverter, 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.

3.3.2.2 Motor earthing

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

3.3.2.3 Earth-fault protection

A fault current to earth can be produced by frequency inverters due to their system characteristics. DC1 series frequency inverters 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).

3.3.3 EMC screw
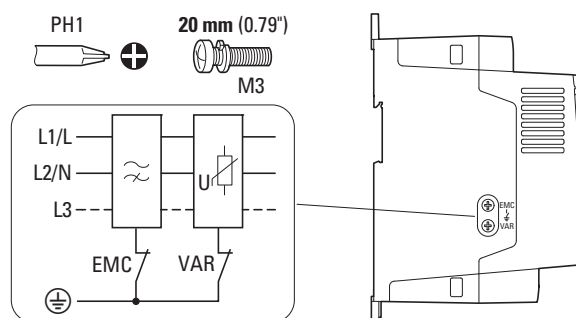
Figure 34:   EMC and VAR screws in a DC1 frequency inverter
with protection type IP20

NOTICE

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

→ The EMC screw 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 frequency inverter to comply with the EMC standard.

Due to their system characteristics, frequency inverters 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).

3.3.4 VAR screw

DC1 series frequency inverters 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 hipot 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. The screw must be screwed back in after the hipot tests are performed and the hipot 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 34, page 60) must not be manipulated as long as the frequency inverter is connected to the mains.

3.3.5 Shielding

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 shield 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).
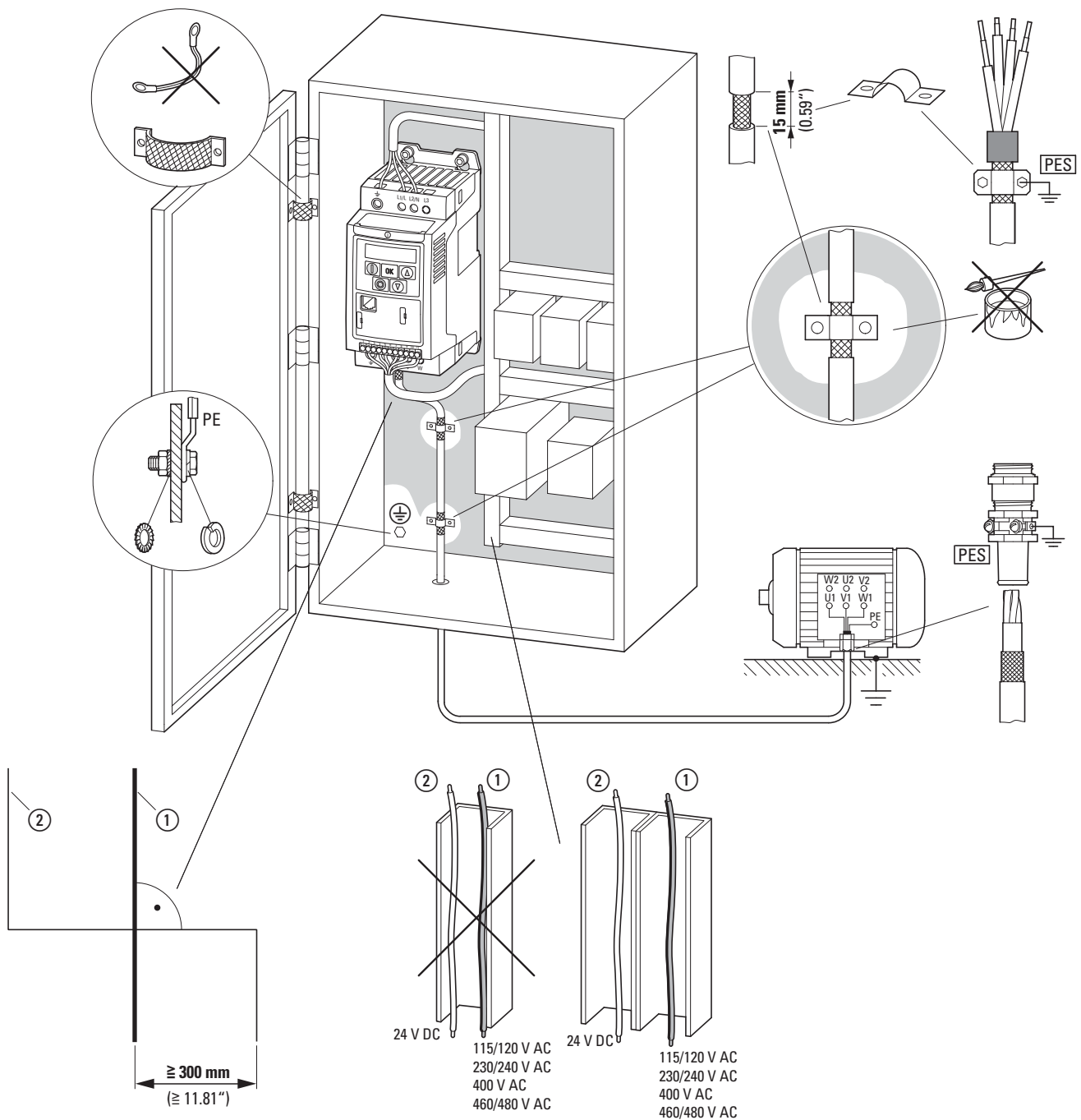
Figure 35: EMC-compliant surface mounting
① Power cable: mains voltage, motor connection, braking resistor
② Control and signal lines, fieldbus connections
Large-area connection of all metallic control panel components.
Mounting surfaces of frequency inverter and cable screen must be free from paint.
Cable screen of cables at frequency inverter'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.

3.4 Electrical Installation

> ⚠ **CAUTION**
>
> Carry out the wiring work only after the frequency inverter has been correctly mounted and secured.

> ⚠ **DANGER**
>
> Electric shock hazard - risk of injuries!
> Carry out wiring work only if the unit is de-energized.

> *NOTICE*
>
> Fire hazard!
> Only use cables, protective switches, and contactors that feature the indicated permissible nominal current value.

> *NOTICE*
>
> In DC1 frequency inverters, earth leakage currents are greater than 3.5 mA (AC). Because of this, and as per product standard IEC/EN 61800-5-1, an additional protective conductor must be connected, or the cross-sectional area of the protective conductor must be at least 10 mm^2.

> ⚠ **DANGER**
>
> The components in the frequency inverter'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**
> 5 MIN

➡ Complete the following steps with the specified tools and without using force.

3.4.1 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 for DC voltage supplies
- U, V, W, PE for the supply cable to the motor
- BR, DC+ for an external braking resistance
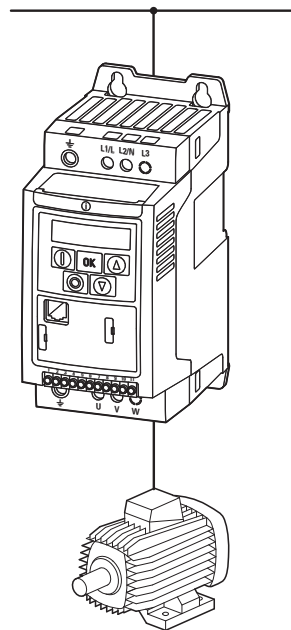
Figure 36:   Connection in power section (schematic)

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

> *NOTICE*
>
> The frequency inverter must always be connected with ground potential via a grounding conductor (PE).
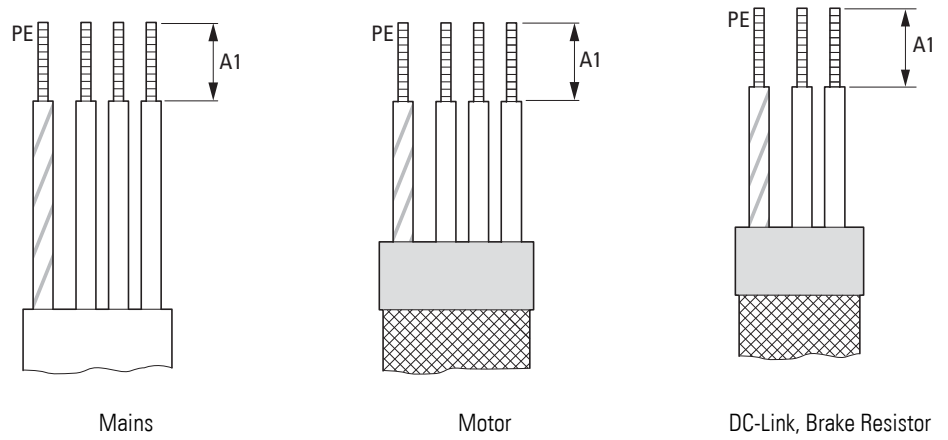
Figure 37: Stripping lengths in the power section

mm (in)	A1
FS1	8 (0.3)
FS2	8 (0.3)
FS3	8 (0.3)

MAINS = Electrical power network

3.4.1.1 Terminals in power section

Table 8:   Terminals

Frame size	Terminations	Description
FS1	PE L N ⏚ L1/L L2/N L3	Connection with single-phase supply voltage: • DC1-1D… (115 V) • DC1-S2… (230 V) • DC1-12… (230 V)
	PE L1 L2 L3 ⏚ L1/L L2/N L3	Connection with three-phase supply voltage: • DC1-32… (230 V) • DC1-34… (400 V, 480 V)
	⏚ U V W PES M 3 ~	Motor connection for three-phase motors: • DC1-1D… (230 V) • DC1-12… (230 V) • DC1-32… (230 V) • DC1-34… (400 V, 460 V)
	⏚ U V W PES M ~	Motor connection for single-phase AC motors: • DC1-S2… (230 V)

Frame size	Terminations	Description
FS2, FS3	PE — L — N ⏚ — DC- — L1/L — L2/N — L3	Connection with single-phase supply voltage (115 V, 230 V): • DC1-1… • DC1-S…
	PE — L1 — L2 — L3 ⏚ — DC- — L1/L — L2/N — L3	Connection with three-phase supply voltage: • DC1-32… (230 V) • DC1-34… (400 V, 480 V)
	⏚ — DC+ — BR — U — V — W PES R_B M 3~	Motor connection for three-phase motors: • DC1-1D… (230 V) • DC1-12… (230 V) • DC1-32… (230 V) • DC1-34… (400 V, 460 V) optional: External braking resistance (R_B)

➡ In sizes FS2 and FS3, the DC+, DC-, and BR terminals are covered with plastic covers at the factory. They can be uncovered if necessary.

In all single-phase supply frequency inverters (DC1-1D…, DC1-S2…, DC1-12…), terminal L3 is covered with a plastic cover. Do not uncover this terminal!

In frequency inverters suitable for alternating current (DC1-S2…), terminals L3 and W are covered with plastic covers. Do not uncover these terminals!

3.4.1.2 connection cables

The screened cables between the frequency inverter 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 screening's protective earth (PES) connection should be in the immediate proximity of the frequency inverter.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. As an alternative, in addition to a broad area cable clip, you can also twist the shielding braid at the end and connect to protective ground with a cable clip. To prevent EMC interference, this twisted screening connection should be as short as possible (→ Figure 39).
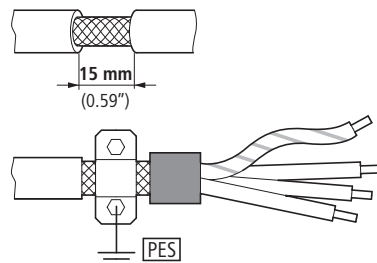
Figure 38:   Screened connection cable
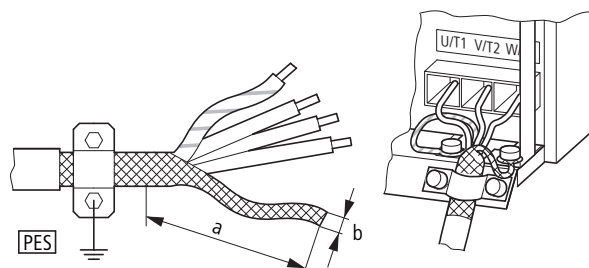
Figure 39:   Connection with twisted cable screen
Recommended value for twisted cable shielding:
b ≅ 1/5 a

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 frequency inverter 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).
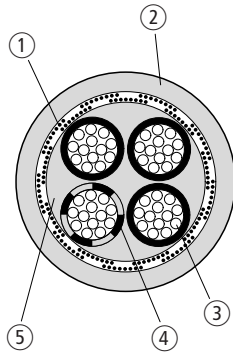
Figure 40: Four-core, screened motor supply cable

① Cu shield 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 reactor, sinusoidal 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.

3.4.1.3 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-sections to be used in the connections and the tightening torques for screws are listed in the following.

Table 9: Cross-sectional areas and tightening torques

Size	mm²	AWG	MM	in	N/m	MM
FS1, FS2, FS3	0.2 - 2.5	24 - 12	8	0.31	0.5	0.6 x 3.5

3.4.2 Connection on control section

The 11-terminal control terminal block is a plug-in block and is located on the front.
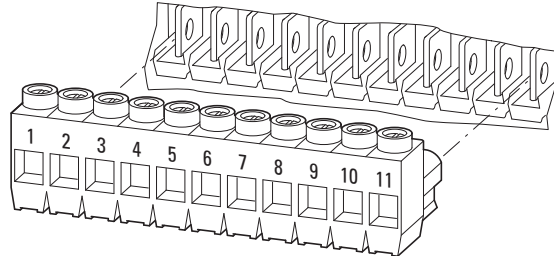
Figure 41:   Location of plug-in control signal terminals

The control cables should be screened and twisted. The screening is applied on one side in the proximity of the frequency inverter (PES).

→   Prevent the screening from becoming unbraided, i.e. by pushing the separated plastic covering over the end of the shielding or with a rubber grommet on the end of the screening.
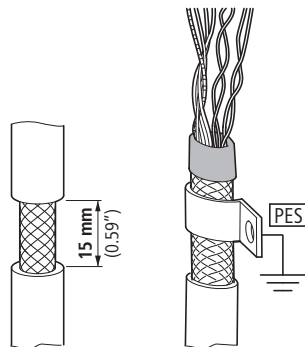
Figure 42:   Prevent the shield from becoming unbraided

Alternatively, in addition to the broad area gland plate, you can also twist the screen braid at the end and connect to the protective earth with a cable lug. To prevent EMC disturbance, this twisted shielding connection should be made as short as possible (→ Figure 39, page 68).

Prevent the screen from becoming unbraided at the other end of the control cable, e.g. by using a rubber grommet. The shield braid must not make any connection with the protective ground here because this would cause problems with an interference loop.
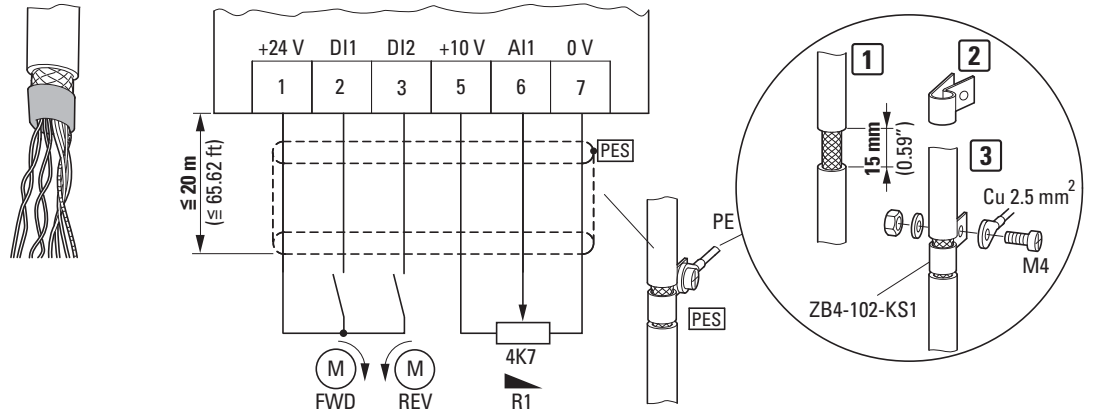
Figure 43:   Example for an insulated end of the control cable

3.4.2.1 Arrangement and designation

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

The following figure shows the arrangement and designations of the control
signal terminals for the DC1 frequency inverter.
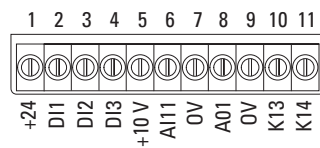
Figure 44:   Arrangement and factory designations for the control signal terminals

The control signal terminals are plug-in terminals. Their functions and their
electrical connected loads can be expanded using the DXC-EXT-… optional
modules.

Figure 45:   Control signal terminal sizes and designs

mm²	mm²	AWG	MM	in	N/m	ft-lbs	MM
0.14 - 1.5	0.25 - 0.5	26 - 16	5	0.2	0.22 - 0.25	0.16 - 0.18	0.4 x 2.5

3.4.2.2 Functions of control signal terminals

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 10:   Factory-set functions of the control terminals

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 kΩ)	Start enable FWD **Note:** No function in DC1-1S… (⟶ P-15 = 0)
3	DI2	Digital input 2	8 - +30 V (High, R_i > 6 kΩ)	Start enable REV

4	DI3
	AI2
		Digital input 3
		Analog input 2
			• digital: 8 - 30 V (high)
			• Analog: 0 - +10 V (R_i > 72 kΩ)
			  0/4 - 20 mA (R_B = 500 Ω)
			  Can be switched with parameter P-16
				Fixed frequency FF1

5	+10 V	Reference voltage, Output (+10 V)	Maximum load: 10 mA, minimum 1 kΩ Reference potential: 0 V	–

6	AI1
	DI4
		Analog input 1
		Digital input 4
			• Analog: 0 - +10 V (R_i > 72 kΩ)
			  0/4 - 20 mA (R_B = 500 Ω)
			  Can be switched with parameter P-16
			• digital: 8 - 30 V (high)
				Frequency reference value (fixed frequency)

7	0 V	Reference potential	0 V = connection terminal 9	–
8	AO1 DO1	Analog output 1 Digital output 1	• Analog: 0 - +10 V, maximum 20 mA Can be switched with parameter P-25 • digital: 0 - +24 V	Output Frequency
9	0 V	Reference potential	0 V = connection terminal 7	–
10	K13	Relay 1, normally open contact	Maximum switching load: 250 V AC/6 A or 30 V DC/5 A	active = RUN
11	K14	Relay 1, normally open contact	Maximum switching load: 250 V AC/6 A or 30 V DC/5 A	active = RUN

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

The frequency inverter 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 frequency inverter when it is delivered.
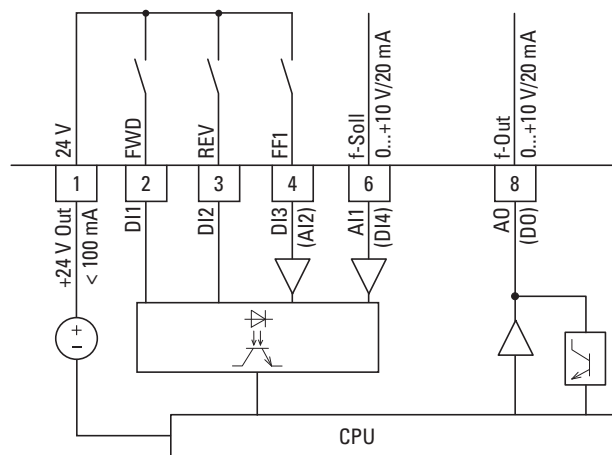
Figure 46:   Control signal terminals (digital / analog)

3.4.2.3 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)

→ The assignments between the values and functions are described in → Section 6.2.2, "Analog Input (AI)", page 109.

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

3.4.2.4 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 (→ Table 12, Page 98).
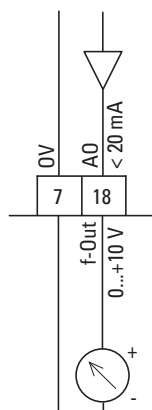
Figure 47:   Analog output (AO)
(connecting example)

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

3.4.2.5 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 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 ±5 % $\Delta U_a/U_a$.

The parameter configuration and the way functions are assigned are described in → Section 6.2.1, "Digital Input (DI)", page 108.

→ 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 integrate the digital inputs (DI1 to DI4), optically isolated, directly into controllers with 110 V / 230 V. Values of 80 to 110/230 V AC will be recognized as a high signal.

3.4.2.6 Digital Output (Transistor)

Control signal terminal 8 is set as an analog output (AO) in the default configuration.
It can be set to work as a digital input instead by using parameter P-25
(→ Table 12, Page 98).

Transistor output DO can deliver a digital signal via control signal terminal 8 with the device's internal control voltage (+24 V). The maximum permissible load current is 20 mA.
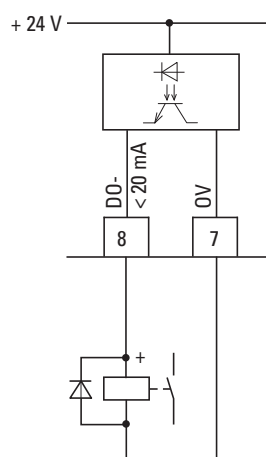
Figure 48:   Connection examples (coupling relay with freewheeling diode: ETS4-VS3; Article no.. 083094)

→   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 "Digital / analog outputs", Page 116.

3.4.2.7 Digital Output (Relay)

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

The relay function can be configured with parameter P-18 (→ Table 12, Page 96).

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

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

We recommend connecting any connected loads as follows:

250 V ~ : ≦ 6 A
30 V ⎓ : ≦ 5 A

Varistor   RC filter   Diode

AC   AC   AC   DC
DC
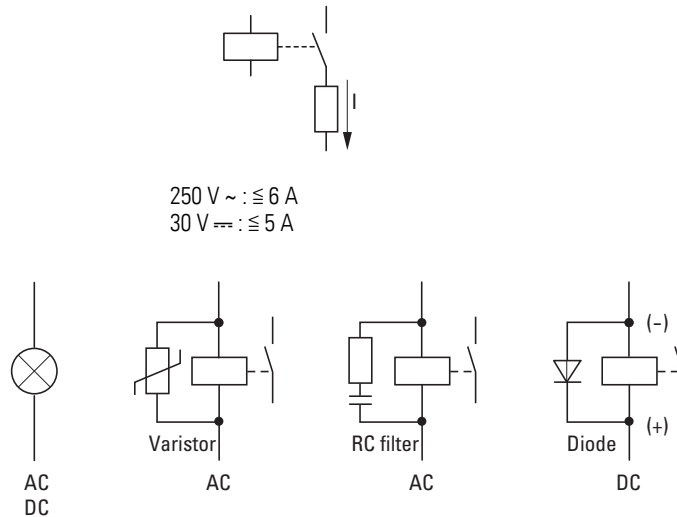
Figure 49:   Connection examples with suppressor circuit

3.4.2.8 RJ 45 interface

The RJ-45 port located on the front of the DC1 frequency inverter makes it possible to connect directly to communication modules and fieldbuses.

The internal RS-485 connection transmits Modbus RTU.

X1

PIN 8
(PIN 2)

PIN 7
(PIN 1)

RS485
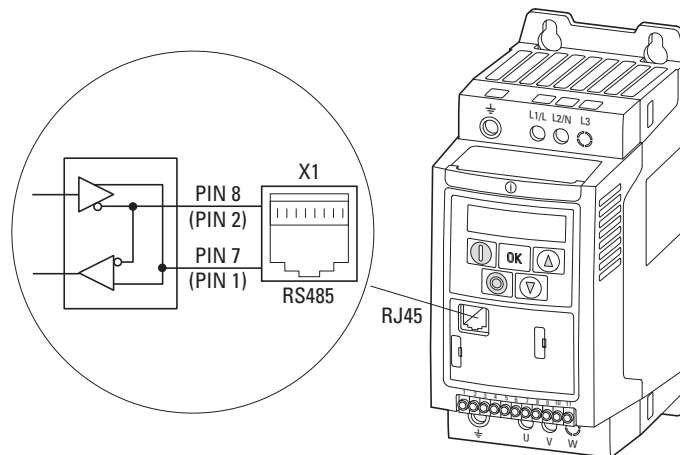
RJ45

Figure 50:   RJ 45 interface

→ DC1 frequency inverters do not have an internal bus termination resistor.
Use DX-CBL-TERM if necessary.

3.4.3 Block diagrams

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

3.4.3.1 DC1-1DxxxN…
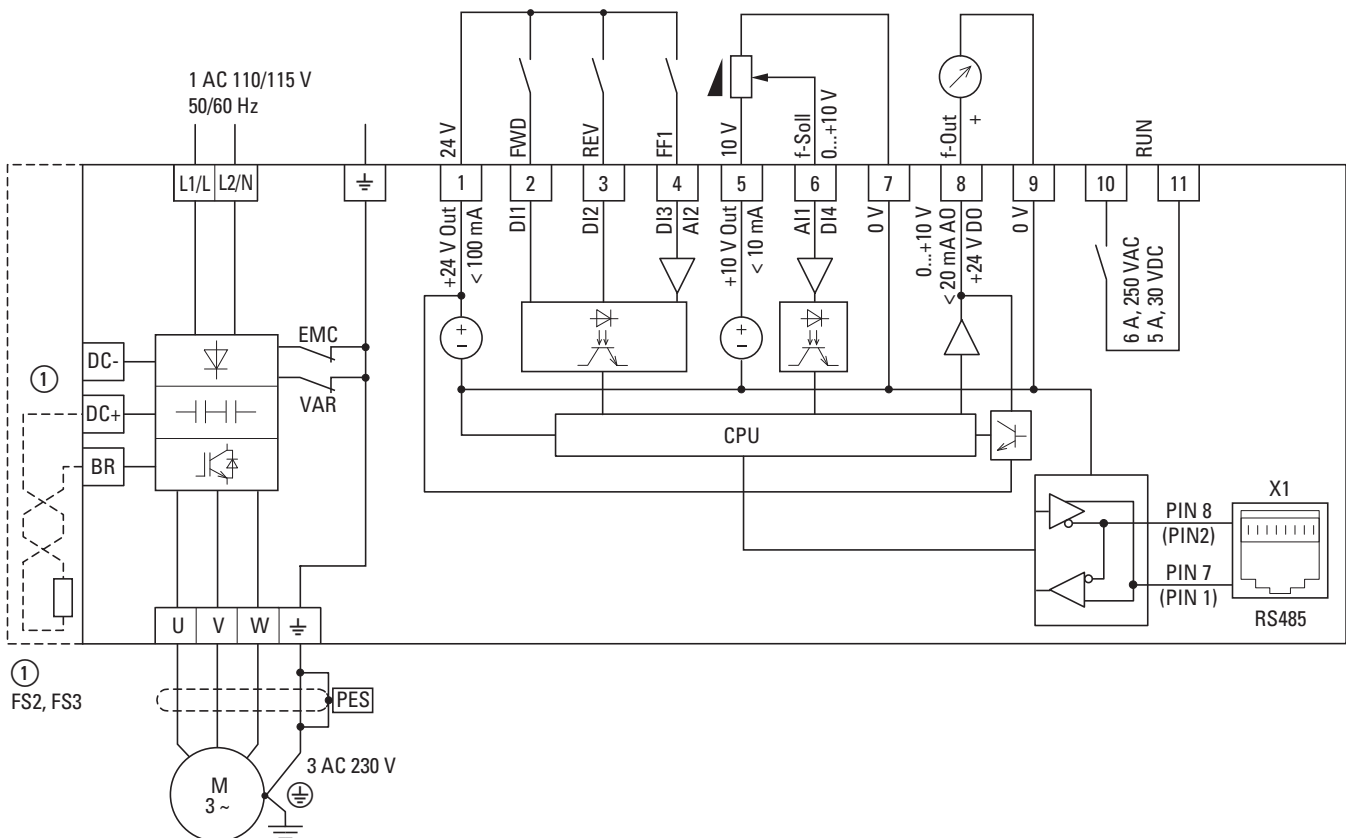
Figure 51: DC1-1DxxxN… block diagram
The DC1-1DxxxN… frequency inverter has a voltage doubler in the internal DC link. When there is a connected voltage of 1 AC 110 - 115 V, a motor voltage of up to 3 AC 230 V will be output.
FS2-size devices make it possible to connect braking resistors.

→ DC1-1DxxxN… frequency inverters do not feature an internal radio interference suppression filter.
An external radio interference suppression filter is required for operation as per EN 61800-3.

3.4.3.2 DC1-12…
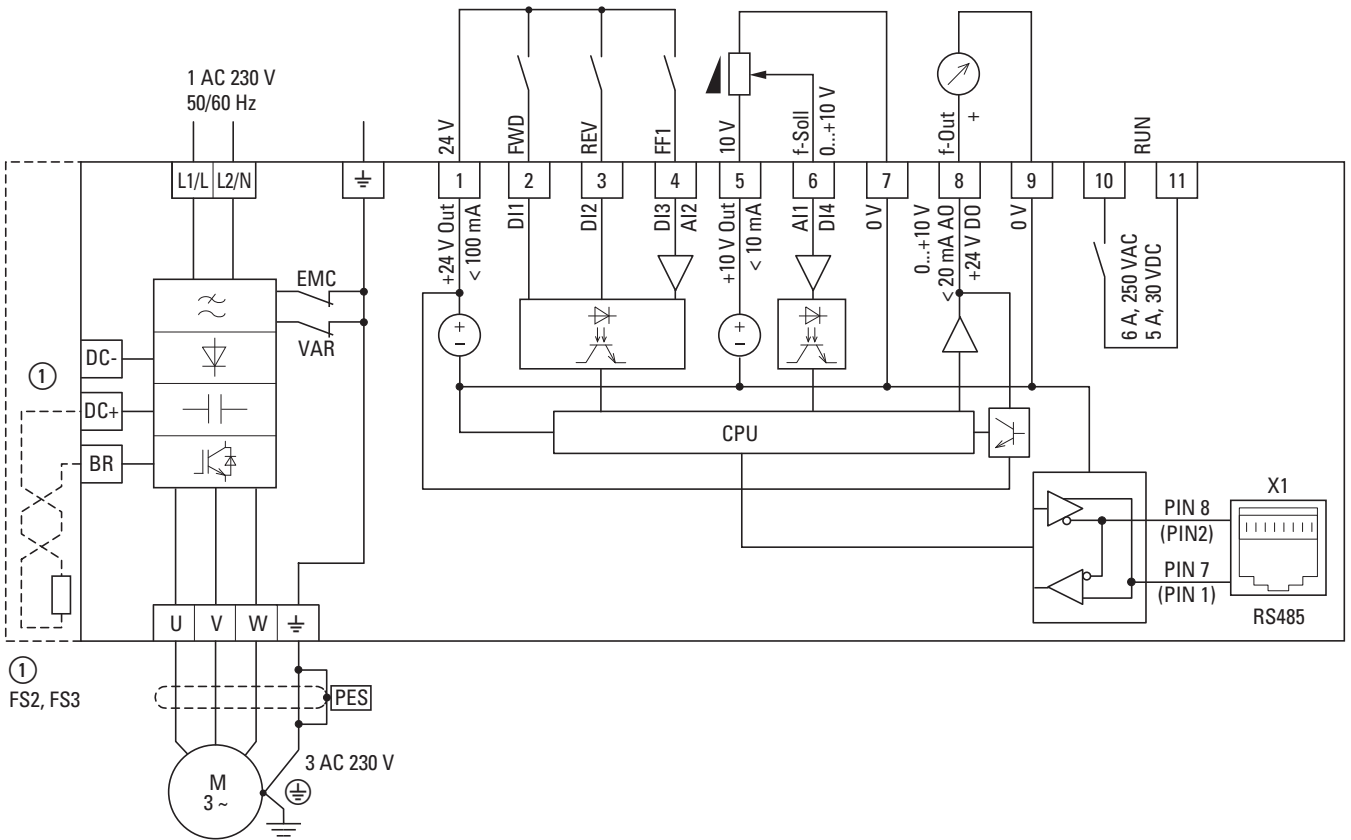
Figure 52: DC1-12… block diagram
Frequency inverter with single-phase supply system voltage and three-phase motor connection

① FS2 and FS3 make it possible to connect external braking resistors.
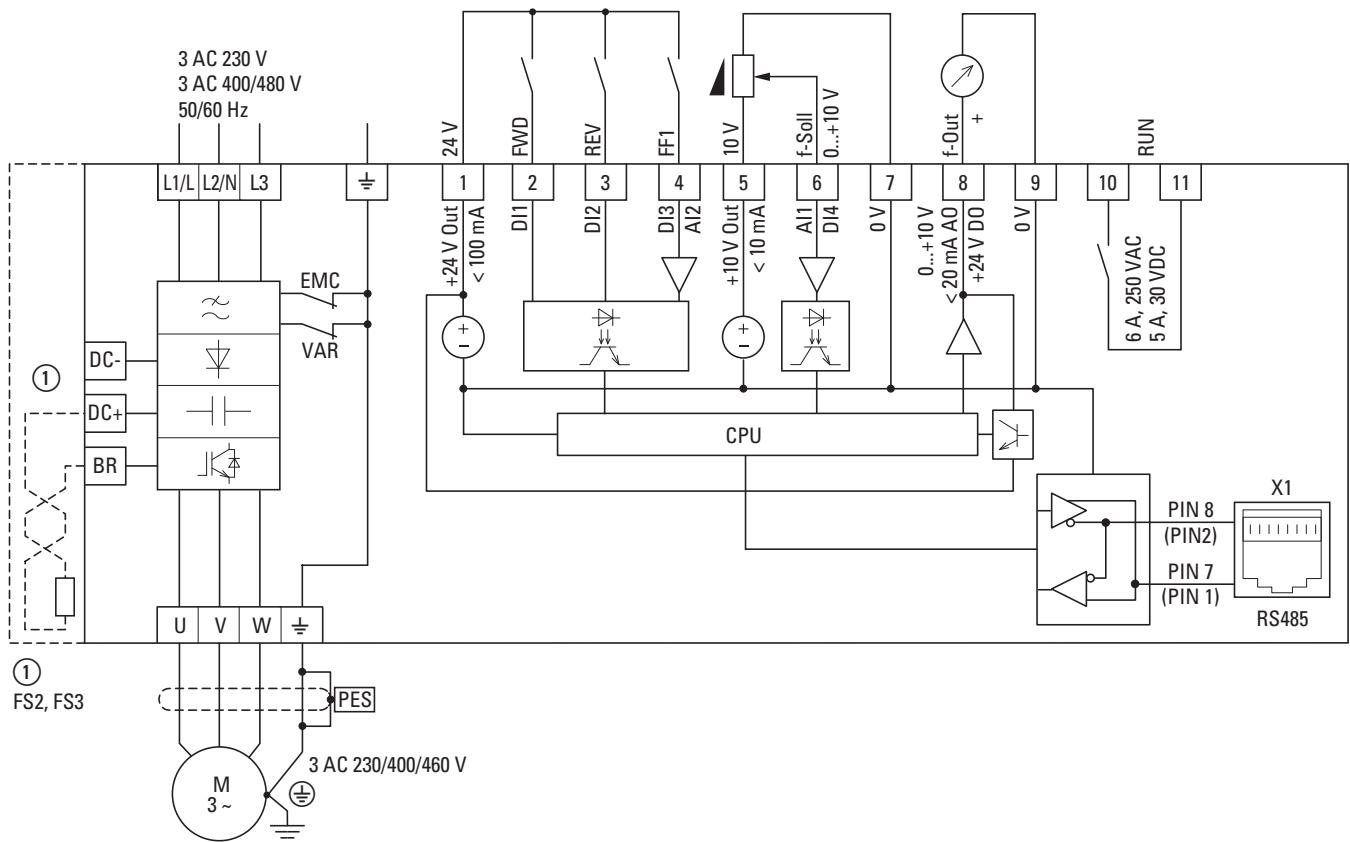
3.4.3.3 DC1-32…, DC1-34…

Figure 53: DC1-32…, DC1-34… block diagram
Frequency inverter with three-phase mains supply voltage and three-phase motor connection

① FS2 and FS3 make it possible to connect external braking resistors.

3.4.3.4 DC1-S2…
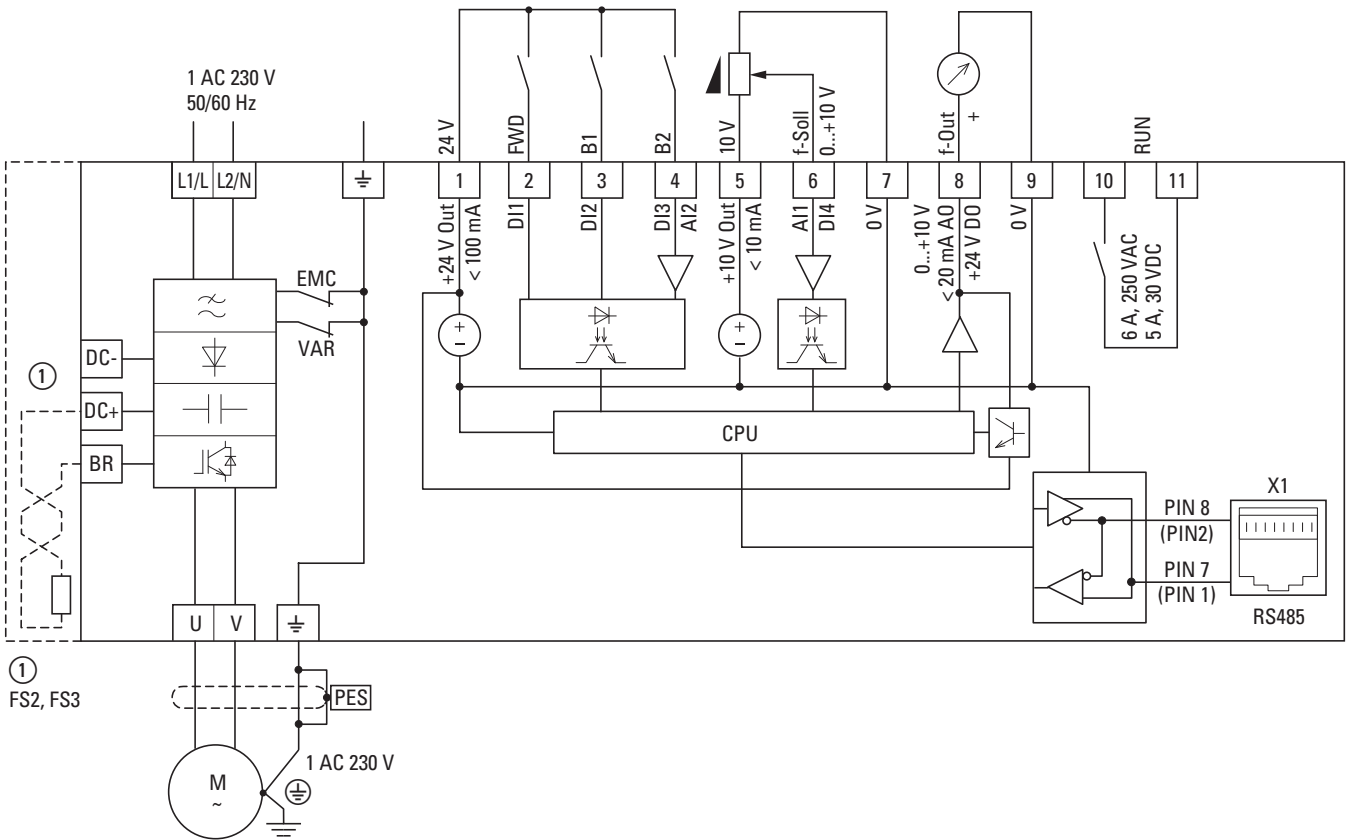
Figure 54:   DC1-S2… block diagram
Frequency inverter for AC motors with single-phase supply voltage and single-phase motor connection

➜   DC1-S2… frequency inverters do not feature an internal radio interference suppression filter.
An external radio interference suppression filter is required for operation as per EN 61800-3.

3.4.4 Insulation test

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

> ⚠️ **CAUTION**
>
> On the control signal and the connection terminals of the frequency inverter, 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 frequency inverter.

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

3.4.4.1 Testing the motor cable insulation

▶ Disconnect the motor cable from the connection terminals U, V and W of the frequency inverter 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.

3.4.4.2 Testing the mains cable insulation

▶ Disconnect the power cable from the mains supply network and from the connection terminals 1/L, L2/N and L3 of the frequency inverter. 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.

3.4.4.3 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 in accordance with the corresponding instructional leaflet (→ IL04020009Z, IL04020013Z, IL04020014Z).	
2	All wiring and line section leftovers, as well as all the tools used, have been removed from the frequency inverter's proximity.	
3	All 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 frequency inverter are **not** short-circuited and are **not** connected to ground (PE).	
5	The frequency inverter has been earthed properly (PE).	
6	All electrical terminals in the power section (L1/L, L2/N, L3, U, V, W, DC+, DC-, BR, PE) were implemented properly and were designed in line with the corresponding require-ments.	
7	Each single phase of the supply voltage (L or L1, L2, L3) is protected with a fuse.	
8	The frequency inverter and the motor are adapted to the mains voltage. (→ Section 1.4.1, „Rating data on the nameplate", page13, 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 frequency inverter and the motor.	
10	All connected control cables comply with the correspond-ing stop conditions (e.g., switch in OFF position and set-point value= zero).	
11	The parameters that were preset at the factory have been checked with the list of parameters.(Table 12, page 93).	
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.	

4.2 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 frequency inverter's power section are energized if the supply voltage (mains voltage) is connected.
> For instance: power terminals L1/L, L2/N, L3, DC+, DC-, BR, U/T1, V/T2, W/T3.
> 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 frequency inverter 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 frequency inverter'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**
> 5 MIN

> **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).

> *NOTICE*
>
> Any contactors and switching devices on the power side are not to be opened during motor operation. Inching operation using the power switch 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 frequency inverter 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 frequency inverters are set in the factory and can be started directly via the control signal terminals by connecting the motor outputs allocated for the mains voltage (see connection example below).

➜ You can skip this section if you want to set up the parameters directly for optimal operation of the frequency inverter 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 power supply connection (DC1-1D…, DC1-12…)	Three-phase power supply connection (DC1-32…, DC1-34…)
	L2/N		
	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 frequency inverter 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 kΩ, up to a maximum of 10 kΩ.
A standard fixed resistance of 4.7 kΩ 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 (STOP). At this point, the frequency inverter 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); no function in DC1-S2… (no start enable)

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

Connecting example for AC motor

Connecting example for AC motor	Terminal	designation
	L1/L	Single-phase power supply connection DC1-S2…
	L2/N	
	⏚	Ground connection
	1	Control voltage +24 V (output, maximum 100 mA)
	2	FWD, start enable (the rotating field will depend on the motor connection)
	U	Connection for a single-phase AC motor
	V	
	⏚	
	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)

The frequency is shown with a minus sign with a start release with a left rotating field (not for DC1-S2…).

▶ 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. In the factory settings, these times are set to 5 seconds and to 10 seconds from a frame size FS4.

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

Figure55 on Page 88 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 Figure55).

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 118.

4.3 Commissioning with control signal terminals (default settings)
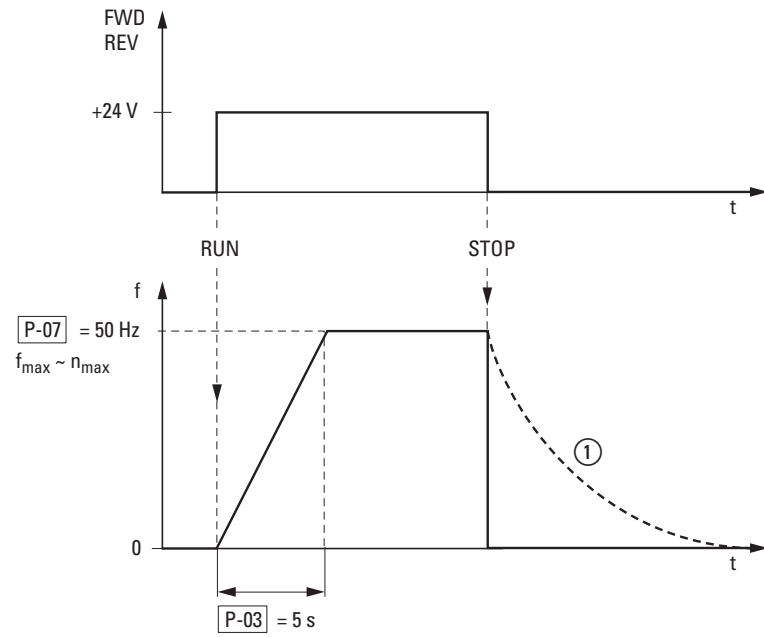
Figure 55:   Start-Stop command with maximum setpoint value voltage,
acceleration ramp 5 s

5 Error messages

5.1 Introduction

DC1 series frequency inverters come with several internal monitoring functions. When a deviation from the correct operating status 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).

5.1.1 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 and the PO monitor values.

5.1.2 Acknowledge fault (Reset)

To acknowledge and reset the current error message, you can either switch off the supply voltage or press the STOP button. Error messages (a maximum of four) are stored in parameter P-13.

5.1.2.1 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.
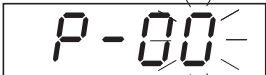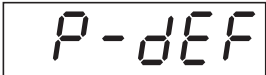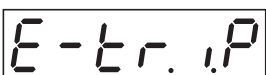
➜ To get more information regarding the fault, go to the "Monitor" menu (P0-…).
The values in the fault log (P-13) will not be deleted if the frequency inverter is reset to its default settings!

The example below shows how to access the fault log.

Indicator	Explanation
$5 t o P$	Operating state Stop
OK	Press OK button
$P - 00$	The parameter that was last accessed will be shown. The last digit on the display will flash.
▲/▼	
$P - 13$	Use the ▲ (Up) or ▼ (Down) arrow buttons to select parameter P-13 and confirm your selection by pressing the OK pushbutton.
OK	
$P - dEF$	Last error message. Example: $P - dEF$ (Parameter default = Default setting loaded).
▲	Use the arrow button ▲ (Up) to go to the next error message.
$U - UoL.t$	Second most recent error message: Example: $U - UoL t$ ("Voltage too low" message). The dot on the right will flash.
▲	The third most recent error message will be shown after pressing the ▲ arrow button (Up).
$E - tr. iP$	Example: $E - tr iP$ (external error message). The two dots on the right will flash.
▲	The oldest error message will be shown after you press the ▲ arrow button (Up) once more.
$U - U.o.L.t$	Example: $U - UoL t$ ("Voltage too low" message) The three dots on the right will flash.

5.1.3 Error list

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

Table 11:   Error messages list

Indicator	designation	Possible cause	Notes
P-dEF	Parameter default	The parameter's default setting has been loaded.	Press the STOP pushbutton. The DC1 frequency inverter is ready for an application-specific configuration.
O-I	Overcurrent motor	• Overcurrent at output • Overload at motor • Overtemperature at heat sink	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 frequency inverter is required. Cable fault between frequency inverter and motor.
I.t-trF	Thermal motor overload	The DC1 frequency inverter was switched off after more than 100 % of the value set in P-08 was delivered for a period of time.	Check whether the decimal places are flashing (frequency inverter overloaded) and either raise the acceleration ramp (P-03) or reduce the motor load. Make sure that the cable length matches the frequency inverter 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.
OI-b	Overcurrent braking resistance	Brake chopper overcurrent	Overcurrent in braking resistor circuit. Check the wiring to the braking resistor. Check the brake resistor value. Make sure that the minimum resistance values are being adhered to.
OI-br	Thermal overload braking resistance	Overload braking resistance	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.
PS-trF	Fault in power section	Fault in power section	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 frequency inverter's ambient air temperature. Check whether additional clearance or cooling is required. Make sure that the frequency inverter is not being overloaded.
O.Uolt	Overvoltage DC link	Overvoltage at DC link	Power supply problem Increase the deceleration ramp time P-04.
U.Uolt	DC link undervoltage	DC link undervoltage	Normally occurs if the power is switched off. If it occurs during running, check the power supply voltage.
O-t	Overtemperature	Heat sink overtemperature	Check the frequency inverter's ambient air temperature. Check whether additional clearance or cooling is required.
U-t	Excessively low temperature (frost)	Under-temperature	The frequency inverter 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 frequency inverter.
th-Frt	Thermistor fault	Defective thermistor on heat sink	Please contact your closest Eaton representative.

5 Error messages

5.1 Introduction

Indicator	designation	Possible cause	Notes
E-trIP	External fault	External shutdown (on digital input 3)	External safety shutdown on digital input 3. The normally-closed contact opened for some reason. If a motor thermistor is connected, check whether the motor is too hot.
SC-ErF	Communication fault	Communication loss error	Check the communications connection between the frequency inverter and external devices. Make sure that each individual frequency inverter on the network has a unique address.
P-loSS	Mains connection phase fault	Input phase loss Shutdown	A frequency inverter intended for use with a three-phase supply has lost one of its input phases.
SPIn-F		Motor pick-up control function (for catching spinning motors) failed	The motor pick-up control function did not determine the motor speed.
dAtA-F	Data error	Internal memory error	Parameter not stored; default settings loaded back. If the problem occurs again, please contact your closest Eaton representative.
4-20F	Live zero error	Analog input current outside range	Make sure that the input current falls within the range defined by P-16.
SC-FLt	Internal error	Internal frequency inverter fault	Please contact your closest Eaton representative.
FAHLEH	Internal error	Internal error	Please contact your closest Eaton representative.

6 Parameters

Table 12: Description list for DC1 parameters

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
P-01	129	✓	rw		Maximum frequency / maximum speed	50.0
					P-10 = 0 → P-02 - 5 x P-09 → Hz P-10 > 0 → P02 - 5 x P-09 x 60 s → min-1 The maximum output frequency / motor speed limit – shown in Hz or rpm (if P-10 > 0).	
P-02	130	✓	rw		Minimum frequency / minimum speed	0
					P-10 = 0 → 0 - P-01 → Hz P-10 > 0 → 0 - P01 → min-1 The minimum output frequency / minimum speed – shown in Hz or rpm (if P-10 > 0).	
P-03	131	✓	rw		Acceleration time (acc1)	5
					0.1 - 600 s (→ Figure 68, page 119)	
P-04	132	✓	rw		Deceleration time (dec1)	5
					0.1 - 600 s (→ Figure 68, page 119)	
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 resistor (optional) (→ Section 6.2.11.2, „Regenerative braking", page132)	
				1	Free coasting After the start enable (FWD/REV) is switched off or the STOP push-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 resistor (optional) (→ Section 6.2.11.2, „Regenerative braking", page132)	
P-06	134	✓	rw		Energy optimization	0
				0	Deactivated	
				1	activated If this option is selected, the energy optimization function will attempt to reduce the total energy consumed by the frequency inverter and the motor during operation at constant speeds and with light loads. The output voltage applied at the motor will be reduced. The energy optimization function is intended for applications in which the frequency inverter is run for specific periods at a constant speed and with a light load, independently of whether the torque is constant or varies.	

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
P-07	135	–	rw		Nominal voltage of the motor	230[1]
					Setting range: 0. 20 - 250 / 500 V (⟶ Motor ratings 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 frequency inverter's rated operational data (U_{LN} = 100 %). This may cause the over-excitation of the motor and thus lead to an increased thermal load.	
P-08	136	✓	rw		Rated motor current	4.8[1]
					Setting range: 0.2 x I_e - 2 x I_e [A] I_e = Frequency inverter's rated operational current (⟶ Motor rating plate)	
P-09	137	–	rw		Nominal frequency of the motor	50.0[1]
					Setting range: 25 – 500 Hz (⟶ Motor ratings plate)	
					Note: This parameter value is also automatically applied as the cut-off frequency for the V/Hz characteristic curve.	
P-10	138	✓	rw		Nominal speed of the motor	0
					0 - 30,000 rpm (min^{-1}) (⟶ motor rating plate)	
					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 frequency inverter'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-11	139	✓	rw		Voltage amplification	3.0
					0.00 - 20.0 %	
					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.	

PNU	ID	Access rights		Value	Description	DS
		RUN	**ro/rw**			
P-12	140	–	rw		Control level	0
				0	Control signal terminals (I/O) The frequency inverter will respond directly to signals applied to the control signal terminals.	
				1	Keypad (KEYPAD FWD) The frequency inverter can only be controlled in the forward direction if an external or remote control keypad is used.	
				2	Keypad (KEYPAD FWD/REV) The frequency inverter 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 counterclockwise rotating field (REV) by pressing the START button.	
				3	Modbus Control via Modbus RTU (RS-485) 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	
P-13	141	–	ro		Fault log history	–
					The most recent four errors will be stored in the order in which they occurred. The most recent one will be in the first place. Use the ▲ and ▼ arrow buttons to move through all four errors one by one. An undervoltage trip will only be stored once. Additional logging functions concerning the fault are available in the "Monitor" parameter group.	
P-14	142	✓	rw		Parameter range access code	0
					(Depends on P-37 Extended parameter access code) Set the value to 101 (default setting) to enable access to the extended menu. Change the code value in P-38 (parameter access lock) in order to prevent unauthorized access to the extended parameter set.	

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
Extended parameter range (access: P-14 = 101)						
P-15	143	–	rw		Function of digital inputs	5
				0 - 12	Defines the function of the digital inputs depending on the control mode setting in P-12.	
P-16	144	✓	rw		Analog input 1 (AI1), signal range	*U0 - 10*
				U0 - 10	0 - 10 V signal (unipolar) The frequency inverter will remain at 0.0 Hz if the analog signal is < 0.0% after scaling and applying the corresponding offset.	
				b - 10 - 10	0 - 10 V signal (bipolar). The frequency inverter will drive the motor in the reverse operating direction as soon as the analog reference value is less than 0.0 % after scaling and applying the corresponding offset.	
				A0 - 20A	0 - 20 mA signal	
				t 4 - 20	4 - 20 mA signal The frequency inverter will be switched off and show failure code *4 - 20F* as soon as the signal level falls below 3 mA.	
				r 4 - 20	4 - 20 mA signal The frequency inverter will run as per a ramp all the way to a stop as soon as the signal level falls below 3 mA.	
				t 20 - 4	20 - 4 mA Signal The frequency inverter will be switched off and show failure code *4 - 20F* as soon as the signal level falls below 3 mA.	
				r 20 - 4	20 - 4 mA Signal The frequency inverter will run as per a ramp all the way to a stop as soon as the signal level falls below 3 mA.	
P-17	145	✓	rw	4 - 32 kHz	Pulse frequency	16[1]
					Size FS1: 16 kHz Sizes FS2 and FS3: 8 kHz	
					Used to set the frequency inverter's maximum rms pulse frequency. If *r E D* is shown, the pulse frequency has been reduced to the level in P00-14 due to an elevated heat sink temperature in the frequency inverter.	
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, frequency inverter ready for operation	
				2	Output frequency = frequency reference value	
				3	Error message (frequency inverter 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)	

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
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	
P-20	148	✓	rw		Fixed frequency FF1 / speed 1	0.0
					P-10 = 0 → -P-02 - P-01 → Hz P-10 > 0 → -P-02 - P-01 x 60 s → rpm (1/min)	
					0.00 Hz (P-02) up to the maximum frequency value (P-01). Activation via digital inputs depending on parameters P-12 and P-15	
P-21	149	✓	rw		Fixed frequency FF2 / speed 2	0.0
					P-10 = 0 → -P-02 - P-01 → Hz P-10 > 0 → -P-02 - P-01 x 60 s → rpm (1/min)	
					0.00 Hz (P-02) up to the maximum frequency value (P-01). Activation via digital inputs depending on parameters P-12 and P-15	
P-22	150	✓	rw		Fixed frequency FF3 / speed 3	0.0
					P-10 = 0 → -P-02 - P-01 → Hz P-10 > 0 → -P-02 - P-01 x 60 s → rpm (1/min)	
					0.00 Hz (P-02) up to the maximum frequency value (P-01). Activation via digital inputs depending on parameters P-12 and P-15	
P-23	151	✓	rw		Fixed frequency FF4 / speed 4	0.0
					P-10 = 0 → -P-02 - P-01 → Hz P-10 > 0 → -P-02 - P-01 x 60 s → rpm (1/min)	
					0.00 Hz (P-02) up to the maximum frequency value (P-01). Activation via digital inputs depending on parameters P-12 and P-15	
P-24	152	✓	rw		Second deceleration time (dec2)	0.0
					0.1 - 25.0 s (→ Figure 81, page 135)	
					This parameter makes it possible to program an alternative deceleration time, in the frequency inverter, that can be selected via digital inputs (depending on the setting for P-15) or automatically in the event of a mains power failure if P-05 = 2. If the value is 0.00, the frequency inverter will coast all the way to a stop.	

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
P-25	153	✓	rw		AO1 signal (Analog Output)	8
					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)	
					Switch to digital output	
					DA4 (Digital output) → +24 V DC (Value 0 - 7)	
				0	RUN (Frequency inverter released and running / FWD, REV)	
				1	READY, frequency inverter ready for operation / no faults	
				2	Output frequency = frequency reference value	
				3	Error message (frequency inverter 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)	
P-26	154	✓	rw		Frequency skip 1, bandwidth (hysteresis range)	0
					0.00 - P-01 (f_{max})	
P-27	155	✓	rw		Frequency skip 1, center	0
					P-02 (f_{min}) - P-01 (f_{max})	
					The skip frequency function is used to prevent the frequency inverter from being run at a specific output frequency, e.g. at a frequency that will cause mechanical resonance in a specific machine. 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. If the frequency reference value applied to the frequency inverter falls within the band, the output frequency will remain at the upper or lower limit of the band.	
P-28	156	–	rw		V/Hz characteristic curve modification voltage	0
					0.00 - P-07 V	
P-29	157	–	rw	0.00 - P-09 Hz	V/Hz characteristic curve modification frequency	0
					0.00 - P-09 Hz	
					Together with P-28, this parameter is used to set a frequency point at which the voltage set in P-28 will be applied to the motor. It is necessary to exercise caution if this output characteristic is used so as to avoid overheating and damaging the motor. See P-11 for more information.	

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
P-30	158	✓	rw		REAF, Start function with automatic restart, control signal terminals	*EdGE-r*
					Used to define the frequency inverter's behavior concerning the enable digital input and to configure the automatic restart function.	
				EdGE-r	disabled	
					After being switched on, as well as after a reset, the frequency inverter will not start if digital input 1 remains closed (the frequency inverter 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 frequency inverter.	
				AUto-0	The frequency inverter will start automatically. (The frequency inverter will not need a start edge; the signal will continue to be applied.)	
					After being switched on, as well as after a reset, the frequency inverter will start automatically if digital input 1 is closed.	
				AUto-1	The frequency inverter will start automatically once.	
					After a trip, the frequency inverter will make up to five attempts to restart at 20-second intervals. The frequency inverter must be de-energized in order to reset the counter. The number of restart attempts is counted. If the frequency inverter does not start after the last attempt, it will switch to an error condition and request the user to reset the error manually.	
				AUto-2	The frequency inverter will start automatically twice.	
				AUto-3	The frequency inverter will start automatically three times.	
				AUto-4	The frequency inverter will start automatically four times.	
				AUto-5	The frequency inverter will start automatically five times.	
P-31	159	✓	rw		REAF, Start function with automatic restart, operating unit	1
					This parameter will only be active if the keypad control operating mode is being used (P-12 = 1 or P-12 = 2).	
				0	Minimum speed; keypad	
					The keypad's start and stop buttons are enabled, and control signal terminals 1 and 2 must be connected. The frequency inverter will always start with the minimum frequency/speed (P-02).	
				1	Previous speed, keypad	
					The keypad's start and stop buttons are enabled; control signal terminals 1 and 2 must be connected. The frequency inverter will always start with the most recent operating frequency/speed.	
				2	Minimum speed; terminal	
					The frequency inverter will be started directly from the control signal terminals; the keypad's start and stop buttons will be ignored. The frequency inverter will always start with the minimum frequency/speed (P-02).	
				3	Previous speed, terminal	

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
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 frequency inverter 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 frequency inverters 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 frequency inverter 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	
				2	Enabled without overload protection braking resistance	
P-35	163	✓	rw		Analog input 1 scaling	100
					0 - 500 %	
					Used to scale the analog input 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 frequency inverter run at the maximum frequency / speed (P-01).	
P-36	164	–	rw		Serial communication configuration	
					This parameter has three settings that are used to configure serial Modbus RTU communications. These subparameters are as follows:	
				0 - 63	Frequency inverter slave address	1
					Baud rate	OP-buS
				1	OP-buS	
				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 ms
					locked, 30 - 3000 ms	

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
P-37	165	✓	rw	0 - 9999	Access code definition	101
					Used to define the access code that must be entered into P-14 in order to get access to the parameters higher than P-14.	
P-38	166	✓	rw		Parameter access lock	0
				0	Deactivated All parameters will be accessible and can be edited.	
				1	activated Parameter values can be shown, but cannot be edited.	
P-39	167	✓	rw		Offset for analog input 1	0.0
					-500.0 - +500.0 %	
					Used to set an offset as a percentage of the input's full scale range so that this offset will be applied to the analog input signal.	
P-40	168	✓	rw		Speed display scaling factor	0.00
					0.00 - 6.00	
					Enables users to program the frequency inverter in such a way that an alternative output unit, scaled from the output frequency or speed, will be shown (e.g. for showing a conveyor belt's speed in meters per second). This function will be disabled if P-40 = 0.00.	
P-41	169	✓	rw	0.0 - 30.0	PI controller proportional gain	1.0
					Higher values will result in a larger change to the frequency inverter output frequency as a response to small changes in the feedback signal. An excessively high value can cause instability.	
P-42	170	✓	rw	0.0 - 30.0 s	PI controller integral time	1.0
					PI controller integral time. Higher values will result in a more damped response for systems in which the overall process responds slowly.	
P-43	171	✓	rw	0	PI controller action	0
					Higher values will result in a more damped response for systems in which the overall process responds slowly.	
					direct operation	
				1	Reverse action	
P-44	172	✓	rw	0	PI setpoint source selection	0
					Used to select the source for the PI setpoint value.	
					Digital, preset setpoint value (P-45)	
				1	Analog input 1	
P-45	173	✓	rw		Digital setpoint value PI	0.0
					0.0 - 100.0 %	
					If P-44 = 0, this parameter will set the preset digital setpoint value used for the PI controller.	
P-46	174	✓	rw		PI feedback source selection	1
				0	Analog input 2	
				1	Analog input 1	
				2	Motor current	

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
P-47	175	✓	rw		Analog input 2 signal format	t 4-20
				$U0$-10	0 - 10 V signal	
				$A0$-20	0 - 20 mA	
				t 4-20	4 - 20 mA (≦ 3 mA → error message: 4-20F)	
				r 4-20	4 - 20 mA (≦ 3 mA → delay time 1)	
				t 20-4	20 - 4 mA (≦ 3 mA → error message: 4-20F)	
				r 20-4	20 - 4 mA (≦ 3 mA → delay time 1)	
P-48	176	✓	rw	0.0 - 25.0 s	Standby time 0 = Deactivated The drive will switch to standby mode (i.e., output deactivated) if the minimum speed (P-02) remains constant during the length of time specified here.	20
P-49	177	✓	rw	0.0 - 100.0 %	PI feedback wake up level Error value (difference between PI setpoint and process value) for the PI controller. If the value measured by the PI controller is higher than this value, the drive will leave the stand-by mode.	0
P-50	178	✓	rw		CANopen baud rate for CANopen communications	2
				0	125 kbit/s	
				1	250 kBit/s	
				2	500 kBit/s	
				3	1000 kBit/s	
P00-…-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	23		ro	Hz/rpm	Frequency reference value / Motor shaft speed	
					Shown in Hz if P-10 = 0; otherwise shown in rpm	
P00-04	11		ro	DI1 - DI4 status	Digital inputs 1 - 4	
					State of the frequency inverter'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 frequency inverter's operating time	
					Not affected when the parameters are reset to their default settings.	

PNU	ID	Access rights		Value	Description	DS
		RUN	**ro/rw**			
P00-11			ro	HH:MM:SS	The frequency inverter's operating time since the last trip (1)	
					Operating time clock stopped by frequency inverter lockup (or trip). Reset with next enable only if a trip occurred. Also reset with next enable after the frequency inverter's mains power is switched off.	
P00-12			ro	HH:MM:SS	The frequency inverter's operating time since the last trip (2)	
					Operating time clock stopped by frequency inverter 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.	
P00-13			ro	HH:MM:SS	The frequency inverter's operating time since the last lockup	
					The frequency inverter's operating time clock was stopped with the lockup. → Reset the value with next enable.	
P00-14			ro	4 - 32 kHz	Pulse frequency	
					The frequency inverter's actual rms output pulse frequency. If the frequency inverter is too hot, this value may be lower than the frequency selected in P-17. The frequency inverter will automatically reduce the pulse frequency in order to prevent an excess temperature trip and maintain operation.	
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	Log for thermistor temperature	
					The eight most recent values before the trip Updated every 500 ms.	
P00-17			ro	0 - 2 x rated operational current	Motor current	
					The eight most recent values before the trip Updated every 250 ms.	
P00-18	15		ro	–	Software version	
	16				Version number and checksum 1 = I/O processor (on the left side of the frequency inverter) 2 = motor control	
P00-19			ro	–	Serial number of frequency inverter	
					The frequency inverter's unique serial number Example: 540102 / 32 / 005	
P00-20	12		ro	–	Frequency inverter part no.	
	13				Rated power of frequency inverter	
	14				Frequency inverter type (example: 0.37, 1 230, 3P-out)	

6.1 Operating unit

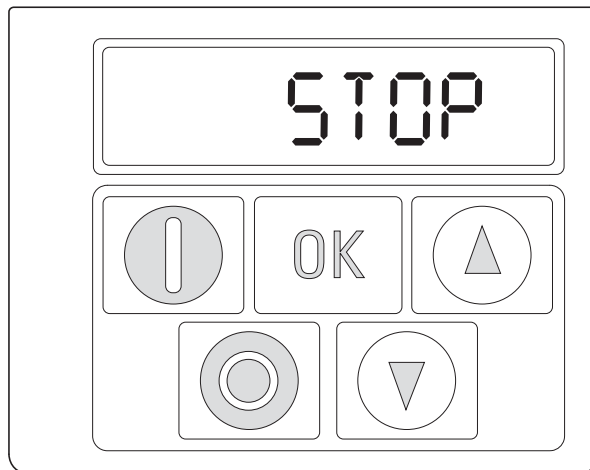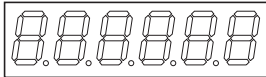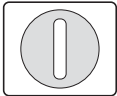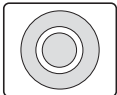The following figure shows the elements of the DC1 frequency inverter integrated operating unit.
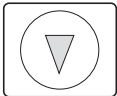

Figure 56: Operating unit view

Table 13: Operating unit elements

Operating unit element	Explanation
	Six-digit 7-segment LED display
	Motor starter with pre-selected operating direction if parameter P-12 = 1 (FWD) or P-12 = 2 (FWD / REV). **Note:** • 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). (This setting will be retained even after the supply voltage is switched off.)
	• Stops the running motor if P-12 = 1 or P-12 = 2 • Reset – Resetting after an error message
	• Activate parameter input (editing mode) • Activate parameter value, change (display value flashes) • Confirm (store) and activate configured value
	• Increment numeric value or parameter number • Increase output frequency / motor speed if P-12 = 1 or P-12 = 2
	• Decrement numeric value or parameter number • Reduce output frequency / motor speed if P-12 = 1 or P-12 = 2

6.1.1 Display unit

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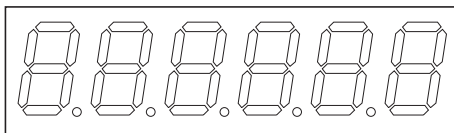

Figure 57: 7-segment LED display

6.1.2 Menu Navigation

When the specified supply voltage (L1/L, L2/N, L3 connection terminals) is applied, the DC1 frequency inverter will automatically perform a self-test: The LED display will light up and, depending on the selected operating mode, will display "Stop" or the appropriate value.

➜ When operating values are displayed (i.e. STOP is not displayed), the frequency inverter will issue an automatic start command.

6.1.3 Setting parameters

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 buttons (Up ▲ or Down ▼).

Sequence	Commands	Indicator	Description
0		StoP	Stop status: The frequency inverter is ready for operation.
1			Hold down the OK button for about a second. Parameter P-01 will be displayed (the digit on the right, "1", will flash)
2	OK		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 button. The display will jump back to the parameter name (P-01).
		P - 12	The numerical first value is always shown from the selected main menu. Example: Main menu PAR, Parameter P1.1 The display automatically switches between the parameter number and the defined value. P1.1 =1 is displayed at the first switch on and after the default settings have been activated.

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

6.1.4 Parameter selection

Parameter P-14 is used to select between a limited range of parameters (P-14 = 0) or all parameters (P-14 = P-37, WE = 101).

Parameter P-37 is used to change the access code used to access all the parameters. Once you confirm parameter P-37, the extended parameters will be locked.

You can use parameter P-38 to block access to all parameters, with the exception of parameter P-14 (read-only).

6.2 Digital and analog inputs

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.
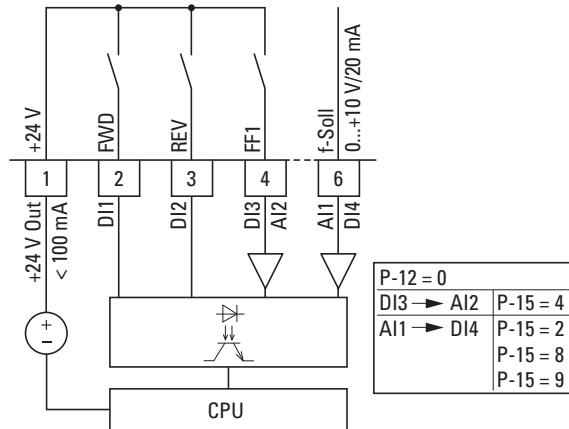

Figure 58: Digital and analog inputs

The operation of the DC1 frequency inverter via control signal terminals (P-12 = 0, P-15 = 5) is active with default 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; DS = 15 Hz)
*   AI1/DI4 (control signal terminal 6): analog setpoint input (0 - 10 V)

When control signal terminal 2 (FWD) and control signal terminal 3 (REV) are activated at the same time, the default configuration will activate quick stop dec2 (P-24).

6.2.1 Digital Input (DI)

Control signal terminals 2, 3, 4, and 6 can be used as digital inputs (DI). The digital inputs' function and mode of operation are configured in parameter P-15.

Example

Desired options:

- Clockwise rotating field (FWD),
- Anticlockwise rotating field (REV),
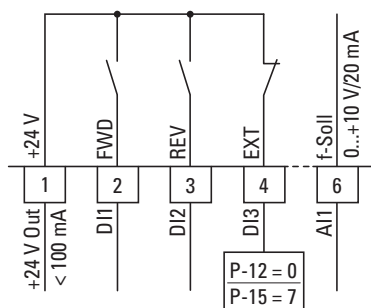- external fault,
- Setpoint value via AI1.

Figure 59:   Example of an external fault (EXT)

Table 14:   Digital input wiring

P-15	DI1	DI2	DI3	AI1
7	0 = locked 1 = Start enable FWD	0 = locked 1 = Start enable REV	**External fault** 0 = Fault 1 = Enable	Setpoint value AI1 (0 - 10 V)
	DI1 + DI2 = Quick stop (P-24)			

- DI1 (control signal terminal 2): FWD (Forward = Start enable clockwise rotating field)
- DI2 (control signal terminal 3): REV (Reverse = Start enable anti-clockwise rotating field)
- DI3 (control signal terminal 4): external fault
- AI1 (control signal terminal 6): analog setpoint value

6.2.2 Analog Input (AI)

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, 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 open-circuit monitoring
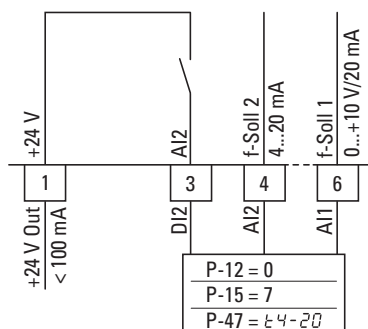- Switching the setpoint source between AI1 and AI2 via DI2.

Figure 60: Switching setpoint sources

Table 15: Analog and digital input wiring

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

6.2.2.1 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 frequency inverter running at its maximum frequency/speed (P-01). Values lower than 100 % limit the maximum frequency; values greater than 100 % are used for low signal levels, e.g. for sensors with a 0 to 5 V output.
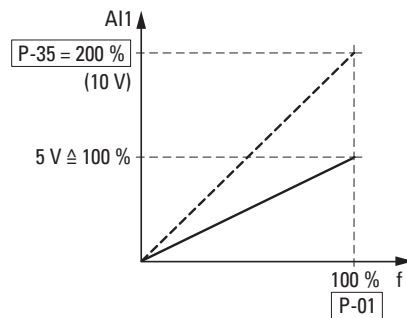

Figure 61: Scaled input signal

6.2.2.2 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
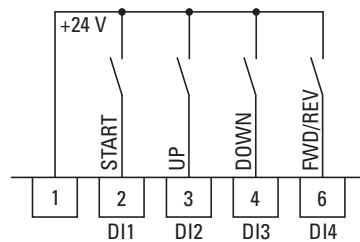

Figure 62:   Motor potentiometer for
                 both operating directions (FWD / REV)

The start enable is applied with a permanent contact on control signal terminal 2 (DI1); the operating direction (FWD or REV) is chosen with control signal terminal 6 (DI4) – only if P-12 = 2. If P-12 = 1, the operating direction cannot be changed. The frequency reference value can then be increased with a control command (pulse) on terminal 3 (DI2) (UP). The acceleration will take place using the time set in P-03 (acc1) all the way to the maximum output frequency set in P-01.

Parameter P-31 is used to define the behavior of the frequency inverter in the event of a restart:
- P-31 = 2: The DC1 frequency inverter will start off from the minimum frequency (P-02).
- P-31 = 3: The frequency inverter will store the set value and move to the previously set frequency reference value when starting.
  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.
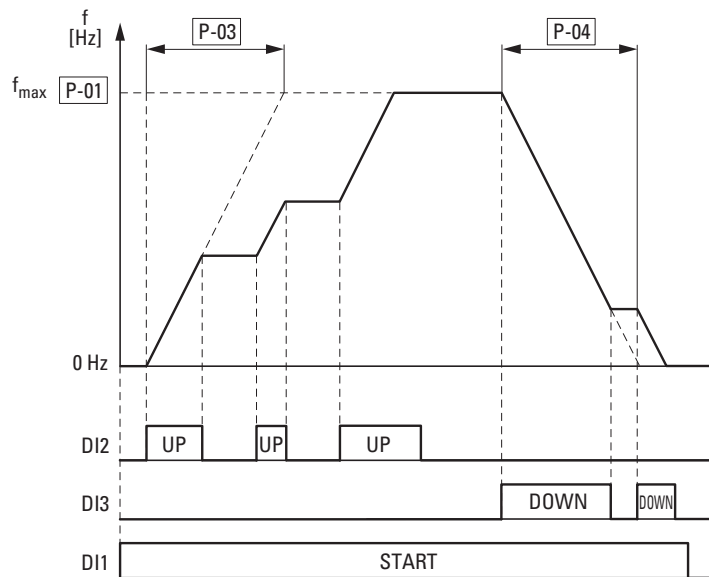
Figure 63:   Motor potentiometer example

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 (DI1) is switched off.
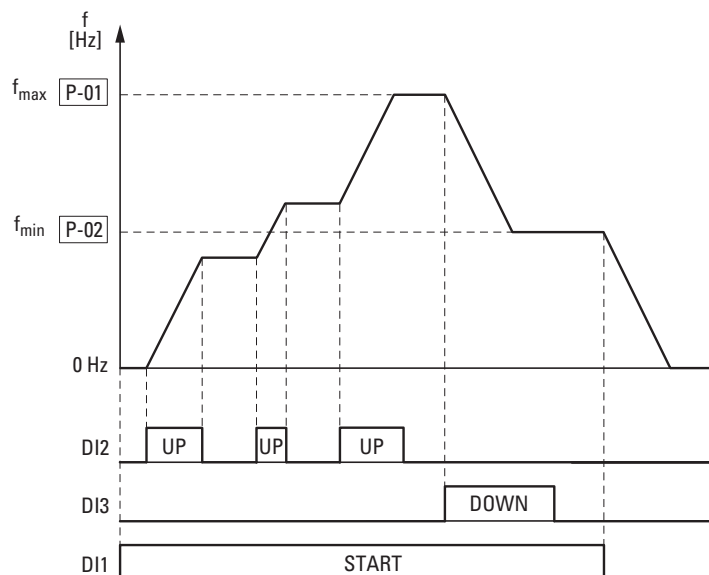

Figure 64:   Motor potentiometer with f$_{min}$ limit

6.2.2.3 Two-wire control

For two-wire control, the parameters must be configured as shown in the following tables:

- P-12 = 0 ➔ P-15 = 0, 6, 8
- P-12 = 1 or = 2 ➔ P-15 = 0, 1, 5, 6, 8, 9, 10, 11, 12
- P-12 = 5 ➔ P-15 = 8

Control signal terminal (P-12 = 0)

P-15	DI1	DI2	DI3 / AI2	AI1 / DI4	Explanation
0	0 = Stop 1 = Run	0 = FWD 1 = REV	0 = Selected setpoint source 1 = Fixed frequency 1 (P-20)	Setpoint value AI1	
6	0 = Stop 1 = Run	0 = FWD 1 = REV	external fault: 0 = Fault 1 = Run	Setpoint value AI1	
8	0 = Stop 1 = Run	0 = FWD 1 = REV	0	0	Fixed frequency 1 (P-20)
			1	0	Fixed frequency 2 (P-21)
			0	1	Fixed frequency 3 (P-22)
			1	1	Fixed frequency 4 (P-23)

Operating unit (P-12 = 1 or P-12 = 2)

P-15	DI1	DI2	DI3 / AI2	AI1 / DI4
0, 1, 5, 8, 9, 10, 11, 12	0 = Stop 1 = Run	1 = Increase frequency	1 = Reduce frequency	0 = FWD 1 = REV
6	0 = Stop 1 = Run	0 = FWD 1 = REV	external fault: 0 = Fault 1 = Run	0 = Keypad setpoint value 1 = Fixed frequency 1 (P-20)

PI controller with external actual value (P-12 = 5)

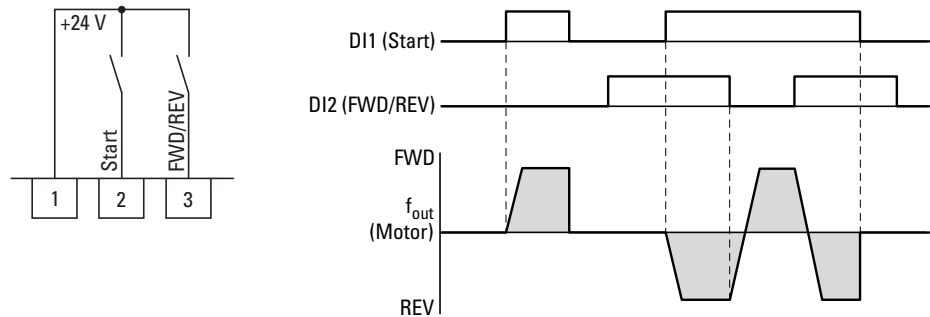| P-15	DI1	DI2	DI3 / AI2	AI1 / DI4
8	0 = Stop 1 = Run	0 = FWD 1 = REV	PI feedback AI	Setpoint value AI

Example

P-12 = 0; P-15 = 0

Figure 65: DI1 (Start), Two-wire control DI1 + DI2 = REV

The start enable via control signal terminal 3 (DI1) is always required for operation:

*   Actuation control signal terminal 3 (DI1) = Start enable, clockwise rotating field (FWD)
*   Actuation control signal terminal 3 (DI1) plus control signal terminal 4 (DI2) = Start enable anticlockwise rotating field (REV)

The separate actuation of control signal terminal 4 (DI2) does not allow any start enable.

6.2.2.4 Three-wire control

With the so-called three-wire control, the start and stop commands are set via spring-return switches (pulse) - similar to a contactor control.

The parameters must be configured as follows:

P-12 = 0 ➔ P-15 = 10, 11 ; P-12 = 5 ➔ P-15 = 4, 5, 6

Keypad Mode (P-12 = 0)

P-15	DI1	DI2	DI3	AI1
10	Normally Open (NO) Rising edge at start	Normally Closed (NC) Falling edge at stop	0 = Selected setpoint source 1 = Fixed frequency 1	Setpoint value AI1
11	Normally Open (NO) Rising edge at start	Normally Closed (NC) Falling edge at stop	Normally Open (NO) Rising edge for reverse	Setpoint value AI1

User PI control mode (P-12 = 5)

| P-15	DI1	DI2	DI3	AI1
4	Normally Open (NO) Rising edge for start	Normally Closed (NC) Falling edge for stop	PI feedback Analog Input	Analog Input
5	Normally Open (NO) Rising edge for start	Normally Closed (NC) Falling edge for stop	0 = PI Regulation 1 = Fixed frequency 1	PI feedback Analog Input
6	Normally Open (NO) Rising edge for start	Normally Closed (NC) Falling edge for stop	external fault: 0 = Fault 1 = Run	PI feedback Analog Input

Example

P-12 = 0; P-15 = 11
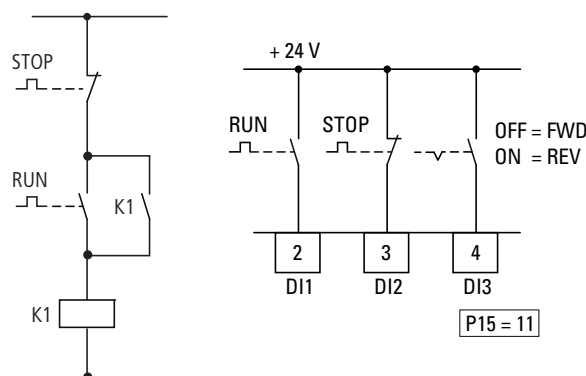
Figure 66: Example of contactor control and three-wire control

Standard control section for a drive with spring-return switch (N/C, N/O) and latching:

If parameter P-15 = 11, this control section can be recreated with control signal terminals 2 (DI1) and 3 (DI2), and control signal terminal 4 (DI3) can be used to activate an operating direction change (FWD ↔ REV) (reversing starter).

6.2.3 Digital / analog outputs

DC1 series frequency inverters feature a digital/analog output and a relay output with different characteristics.

- Digital / analog output:
  - Transistor output DO (+24 V):
    control signal terminals 8 and 9 (P-25 = 0, … ,7)
  - Analog output AO: (0 - +10 VDC, max. 20 mA):
    control signal terminals 8 and 9 (P-25 = 8, 9)
- Relay output K1 (250 V, 6 A AC / 30 V 5 A DC NO):
  control signal terminals 10 and 11 (P-18)

In the default settings (P-25 = 8), the analog output's voltage signal (0 - 10 V) will be proportional to output frequency f_{Out} = 0 - f_{max} (P-01).

➡ The output signal at control signal terminal 8 (AO) is not monitored by the frequency inverter.

Example

Desired options:

- Relay output K1 should output an alarm message if there is a 10 % overcurrent.
- 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)).
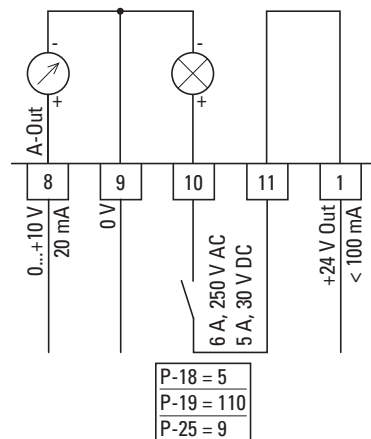

Figure 67:   Example: Overcurrent monitor

If the motor (I_e = 2.3 A) from ➡ Section "6.2.8 Motor" is used as an example, relay K1 will switch as soon as the motor draws a current of 2.53 A. The analog output will output a voltage of 5.5 V. The frequency inverter will then switch off automatically due to an overload (I_e > 100 %). The following error message will be displayed: $I.t - t r P$

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, frequency inverter ready for operation	
				2	Output frequency = frequency reference value	
				3	Error message (frequency inverter not ready)	
				4	Output frequency $\geqq$ limit value (P-19)	
				5	Output current $\geqq$ 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	
P-25	153	✓	rw		AO1 signal (Analog Output 1)	8
					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)	
					Switch to digital output	
					DA4 (Digital output) → +24 V DC (Values 0 - 7)	
				0	RUN (Frequency inverter released and running / FWD, REV)	
				1	READY, frequency inverter ready for operation / no faults	
				2	Output frequency = frequency reference value	
				3	Error message (frequency inverter is not ready)	
				4	Output frequency $\geqq$ limit value (P-19)	
				5	Output current $\geqq$ limit value (P-19)	
				6	Output frequency < limit value (P-19)	
				7	Output current < limit value (P-19)	

6.2.4 Drives control

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

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
P-12	140	–	rw		Control level	0
				0	Control signal terminals (I/O) The frequency inverter will respond directly to signals applied to the control signal terminals.	
				1	Keypad (KEYPAD FWD) The frequency inverter can only be controlled in the forward direction if an external or remote control keypad is used.	
				2	Keypad (KEYPAD FWD/REV) The frequency inverter 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 counterclockwise 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	

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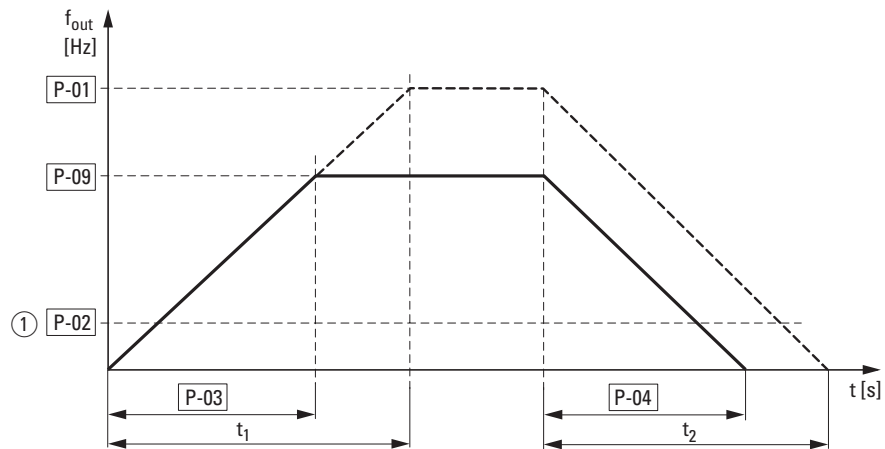
6.2.5 Second acceleration and deceleration time

Figure 68: Acceleration and deceleration time
0 Hz (P-02) and the maximum output frequency f_{max} (P-01) are always refer-
ence points for the acceleration and deceleration times set in parameters P-03
and P-04.
① If a minimum output frequency (P-02 > 0 Hz) is set,
the drive's acceleration and deceleration times will be reduced to t_1 / t_2.

The values for the acceleration time t_1 and the deceleration time t_2 are calcu-
lated as follows:

$$t_1 = \frac{(P\text{-}01 - P\text{-}02) \times P\text{-}03}{P\text{-}01}$$

$$t_2 = \frac{(P\text{-}01 - P\text{-}02) \times P\text{-}04}{P\text{-}01}$$

→ 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 fre-
quency (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 decelera-
tion times for the drive than that configured in P-04.

6.2.6 frequency jump

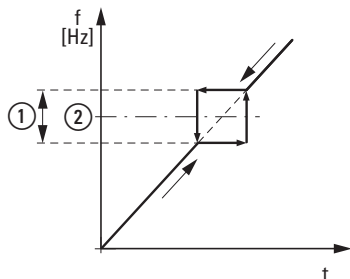In systems with mechanical resonances, you can skip this frequency range for stationary operation.

Figure 69:   Setting range for frequency masking

① P-26
② P-27

| PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
P-26	154	✓	rw		Frequency skip 1, bandwidth (hysteresis range)	0
					0.00 - P-01 (f_{max})	
P-27	155	✓	rw		Frequency skip 1, center	0
					P-02 (f_{min}) - P-01 (f_{max})	
					The skip frequency function is used to prevent the frequency inverter from being run at a specific output frequency, e.g. at a frequency that will cause mechanical resonance in a specific machine.	
					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. If the frequency reference value applied to the frequency inverter falls within the band, the output frequency will remain at the upper or lower limit of the band.	

6.2.7 Start Function

Example

P-30: AUto-2
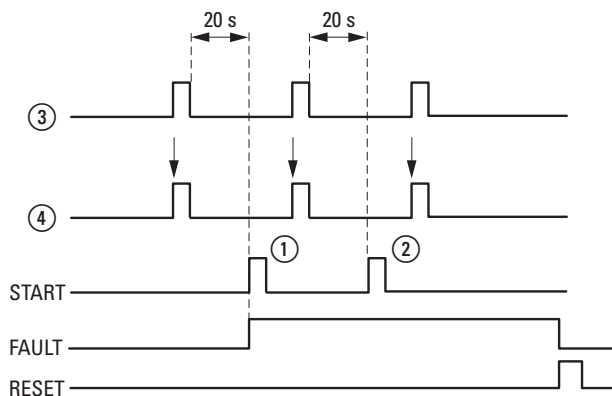
Figure 70:   Automatic restart after error message (two start attempts)

① First automatic restart
② Second automatic restart
③ Switch-off when error detected

④ Motor Stop Signal
    TEST = monitored test time
    FAULT = shut-off when error message occurs
    RESET = reset error message (FAULT)

PNU	ID	Access rights		Value	Description	DS
		RUN	**ro/rw**			
P-30	158	✓	rw		REAF, Start function with automatic restart, control signal terminals	E d9E - r
					Used to define the frequency inverter's behavior concerning the enable digital input and to configure the automatic restart function.	
				E d9E - r	disabled	
					After being switched on, as well as after a reset, the frequency inverter will not start if digital input 1 remains closed (the frequency inverter 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 frequency inverter.	
				AUto - 0	The frequency inverter will start automatically. (The frequency inverter does not need a start edge; the signal will continue to be applied.)	
					After being switched on, as well as after a reset, the frequency inverter will start automatically if digital input 1 is closed.	
				AUto - 1	The frequency inverter will start automatically once.	
					After a trip, the frequency inverter will make up to five attempts to restart at 20-second intervals. The frequency inverter must be de-energized in order to reset the counter. The number of restart attempts is counted. If the frequency inverter does not start after the last attempt, it will switch to an error condition and request the user to reset the error manually.	
				AUto - 2	The frequency inverter will start automatically twice.	
				AUto - 3	The frequency inverter will start automatically three times.	
				AUto - 4	The frequency inverter will start automatically four times.	
				AUto - 5	The frequency inverter will start automatically five times.	

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

6.2.8 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.
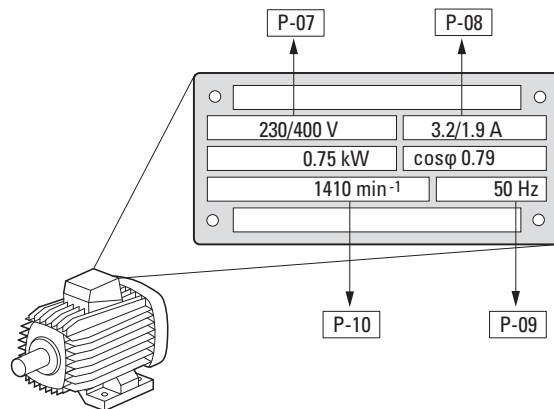

Figure 71:   Motor parameters from ratings plate

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

6.2.8.1 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
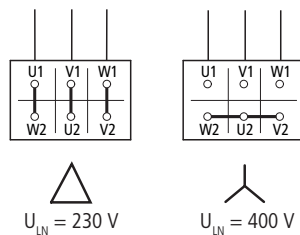- 400 V (P-07) ➔ star-connected circuit ➔ P-08 = 2.3 A

Figure 72:   Circuits (delta, star)

Example

Single-phase connection of DC1-124D8… frequency inverter 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 Figure71). See [1] in the default settings.

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

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
P-07	135	–	rw		Nominal voltage of the motor	230
					Setting range: 0. 20 - 250 / 500 V (⟶ Motor ratings 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 frequency inverter's rated operational data (U_{LN} = 100%). This may cause the over-excitation of the motor and thus lead to an increased thermal load.	
P-08	136	✓	rw		Rated motor current	4.8
					Setting range: $0.2 \times I_e$ - $2 \times I_e$ [A] I_e = Frequency inverter's rated operational current (⟶ Motor rating plate)	
P-09	137	–	rw		Nominal frequency of the motor	50.0
					Setting range: 25 – 500 Hz (⟶ Motor ratings plate)	
					Note: This parameter value is also automatically applied as the cut-off frequency for the V/Hz characteristic curve.	
P-10	138	✓	rw		Nominal speed of the motor	0
					0 - 30,000 rpm (min^{-1}) (⟶ motor rating plate)	
					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 frequency inverter'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.	

6.2.9 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 set value for a fixed frequency is limited by parameter P-01 (maximum frequency).
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 frequency inverter will move to the minimum frequency.

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

6.2.9.1 Fixed frequency

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

In the default settings, fixed frequency FF1 = 15 Hz can be accessed via digital input DI3 (control signal terminal 4).
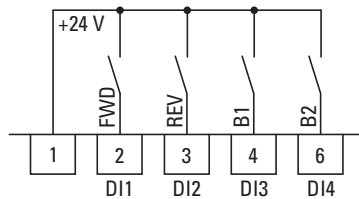

Figure 73:   Example: fixed frequencies FF1 to FF4

Example

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

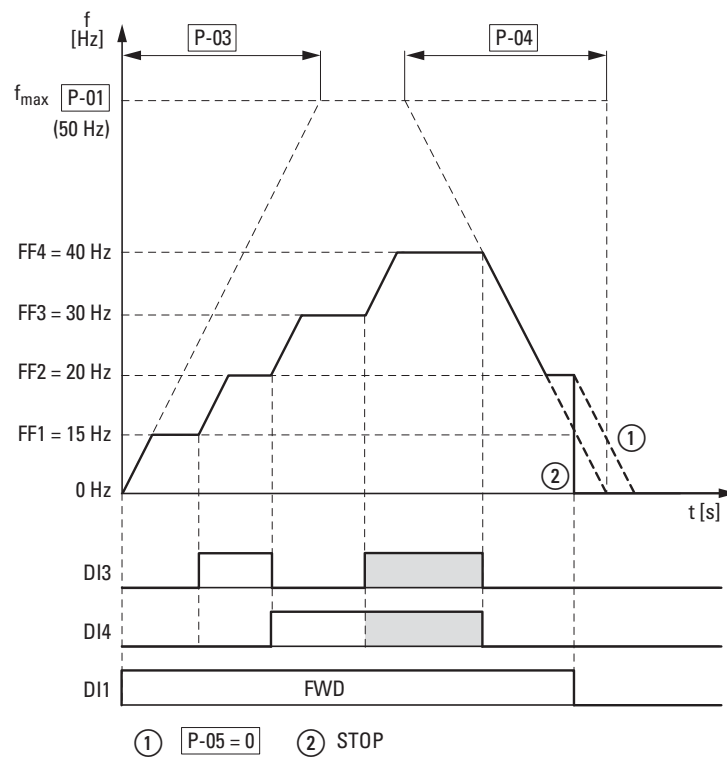| b1	m2	Fixed frequency
0	0	FF1 (P-20)
1	0	FF2 (P-21)
0	1	FF3 (P-22)
1	1	FF4 (P-23)

Figure 74: 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 74). 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.

6.2.10 V/f characteristic curve

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

V/f (P-10 = 0)

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

V/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 V/f-characteristic curve (voltage/frequency characteristic curve) designates a control process for the frequency inverter, 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 behavior 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 V/f-characteristic curve is assigned automatically and corresponds with the values of parameter P-07 (nominal motor voltage) and P-09 (rated motor frequency).
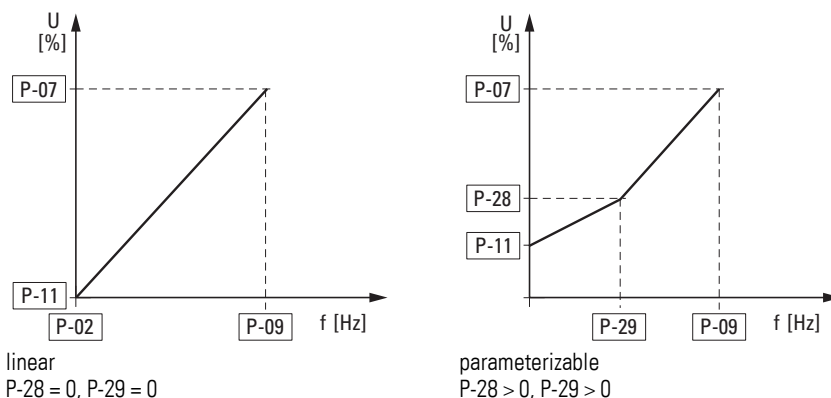

Figure 75:   V/f-characteristic curve

6.2.10.1 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 frequency inverter 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.
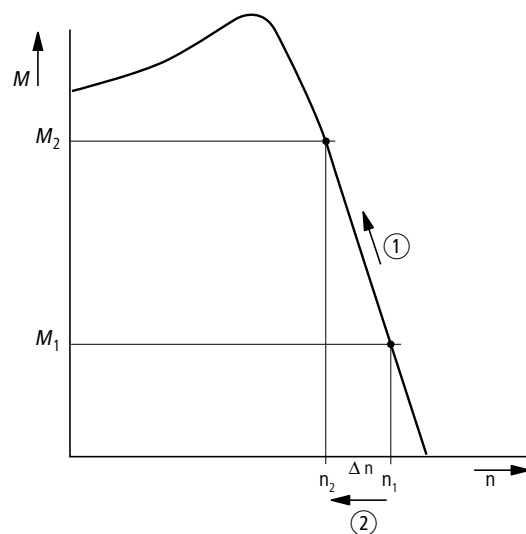

Figure 76:   Speed behavior without slip compensation

6.2.10.2 Speed behavior with slip compensation

In the control mode (V/Hz with slip compensation, P-10 > 0), the frequency inverter 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.
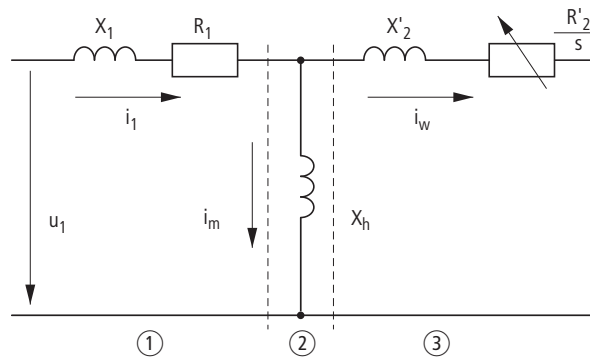

Figure 77:   Equivalent circuit diagram for an asynchronous motor
  ① Stator winding
  ② Air gap
  ③ Transformed rotor winding

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 78).
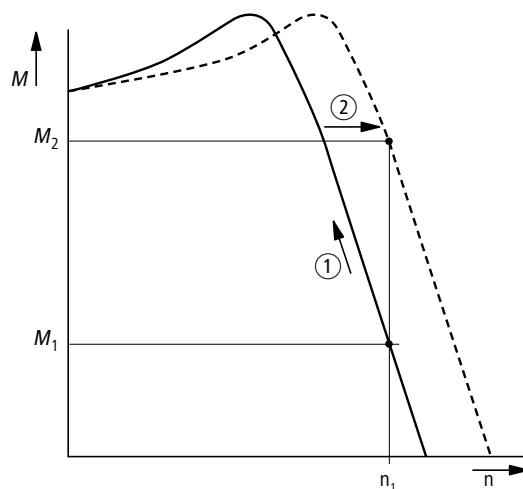

Figure 78:   Speed behavior with slip compensation

PNU	ID	Access rights		Value	Description	DS
		RUN	**ro/rw**			
P-02	130	✓	rw		Minimum frequency / minimum speed	0
					P-10 = 0 → 0 - P-01 → Hz P-10 > 0 → 0 - P01 → min-1 The minimum output frequency / minimum speed – shown in Hz or rpm (if P-10 > 0).	
P-07	135	–	rw		Nominal voltage of the motor	230
					Setting range: 0. 20 - 250/500 V (➝ Motor ratings 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 frequency inverter's rated operational data (U_{LN} = 100 %). This may cause the over-excitation of the motor and thus lead to an increased thermal load.	
P-09	137	–	rw		Nominal frequency of the motor	50.0
					Setting range: 25 – 500 Hz (➝ Motor ratings plate) **Note:** This parameter value is also automatically applied as the cut-off frequency for the V/Hz characteristic curve.	
P-11	139	✓	rw		Voltage amplification	3.0
					0.00 - 20.0 %	
					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.	
P-28	156	–	rw		V/Hz characteristic curve modification voltage	0
					0.00 - P-07 V	
P-29	157	–	rw	0.00 - P-09 Hz	V/Hz characteristic curve modification frequency	0
					0.00 - P-09 Hz	

6.2.11 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.

6.2.11.1 DC-braking

With DC braking, the frequency inverter 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.

6.2.11.2 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 frequency inverter, this generative energy causes an increase in the DC link voltage.

Oversynchronous speeds occur, for example, when the output frequency in frequency inverter 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 frequency inverter 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 frequency inverter. A brake chopper is integrated into DC1 frequency inverters of size FS2 and larger. 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.

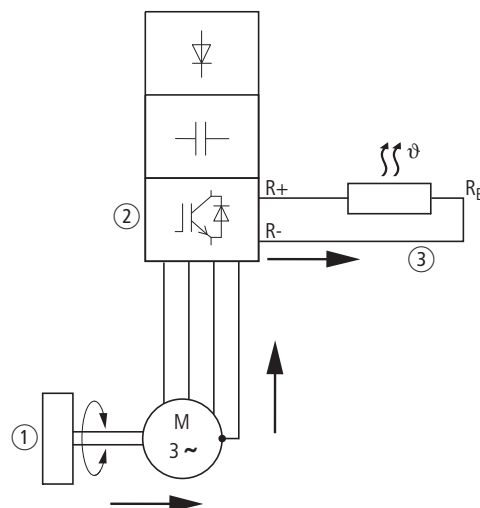The external braking resistor is connected via terminals DC+ and BR.

Figure 79: 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 frequency inverters of size FS2 and FS3.

➜ In frequency inverters without a braking transistor, parameter P-34 has no function.

6.2.11.3 Mechanical brake (actuation)

An external mechanical brake can be actuated via a digital output:

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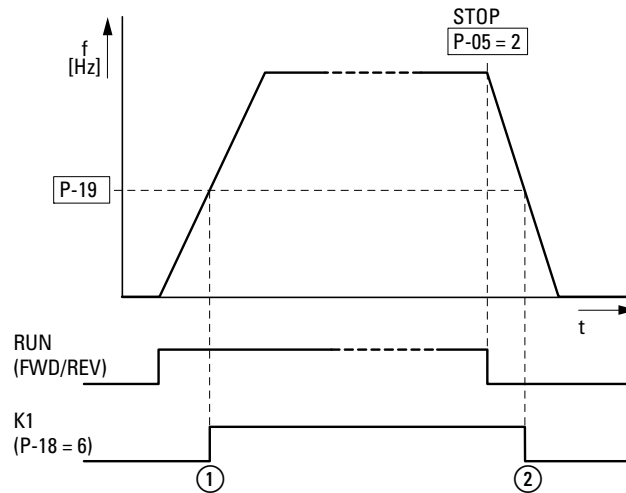

Figure 80:   External brake actuated via K1
① Brake, released
② Brake activates and brakes the drive mechanically.

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 resistor (optional) (→ Section 6.2.11.2, „Regenerative braking", page132).	
				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 resistor (optional).	

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, frequency inverter ready for operation	
				2	Output frequency = frequency reference value	
				3	Error message (frequency inverter not ready)	
				4	Output frequency $\geqq$ limit value (P-19)	
				5	Output current $\geqq$ 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	
P-25	153	✓	rw		Switch to digital output	8
					DA4 (Digital output) → +24 V DC (Value 0 - 7)	
				0	RUN (Frequency inverter released and running / FWD, REV)	
				1	READY, frequency inverter ready for operation / no faults	
				2	Output frequency = frequency reference value	
				3	Error message (frequency inverter is not ready)	
				4	Output frequency $\geqq$ limit value (P-19)	
				5	Output current $\geqq$ limit value (P-19)	
				6	Output frequency < limit value (P-19)	
				7	Output current < limit value (P-19)	
					AO1 signal (Analog Output)	
					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.	

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
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 frequency inverter 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 frequency inverters 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 frequency inverter 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	
				2	Enabled without overload protection braking resistance	

Example
Stop function with two different deceleration times
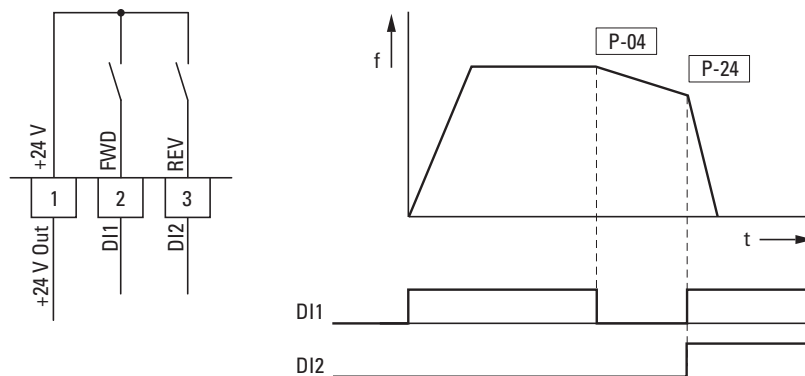
Figure 81:   Stop function with two different deceleration times

You can activate the stop function with a deceleration time 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 frequency inverter's output frequency will be reduced as per the deceleration time (dec1) configured in P-04.

Use parameter P-24 to set the second deceleration time.
In the default settings, the second deceleration time is activated via DI1 and DI2 (control signal terminals 2 and 3).

6.3 Operational data indicator

When the specified supply voltage is applied (L1/L, L2/N, L3), the 7-segment LED display will be illuminated (Power ON); the display will show "Stop".

You can use arrow buttons ▲ 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. If you want to access a different operational data indicator, press the OK button again. You can then make your selection using the ▲ and ▼ arrow buttons 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 rights		Value	Description	DS
		RUN	ro/rw			
P-01	129	✓	rw		Maximum frequency / maximum speed	50.0
					P-10 = 0 → P-02 - 5 x P-09 → Hz P-10 > 0 → P02 - 5 x P-09 x 60 s → min-1 The maximum output frequency / motor speed limit – shown in Hz or rpm (if P-10 > 0).	
P-02	130	✓	rw		Minimum frequency / minimum speed	0
					P-10 = 0 → 0 - P-01 → Hz P-10 > 0 → 0 - P01 → min-1 The minimum output frequency / minimum speed – shown in Hz or rpm (if P-10 > 0).	
P-03	131	✓	rw		Acceleration time (acc1)	5
					0.1 - 600 s (→ Figure 68, page 119)	
P-04	132	✓	rw		Deceleration time (dec1)	5
					0.1 - 600 s (→ Figure 68, page 119)	
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 resistor (optional) (→ Section 6.2.11.2, „Regenerative braking", page132).	
				1	Free coasting After the start enable (FWD/REV) is switched off or the STOP pushbutton 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 resistor (optional) (→ Section 6.2.11.2, „Regenerative braking", page132).	

P-00 - Display values

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
P00-01	20		ro	%	Analog input 1	
					100 % = Maximum input voltage	
P00-02	21		ro	%	Analog input 2	
					100 % = Maximum input voltage	
P00-03	23		ro	Hz/rpm	Frequency reference value / Motor shaft speed	
					Shown in Hz if P-10 = 0; otherwise shown in rpm	
P00-04	11		ro	State DI1, DI2, DI3, DI4	Digital inputs 1 - 4	
					State of the frequency inverter'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 frequency inverter's operating time	
					Not affected when the parameters are reset to their default settings.	
P00-11			ro	HH:MM:SS	The frequency inverter's operating time since the last trip (1)	
					Operating time clock stopped by frequency inverter lockup (or trip). Reset with next enable only if a trip occurred. Also reset with next enable after the frequency inverter's mains power is switched off.	
P00-12			ro	HH:MM:SS	The frequency inverter's operating time since the last trip (2)	
					Operating time clock stopped by frequency inverter 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.	
P00-13			ro	HH:MM:SS	The frequency inverter's operating time since the last lockup	
					The frequency inverter's operating time clock was stopped with the lockup. $\longrightarrow$ Reset the value with next enable.	
P00-14			ro	4 - 32 kHz	Pulse frequency	
					The frequency inverter's actual rms output pulse frequency. If the frequency inverter is too hot, this value may be lower than the frequency selected in P-17. The frequency inverter will automatically reduce the pulse frequency in order to prevent an excess temperature trip and maintain operation.	
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	Log for thermistor temperature	
					The eight most recent values before the trip Updated every 500 ms.	

PNU	ID	Access rights		Value	Description	DS
		RUN	ro/rw			
P00-17			ro	0 - 2 x rated operational current	Motor current	
					The eight most recent values before the trip Updated every 250 ms.	
P00-18	15		ro	–	Software version	
	16				Version number and checksum 1 = I/O processor (on the left side) 2 = motor control	
P00-19			ro	–	Serial number of frequency inverter	
					The frequency inverter's unique serial number Example: 540102 / 32 / 005	
P00-20	12		ro	–	Frequency inverter part no.	
	13				Rated power of frequency inverter	
	14				Frequency inverter type (example: 0.37, 1 230, 3P-out)	

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) activates the frequency inverter's inputs (DI1 to 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)

6.4 Setpoint input (REF)

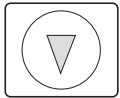REF: Setpoint value definition (Reference) via the operating unit
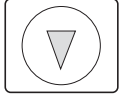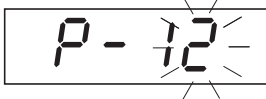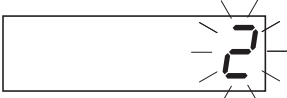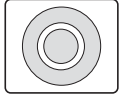
The frequency reference value settings configured via the keypad have the same effect as the function of an electronic motor potentiometer. The value set with the ▲ and ▼ buttons will be retained even after the supply voltage is switched off.

➡ For control via the keypad, control signal terminal 1 must be connected to control signal terminal 2 in order to get an enable.
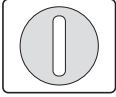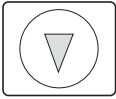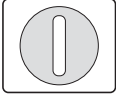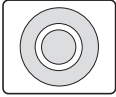
The following table shows a good example of specifying the frequency reference value via the operating unit.

Note: The information in the table may vary depending on the setting configured for P-15.

Sequence	Commands	Indicator	Description
1	OK ▲ ▼	P-12 2	Set parameter P-12 to 1 or 2 in order to hand over control to the keypad. 1: Operating unit (keypad FWD): one operating direction 2: Operating unit (keypad FWD/REV): both operating directions
2	◉ ▲ ▼	StoP	Connect control signal terminal 1 to control signal terminal 2 in order to get a start enable. Press the Stop pushbutton in order to get to the setpoint input display automatically.
		H 0.0	Use the ▲ and ▼ arrow buttons to change the setpoint value.

Sequence	Commands	Indicator	Description
3			Press the Start button to start the frequency inverter. It will then run with the acceleration time set in P-03 all the way to the setpoint value on the keypad. You can use the ▲ and ▼ arrow buttons to change the setpoint value in RUN mode.
4			Pressing the Start pushbutton again will change the operating direction (P-12 = 2). **Note:** When the REV operating direction is in effect, the frequency will have a minus sign.
	FWD	H 15.7	
	REV	H $-$ 15.7	Minus sign for REV operating direction
5			When the Stop pushbutton is pressed, the frequency inverter will be stopped with the deceleration time configured in P-04.

7 Serial interface (Modbus RTU)

7.1 General

Modbus is a centrally polled bus system in which a so-called master (PLC) controls the entire data transfer on the bus. Cross-traffic 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).

➜ More information on Modbus can be found under www.modbus.org.
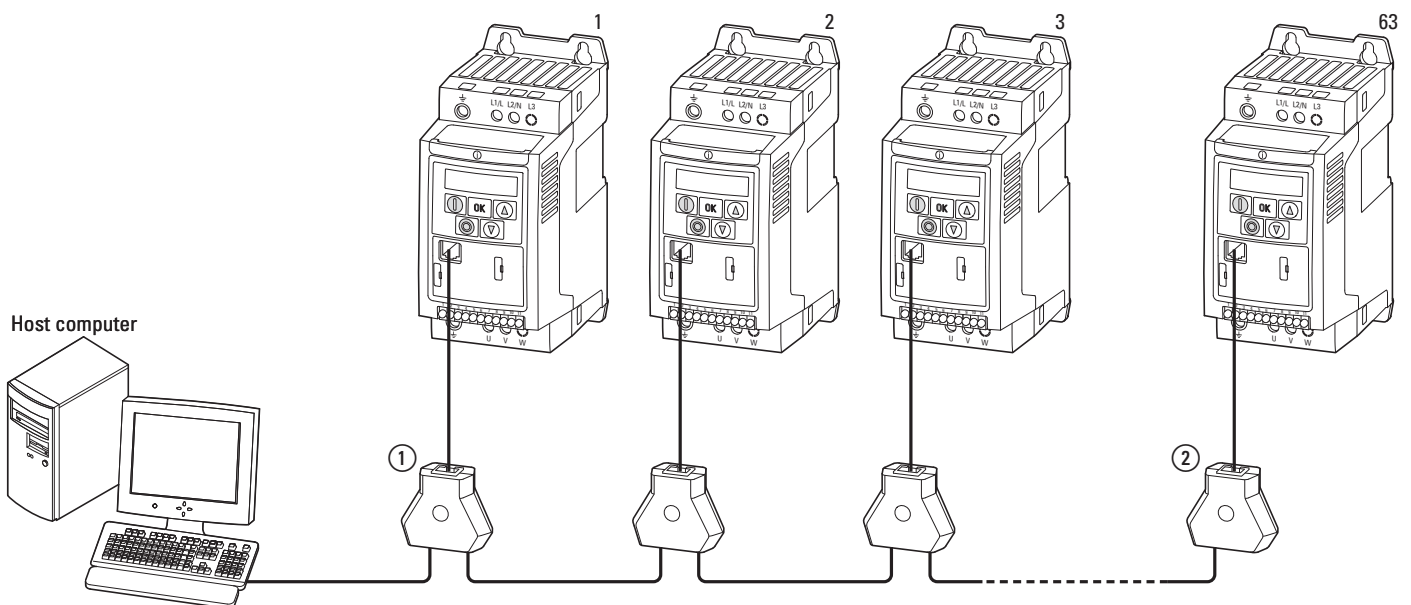
7.1.1 Communication

Figure 82: 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 frequency inverters (slaves). Each frequency inverter has a unique address on the network. Addresses are assigned individually to each DC1 frequency inverter with the P-36 parameter and are independent of their physical connection (position) within the network.

7.1.2 Serial interface A-B

The electrical connection between the master and the slaves is established with RJ-45 cables. If multiple slaves are being used, they are connected in parallel by using RJ-45 cables and DX-SPL-RJ45-3SL splitters.

The DC1 frequency inverter 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.

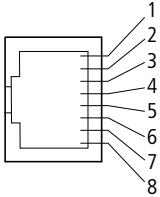Splitter model DX-CBL-TERM includes the required resistor mentioned above.

	Pin	Meaning
	1	CANopen -
	2	CANopen +
	3	0 V
	4	RJ45 connection / external operating unit / PC connection -
	5	RJ45 connection / external operating unit / PC connection +
	6	24 V DC power supply
	7	RS485- Modbus RTU
	8	RS485+ Modbus RTU

Figure 83:   RJ-45 socket wiring

7.2 Modbus parameters

The following table 16 shows the Modbus parameters in the DC1 frequency inverter.

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.

Table 16:   Modbus parameters

PNU	ID	Access rights		Designation	Value range	DS
		RUN	ro/rw			
P-36	164	–	rw	Frequency inverter slave address	0 - 63	1
			rw	Baud rate	1 = OP-buS 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	OP-buS
			rw	TimedOut	0 - 3000 ms	3000 ms
P-12	140	–	rw	Control level	0 = Control signal terminals (I/O) 1 = Keypad (KEYPAD FWD) 2 = Keypad (KEYPAD FWD/REV) 3 = Modbus, with internal acceleration and deceleration ramp 4 = Modbus, acceleration and deceleration ramps via bus 5 = PI controller with external actual value 6 = PI controller with external actual value and totalized value of AI1 7 = CANopen, with internal acceleration and deceleration ramp 8 = CANopen, acceleration and deceleration ramps via bus	0

7.3 Operating mode Modbus RTU

Operating mode Modbus RTU (Remote Terminal Unit) transfers the data in binary format (faster data rate) and determines the transfer format for the data request and the data response. Each message byte that is sent contains two hexadecimal characters (0 … 9, A … F).

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

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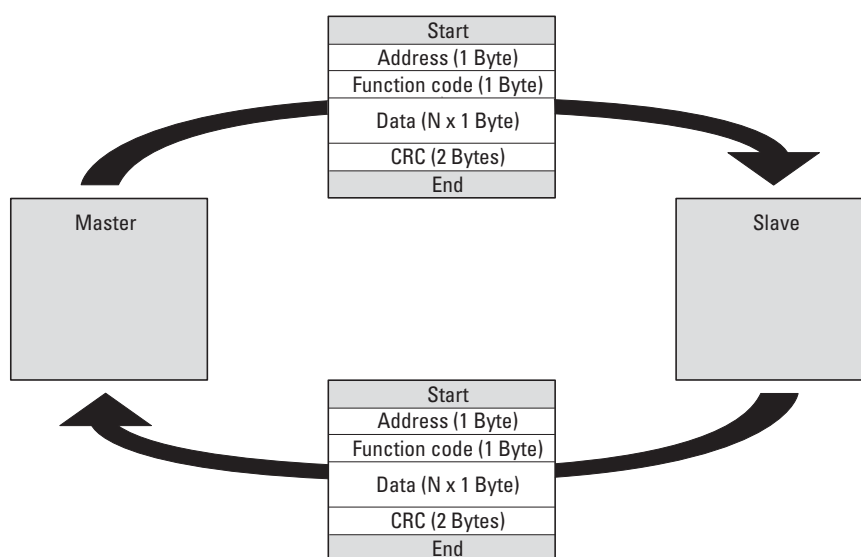

Figure 84: Data exchange between master and slave

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

7.3.1 Structure of the master request

7.3.1.1 Address

- P-36 is used to enter the address (1 to 63) of the frequency inverter to which the request is being sent. Only the frequency inverter 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 slaves cannot be addressed and data cannot be output from the slaves.

7.3.1.2 Function code

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

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.

7.3.1.3 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).

7.3.1.4 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 is always performed independently of the parity check for the frame's individual values. 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 the values do not match, an error will be set.

7.3.2 Structure of the slave response

7.3.2.1 Required transfer time

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

7.3.2.2 Normal slave response

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

7.3.2.3 No slave response

In the following cases, the frequency inverter 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 frequency inverter'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.

7.3.3 Modbus: Register mapping

Register mapping makes it possible to process, in DC1 frequency inverters, 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 12, page 93
Input process data	1 - 4	→ Section 7.3.3.1, „Input process data", page147
Output process data	6 - 24	→ Section 7.3.3.2, „Output process data", page149

→ 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 frequency inverter's display is 0.3 A, it will be transmitted as 003_{dez} via Modbus.

7.3.3.1 Input process data

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

ID	Designation	Scaling Factor	Unit
1	Field bus control word	–	Binary code
2	Field bus speed reference value	0.1	Hz
3	reserved	–	
4	Modbus ramp time	0.01	s

Control word (ID 1)

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

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	Not used	
6	No action	Block setpoint value (speed not variable)
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 0 to P-01 (max. frequency). This value will be 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

7.3.3.2 Output process data

The output process data is used to monitor the frequency inverter.

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	Frequency inverter 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	Frequency inverter temperature	1	°C

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								Status word							

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	

Fault word

Failure code [hex]	Value shown on display	Description
00	$StoP$	Stop, ready for operation
01	$OI-b$	Brake chopper overcurrent
02	$OL-br$	Braking resistor overload
03	$O-I$	• Overcurrent at frequency inverter output • Motor overload • Overtemperature on frequency inverter heat sink
04	I_t-trP	Motor, thermal overload
05	$PS-trP$	Internal fault (power section)
06	$O\_Uo\ IE$	Overvoltage (DC link)
07	$H\_Uo\ IE$	Undervoltage (DC link)
08	$O-t$	Overtemperature (heat sink)
09	$U-t$	Overtemperature (heat sink)
0A	$P-dEF$	Default settings (parameters have been loaded)
C0	$E-tr\ iP$	external error message
0C	$SC-trP$	Field bus error
0D		reserved
0E	$P-LOSS$	Phase failure (mains side)
0F	$SPI\ n-F$	Motor pick-up control function (for catching spinning motors) failed
10	$th-FIt$	Internal thermistor fault (heat sink)
11	$dAtA-F$	EEPROM checksum fault
12	$4-20\ F$	Analog input: • Out-of-range value • Wire breakage (4-mA monitoring)

Actual speed (ID 7)

The frequency inverter's actual speed falls within a value range of 0 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

Current (ID 8)

The current is specified with one decimal place.

Example: 34 ≙ 3.4 A.

Status DIs (ID 11)

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

Type (ID 12)

```
x   x   x   x    Explanation

            └──  Default settings (country-specific)
                 0 = kW
                 1 = HP

        └──────  part no.
                 4 = DC1

    └──────────  Power rating
                 0 = No decimal places
                 1 = One decimal place
                 2 = Two decimal places

└──────────────  Size (FS)
                 1 = FS1
                 2 = FS2
                 3 = FS3
```
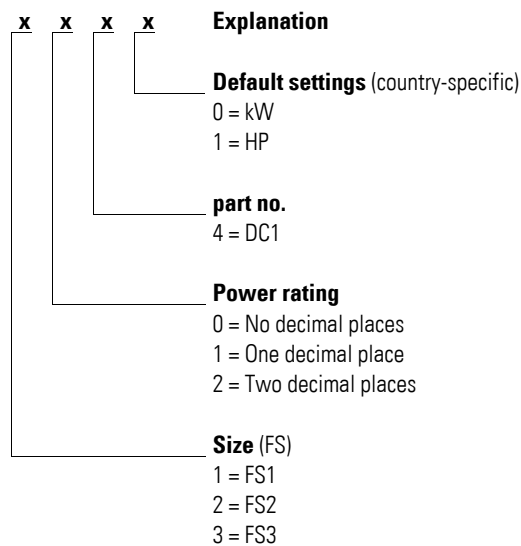
Rated outputs (ID 13)

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

Example:
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 ≙ 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.

Frequency inverter recognition (ID 17)

The device's unique serial number.

7.3.4 Explanation of function code

7.3.4.1 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 frequency inverter with slave address 1.

Master request: 01 03 0005 0001 940B$_{hex}$

hex	Name
01	Station 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
C940	CRC

Slave response: 01 03 02 0000 B844$_{hex}$

hex	Name
01	Station 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

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

This function writes data to a holding register.

Example

Writing of the control word (ID 1) of a DC1 frequency inverter with the slave address 1.

Master request: 01 06 0000 0001 480A$_{hex}$

hex	Name
01	Station 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 480$_{hex}$

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

hex	Name
01	Station 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.

8 CANopen

This chapter is intended for automation experts and engineers.
It is expected that readers will 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 frequency inverter.

References

[1] CANopen – Application Layer and Communication Profile

CiA Draft Standard DS301, Version 4.02, February, 13, 2002

8.1 Data Types

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

Table 17:   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
PC	Personal Computer
PDO	Process Data Object
ROM	Read Only Memory
Rx	Receive
SDO	Service Data Object
Tx	Transmit

8.2 System overview

The DC1 frequency inverter's CANopen slaves are integrated into a CANopen fieldbus system.
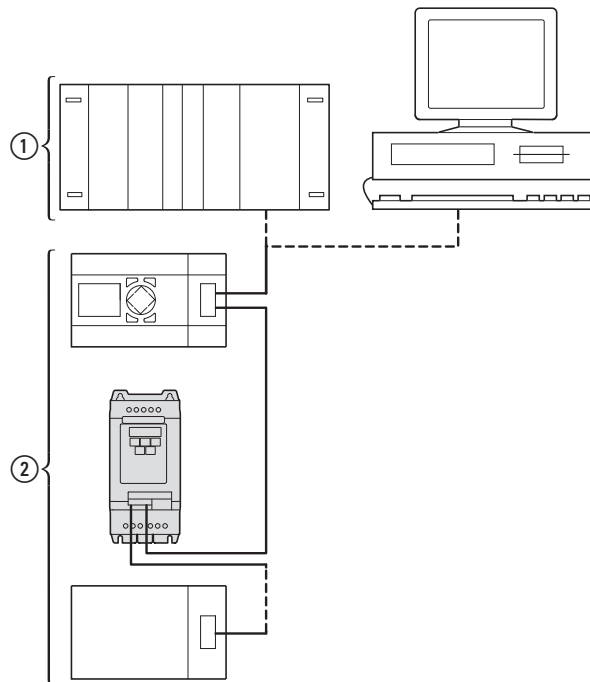
Figure 85:   Integration into the CANopen network
① Master area, PLC (e. g.: XC100, XC200) or PC with CANopen card
② Slave area: Frequency inverters with CANopen interface

The RJ-45 connector enables DC1 series frequency inverters to connect to a CANopen communication 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 frequency inverter 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 frequency inverter. As a general rule, the frequency inverter's parameters are configured using SDOs. The parameter data channel makes it possible to store all application-related drive parameters in the higher-level automation system and transfer them to the frequency inverter if necessary. All of the frequency inverter's parameters can be transferred with CANopen by using the appropriate SDO/PDO selection.

Table 18:   Technical Data

Size	Value
Communication profile	DS-301 V4.02
Bus addresses	1 - 63
Data transfer rate	125 kBit/s - 1 MBit/s
Total distance (depending on the baud rate / the repeater)	• 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 one will be enabled in the default settings.
PDO mapping	Variable
Terminal type	Plug-in RJ45 connector

8.2.1 Bus termination resistors

The first and last module of a CANopen network must be terminated by means of a 120 Ω bus termination resistor. This device is interconnected between the CAN_H and CAN_L terminals.

Splitter DX-CBC-TERM1 can be used for this purpose.

CAN_L 1
CAN_H 2
3
4
5
6
7
8
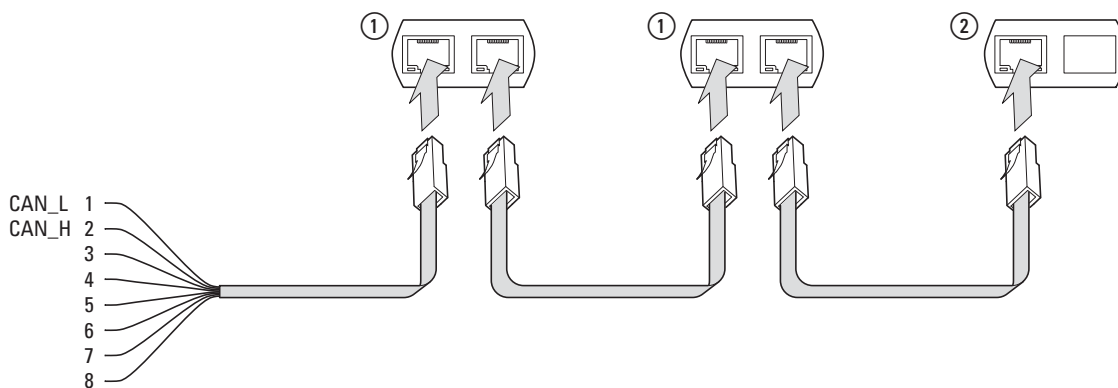
Figure 86:   Bus termination resistors

8.2.2 Baud rate

The baud rate is configured with parameter P5-02. It must be set to the same value for all communication modules on the CANopen bus.

8.2.3 Set CANopen station 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 configure the CANopen address in D1 frequency inverters.

8.2.4 Parameters that need to be configured

PNU	ID	Access rights		Designation	Value range	DS	Value that must be configured
		RUN	ro/rw				
P-12	140	–	rw	Control level	0 = Control terminals (I/O) 1 = Keypad (KEYPAD FWD) 2 = Keypad (KEYPAD FWD / REV) 3 = Modbus, with internal acceleration and deceleration ramp 4 = Modbus, acceleration and deceleration ramps via bus 5 = PI controller with external actual value 6 = PI controller with external actual value and totalized value of A1 7 = CANopen, with internal acceleration and deceleration ramp 8 = CANopen, acceleration and deceleration ramps via bus	0	7 / 8
P-36	164	–	rw	Frequency inverter slave address	0 - 63	1	1 - 63
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

8.3 Object list

8.3.1 EDS file

The DC1 frequency inverter can be integrated into a CANopen structure with the help of a standardized EDS (Electronic Data Sheet) file. EDS describes the functionality of a CANopen device in a 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 is included in the CD-ROM enclosed with every frequency inverter.

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
00 00$_{hex}$ - 1F FF$_{hex}$	Communication-specific objects
20 00$_{hex}$ - 5F FF$_{hex}$	Manufacturer-specific objects (the frequency inverter's parameters)

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

8.3.2 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 frequency inverter 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	Frequency inverter – 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	DA1	The frequency inverter'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	Guard 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

8.3.3 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.

The DC1 frequency inverter supports 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	40000200 40000300 + Node ID	COB-ID of 1st Rx PDO COB-ID of 2nd Rx PDO
	02	Transmission Type	UNSIGNED8	rw	254	PDO transmission type: asynchronous
1600	00	Number of Mapped Application Objects	UNSIGNED8	rw	04	Highest subindex used
	01	1st Mapping Object	UNSIGNED32	rw	20000010	
	02	2nd Mapping Object	UNSIGNED32	rw	20000010	
	03	3rd Mapping Object	UNSIGNED32	rw	20020010	
	04	4th Mapping Object	UNSIGNED32	rw	20020010	
1601	00	Number of Mapped Application Objects	UNSIGNED8	rw	4	Highest subindex used
	01	1st Mapping Object	UNSIGNED32	rw	00060010	
	02	2nd Mapping Object	UNSIGNED32	rw	00060010	
	03	3rd Mapping Object	UNSIGNED32	rw	00060010	
	04	4th Mapping Object	UNSIGNED32	rw	00060010	

DC1 frequency inverter supports 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	254	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	200E0010	
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	200F0010	
	02	2nd Mapping Object	UNSIGNED32	rw	20100010	
	03	3rd Mapping Object	UNSIGNED32	rw	20110010	
	04	4th Mapping Object	UNSIGNED32	rw	200C0010	

8.3.4 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 frequency inverter's object dictionary.

Table 20: Manufacturer-specific objects

Index [hex]	Property Name	Data type	Access rights	Description
2000	Control command register	UNSIGNED16	rw	Control word
2001	Speed reference	Integer16	rw	Frequency reference value
2003	User ramp reference	UNSIGNED16	rw	User ramp time
2004	Speed ref (internal)	Integer16	rw	IDL speed reference
200A	Drive status register	UNSIGNED16	ro	Statusword
C200	Motor speed Hz	UNSIGNED16	ro	Actual value in Hertz (Hz)
200C	Motor speed (internal)	UNSIGNED16	ro	IDL actual speed
200D	Motor current	UNSIGNED16	ro	Motor current
2010	Drive temperature	Integer 16	ro	Frequency inverter 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 frequency inverter parameters
2066 …	P-02 …	…	rw …	
2095	P-49		rw	
2096	P-50		rw	

Control word (Index 2000hex)

The "control word" object is used to control the frequency inverter.
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 coasting
4	Not used	
5	Not used	
6	No action	Block setpoint value (speed not variable)
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	

Frequency reference value (Index 2001hex)

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

Example: $258_{dez} \triangleq 25.8$ Hz

User ramp time (Index 2003hex)

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

Status word (Index 200A$_{hex}$)

Information regarding the frequency inverter'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 value definition
5	–	Zero speed
6	Speed control deactivated	Speed control activated
7	Not used	

8.4 Error Messages

Failure code [hex]	Value shown on display	Description
00	5toP	Stop, ready for operation
01	OI -b	Brake chopper overcurrent
02	OL -br	Braking resistance overload
03	O-I	• Overcurrent at frequency inverter output • Motor overload • Overtemperature on frequency inverter heat sink
04	I.t-trP	Motor, thermal overload
05	P5-trP	Internal fault (power section)
06	O.Ho I E	Overvoltage (DC link)
07	H.Ho I E	Undervoltage (DC link)
08	O-t	Overtemperature (heat sink)
09	H-t	Undertemperature (heat sink)
0A	P-dEF	Default settings (parameters have been loaded)
C0	E-tr iP	external error message
0C	5C-trP	Field bus error
0D	–	reserved
0E	P-LO55	Phase failure (mains side)
0F	5PI n-F	Motor pick-up control function (for catching spinning motors) failed
10	th-FI t	Internal thermistor fault (heat sink)
11	dAtA-F	EEPROM checksum fault
12	4-20 F	Analog input: • Out-of-range value • Wire breakage (4-mA monitoring)

Frequency actual value (Index 200B$_{hex}$)

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

Example: $125_{dez} \triangleq 12.5$ Hz

Current (Index 200D$_{hex}$)

The current is specified with one decimal place.

Example: $34 \triangleq 3.4$ A

9 Appendix

9.1 Special technical data

The following tables show the technical data of the frequency inverter 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.

9.1.1 DC1-1D

Size		Symbol	Unit	2D3	4D3	5D8
Rated operational current		I_e	A	2.3	4.3	5.8
Overload current for 60 s every 600 s at 50 °C		I_L	A	3.45	6.45	8.7
Apparent power at rated operation[1]	230 V	S	kVA	0.92	1.71	2.31
	240 V			0.96	1.79	2.41
Assigned motor rating	(230 V)[1]	P	kW	0.37	0.75	1.1
			HP	0.5	1	1.5
Power side (primary side):						
Number of phases				single-phase or two-phase		
Rated operating voltage		U_{LN}[1]	V	110 - 10 % - 115 + 10 %, 50/60 Hz (99 - 126.5 V ±0 %, 48 - 62 Hz ±0 %)		
Input current		I_{LN}	A	6.7	12.5	16.8
Minimum braking resistance		R_B	Ω			47
Pulse frequency		f_{PWM}	kHz	16 (adjustable 4 – 32)		
Heat dissipation at rated operational current (I_e)		P_v	W	22.3	27.9	33.4
Efficiency		η		0.95	0.95	0.95
Size				FS1	FS1	FS2

1)   Internal voltage doubler connection: U_{LN} = 115 V ➡ U_2 = 230 V; U_{LN} = 120 V ➡ U_2 = 240 V
2)   recommended value (calculated), no standard rating

9.1.2 DC1-S2

Size		Symbol	Unit	4D3	7D0	011
Rated operational current		I_e	A	4.3	7.0	10.5
Overload current for 60 s every 600 s at 50 °C		I_L	A	6.5	10.5	15.8
Apparent power at rated operation	230 V	S	kVA	1.71	2.79	4.38
	240 V			1.79	2.91	4.57
Assigned motor rating	230 V	P	kW	0.37	0.75	1.1
			HP	0.5	1	1.5
Power side (primary side):						
Number of phases				single-phase or two-phase		
Rated operating voltage		U_{LN}	V	200 V - 10 % - 240 V + 10 %, 50/60 Hz (180 - 264 V ±0 %, 48 - 62 Hz ±0 %)		
Input current		I_{LN}	A	6.0	9.3	14.0
Minimum braking resistance		R_B	Ω			47
Pulse frequency		f_{PWM}	kHz	16 (adjustable 4 – 32)		
Efficiency		η		0.95	0.95	0.95
Size				FS1	FS1	FS2

9.1.3 DC1-12

Size		Symbol	Unit	2D3	4D3	7D0	7D0	011	015
Rated operational current (I_e)		I_e	A	2.3	4.3	7.0	7.0	10.5	15
Overload current for 60 s every 600 s at 50 °C		I_L	A	3.45	6.45	10.5	10.5	15.7	22.5
Apparent power in rated operation	400 V	S	kVA	0.92	1.71	2.79	2.79	4.38	5.98
	480 V	S	kVA	0.96	1.79	2.91	2.91	4.57	6.24
Assigned motor rating	400 V	P	kW	0.37	0.75	1.5	1.5	2.2	4.0
	460 V		HP	0.5	1	2	2	3	5
Power side (Primary side)									
Number of phases				three-phase					
Rated voltage		U_{LN}	V	200 V - 10 % - 240 V + 10 %, 50/60 Hz (180 - 264 V ±0 %, 48 - 62 Hz ±0 %)					
Input current		I_{LN}	A	6.7	12.5	14.8	14.8	22.2	31.7
Minimum braking resistance		R_B	Ω				47	47	47
Pulse frequency		f_{PWM}	kHz	16 (adjustable 4 – 32)					
Efficiency		η		0.96	0.96	0.96	0.96	0.96	0.96
Fan (device-internal, temperature-controlled)				✓	✓	✓	✓	✓	✓
Size				FS1	FS1	FS1	FS2	FS3	FS3

9.1.4 DC1-32

Size		Symbol	Unit	2D3	4D3	7D0	7D0	011	018
Rated operational current		I_e	A	2.3	4.3	7.0	7.0	10.5	18
Overload current for 60 s every 600 s at 50 °C		I_L	A	3.45	6.45	10.5	10.5	15.75	27
Apparent power at rated operation	230 V	S	kVA	0.92	1.71	2.79	2.79	4.38	5.98
	240 V			0.96	1.79	2.91	2.91	4.57	6.24
Assigned motor rating	230 V	P	kW	0.37	0.75	1.5	1.5	2.2	4.0
			HP	0.5	1	2	2	3	5
Power side (primary side):									
Number of phases				three-phase					
Rated operating voltage		U_{LN}	V	200 V - 15 % - 240 V +10 %, 50/60 Hz (180 - 264 V ±0 %, 48 - 62 Hz ±0 %)					
Input current		I_{LN}	A	3	5.8	9.2	9.2	13.7	20.7
Minimum braking resistance		R_B	Ω				47	47	47
Pulse frequency		f_{PWM}	kHz	8 (adjustable 4 -32)					
Efficiency		η		0.96	0.96	0.96	0.96	0.96	0.96
Fan (device-internal, temperature-controlled)				✓	✓	✓	✓	✓	✓
Size				FS1	FS1	FS1	FS2	FS2	FS3

9.1.5 DC1-34

Size		Symbol	Unit	2D2	4D1	4D1	5D8	9D5	014	018	024
Rated operational current (I_e)		I_e	A	2.2	4.1	4.1	5.8	9.5	14	18	24
Overload current for 60 s every 600 s at 50 °C		I_L	A	3.3	6.15	6.15	8.7	14.25	21	27	32
Apparent power in rated operation	400 V	S	kVA	1.52	2.84	2.84	4.02	6.58	9.7	12.5	16.6
	480 V	S	kVA	1.83	3.41	3.41	4.82	7.9	11.64	14.96	19.95
Assigned motor rating	400 V	P	kW	0.75	1.5	1.5	2.2	4	5.5	7.5	11
	460 V		HP	1	2	2	3	5	7.5	10	15
Power side (Primary side)											
Number of phases				three-phase							
Rated voltage		U_{LN}	V	380 V - 10 % - 480 V + 10 %, 50/60 Hz (342 - 528 V ±0 %, 48 - 62 Hz ±0 %)							
Input current		I_{LN}	A	2.4	4.3	4.3	6.1	9.8	14.6	18.1	24.7
Standard		M/M_N	%	≦ 30							
Minimum braking resistance		R_B	Ω			100	100	100	47	47	47
Pulse frequency		f_{PWM}	kHz	8 (adjustable 4 – 32)							
Efficiency		η		0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Size				FS1	FS1	FS2	FS1	FS2	FS3	FS3	FS3

9.2 Dimensions and frame size
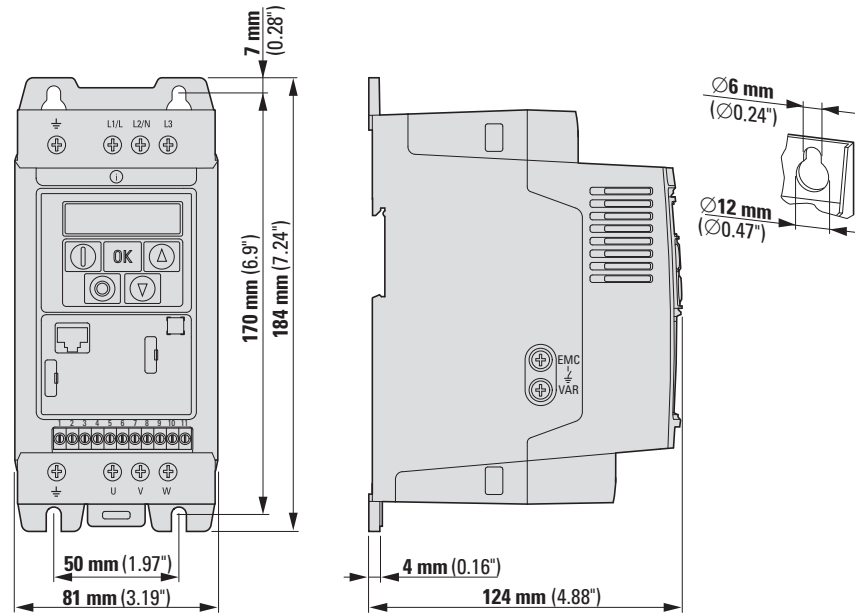
Figure 87:   Size FS1
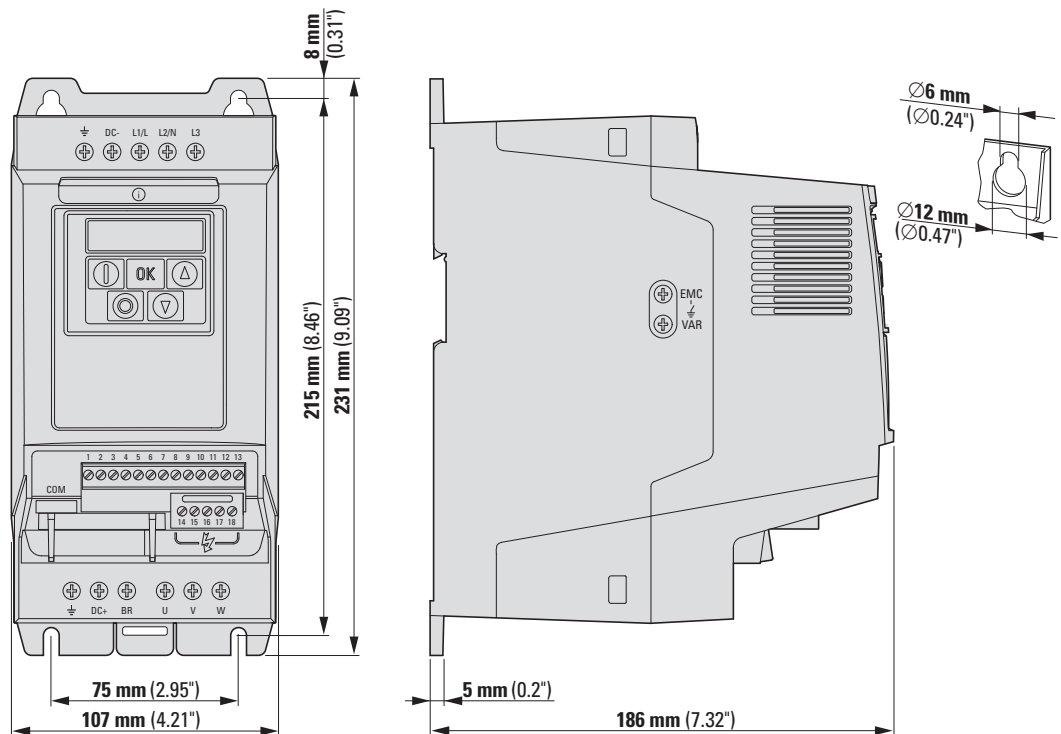
Figure 88:   Size FS2

9.3 PC interface card

9.3.1 DX-COM-STICK
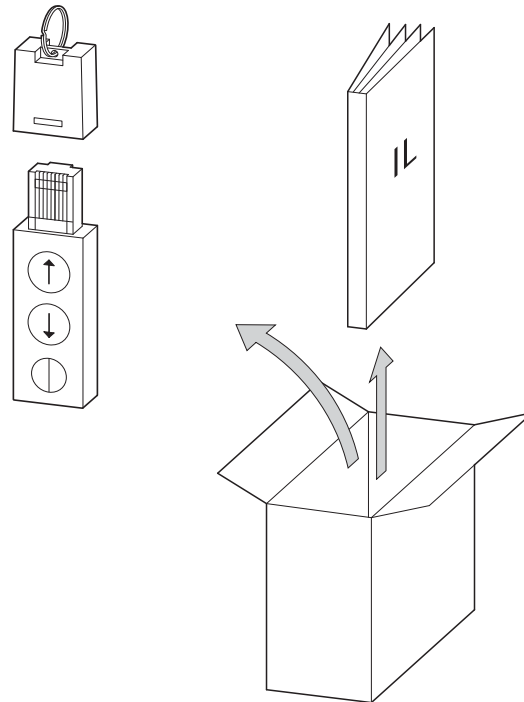
Figure 89:   Equipment supplied DX-COM-STICK

– DX-COM-STICK PC connection module
– Instructional leaflet
– drivesConnect parameter configuration software and driver software

➔ The DX-COM-STICK PC connection card is not supplied with the DC1 frequency inverter.

The DX-COM-STICK computer interface module is designed to enable communications between a DC1 series frequency inverter and a computer with a Windows operating system (point-to-point connection). Together with the drivesConnect parameter configuration software, you can:

• Upload and download all parameters
• Save parameters and compare them to each other
• Print parameter lists
• Show graphs vs. time with the monitor display function.
  You can then save the oscillograms on your computer and print them.

The DX-COM-STICK computer interface module can be installed and connected without tools. DX-COM-STICK is plugged into the front of the DC1 frequency inverter.
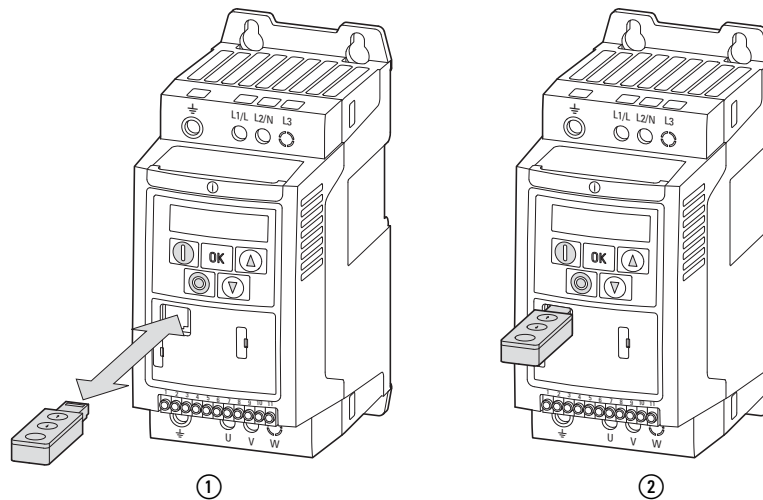
Figure 90:   Mounting DX-COM-STICK

① Fitting DX-COM-STICK
② ready for operation

The interface module can simply be pulled out in order to remove it.

When the supply voltage of the DC1 frequency inverter is switched on with the DX-COM-STICK fitted, the parameters can be copied via the two function keys:

- Upload: the parameters from the frequency inverter (AC-DRIVE) are loaded in DX-COM-STICK.
- Download: the parameters are loaded from the DX-COM-STICK to the frequency inverter (AC-DRIVES).

→ In order to upload or download the parameters, for example for the commissioning of series machines, the frequency inverter must be connected to the mains voltage.

The active data transfer is indicated by the green flashing LED.

Table 21:   Values that the DC1 frequency inverter display may show after a data transfer

Indicator	Explanation
PASS-r	Parameter transfer to DX-COM-STICK interface module was successful
DS-Loc	DX-COM-STICK is interlocked. In order to transfer data, check the switch position on the side.
FAiL-r	Error while attempting to read the parameters from the frequency inverter.
PASS-t	Parameter transfer to frequency inverter successful.
FAiL-P	The parameter set stored in the DX-COM-STICK is for a different output variable (different motor current, motor output, etc.) than that of the connected frequency inverter.
FAil-t	Error when attempting to copy parameter set to frequency inverter
no-dAt	No data found in DX-COM-STICK.
dr-Loc	Parameter set in frequency inverter locked. Unlock frequency inverter first.
dr-rUn	The frequency inverter has an enable signal and cannot take new parameters. Stop the frequency inverter.
tYPE-E	The parameter set stored in the DX-COM-STICK does not match the frequency inverter. Only transfers from the frequency inverter to the DX-COM-STICK are possible.
tYPE-F	The DX-COM-STICK is not compatible with the frequency inverter.

9.3.2 drivesConnect

The drivesConnect parameter software allows fast parameterization, operation, diagnostics and documentation (printout and storage of parameter lists) via a PC and the data transfer with an DC1 frequency inverter.

The drivesConnect program is found in the CD enclosed with the frequency inverter and can also be downloaded for free on the Internet.

The connection cable supplied with the DX-COM-PC-KIT, or a DX-COM-STICK, is required in order to connect to a computer. This connection cable features a galvanically isolated interface converter that makes it possible to connect the RJ45 connector to a USB port on a computer.

9.4 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 22:   Fusing and assigned cross-sectional areas

Device type	F1, Q1 = 1~	3~	L1/L, L2/N, L3 mm²	AWG[1]	U, V, W mm²	AWG[1]	PE mm²	AWG[1]	DC+, DC-, BR mm²	AWG[1]
DC1-1D2D3…	10	–	2 x 1.5	2 x 14	3 x 1.5	3 x 14	1.5	14	1.5	14
DC1-1D4D3…	16 15[2]	–	2 x 1.5	2 x 14	3 x 1.5	3 x 14	1.5	14	1.5	14
DC1-1D5D8…	20	–	2 x 2.5	2 x 12	3 x 1.5	3 x 14	2.5	12	1.5	14
DC1-S24D3…	6	–	2 x 1.5	2 x 14	2 x 1.5	2 x 14	1.5	14	1.5	14
DC1-S27D0…	10	–	2 x 1.5	2 x 14	2 x 1.5	2 x 14	1.5	14	1.5	14
DC1-S2011…	16	–	2 x 2.5	2 x 12	2 x 1.5	2 x 14	2.5	12	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…	25	–	2 x 4	2 x 10	3 x 1.5	3 x 14	4	10	1.5	14
DC1-12011…	32 35[2]	–	2 x 4	2 x 10	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…	-	10	3 x 1.5	3 x 14	3 x 1.5	3 x 14	1.5	14	1.5	14
DC1-327D0…	-	16 15[2]	3 x 2.5	3 x 12	3 x 1.5	3 x 14	2.5	12	2.5	12
DC1-32011…	-	20	3 x 4	3 x 10	3 x 1.5	3 x 14	4	10	4	10
DC1-32018…	-	32 35[2]	3 x 4	3 x 10	3 x 2.5	3 x 12	4	10	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…	-	10	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 2.5	3 x 12	3 x 1.5	3 x 14	2.5	12	2.5	12
DC1-349D5…	-	16 15[2]	3 x 2.5	3 x 12	3 x 1.5	3 x 14	2.5	12	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…	-	35	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

Table 23: Specified fuses

Device type	Maximum permitted mains supply voltage U_{LN} [V]	VDE [A]	UL[1] [A]	Part no. Eaton (VDE) [2]	[3]
DC1-1D2D3…	1 AC 115 V +10 %	10	10	FAZ-B10/1N	–
DC1-1D4D3…	1 AC 115 V +10 %	16	15	FAZ-B16/1N	–
DC1-1D5D8…	1 AC 115 V +10 %	20	20	FAZ-B20/1N	–
DC1-S24D3…	1 AC 240 V +10 %	6	6	FAZ-B6/1N	–
DC1-S27D0…	1 AC 240 V +10 %	10	10	FAZ-B10/1N	–
DC1-S2011…	1 AC 240 V +10 %	16	16	FAZ-B16/1N	–
DC1-122D3…	1 AC 240 V +10 %	10	10	FAZ-B10/1N	–
DC1-124D3…	1 AC 240 V +10 %	16	16	FAZ-B16/1N	–
DC1-127D0…	1 AC 240 V +10 %	25	25	FAZ-B25/1N	–
DC1-12011…	1 AC 240 V +10 %	32	35	FAZ-B32/1N	–
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 %	10	10	FAZ-B10/3	PKM0-10
DC1-327D0…	3 AC 240 V +10 %	16	15	FAZ-B16/3	PKM0-16
DC1-32011…	3 AC 240 V +10 %	20	20	FAZ-B20/3	PKM0-20
DC1-32018…	3 AC 240 V +10 %	32	35	FAZ-B32/3	PKM0-32
DC1-342D2…	3 AC 480 V +10 %	6	6	FAZ-B6/3	PKM0-6,3
DC1-344D1…	3 AC 480 V +10 %	10	10	FAZ-B10/3	PKM0-10
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 %	35	35	FAZ-B32/3	PKM0-32

1) Fuse UL-rated, class J, 600 V
2) I_{cn} = 10 kA
3) I_{cn} = 50 kA

9.5 Mains contactors

→ The mains contactors shown here allow for the input-side rated operating current I_{LN} of the frequency inverter without a main choke. The selection is based on the free air thermal current → $I_{th} = I_e$ (AC-1) at the stated ambient temperature.

NOTICE

The inching operation is not permissible via the mains contactor (Pause time ≧ 60 s between switching off and on).

→ Technical data on the mains contactors can be found in the main catalog HPL, Contactors DILEM and DILM7.
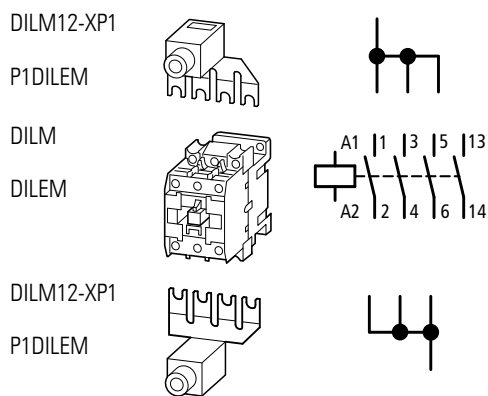
Figure 91: Mains contactor at single-phase connection

Table 24:   Assigned mains contactors

Device type DC1…	Rated operating voltage (50 Hz) U_{LN}	Rated operating voltage (60 Hz) U_{LN}	Rated input current I_{LN} [A]	related mains contactor Part no.	thermal current AC-1 +50 °C I_N [A]	thermal current AC-1 +40 °C I_N [A]
DC1-1D2D3…	1 AC 110 V	1 AC 120 V	6.7	DILEM-10 + DILM12-XP1	20	22
DC1-1D4D3…	1 AC 110 V	1 AC 120 V	12.5	DILEM-10 + DILM12-XP1	20	22
DC1-1D5D8…	1 AC 110 V	1 AC 120 V	16.8	DILEM-10 + DILM12-XP1	20	22
DC1-1S24D3…	1 AC 230 V	1 AC 240 V	6.0	DILEM-10 + DILM12-XP1	20	22
DC1-1S27D0…	1 AC 230 V	1 AC 240 V	9.3	DILEM-10 + DILM12-XP1	20	22
DC1-1S2011…	1 AC 230 V	1 AC 240 V	14.0	DILEM-10 + DILM12-XP1	20	22
DC1-122D3…	1 AC 230 V	1 AC 240 V	6.7	DILEM-10 + DILM12-XP1 DILM7	20 21	22
DC1-124D3…	1 AC 230 V	1 AC 240 V	12.5	DILM7	21	22
DC1-127D0FN…	1 AC 230 V	1 AC 240 V	14.8	DILM7	21	22
DC1-127D0FB…	1 AC 230 V	1 AC 240 V	14.8	DILM7	21	22
DC1-12011…	1 AC 230 V	1 AC 240 V	22.2	DILM17	38	40
DC1-12015…	1 AC 230 V	1 AC 240 V	31.7	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	5.8	DILEM-10	20	22
DC1-327D0FN…	3 AC 230 V	3 AC 240 V	9.2	DILEM-10	20	22
DC1-327D0FB…	3 AC 230 V	3 AC 240 V	9.2	DILEM-10	20	22
DC1-32011…	3 AC 230 V	3 AC 240 V	13.7	DILM7	21	22
DC1-32018…	3 AC 230 V	3 AC 240 V	20.7	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 178
2)   maximum operating temperature +40 °C

➞   For UL® compliant installation and operation, the mains side switching devices must allow for a 1.25 times higher input current. The switching devices meets this requirement.

9.6 Braking resistances

DC1 series frequency inverters of size FS2 and larger come with an internal brake chopper. This brake chopper can be activated using parameter P-34.

A braking resistor connected to the DC+ and BR terminals of a DC1 frequency inverter will be automatically switched on if necessary. The magnitude of the DC link voltage can be read in parameter P00-08.

Braking resistors convert the mechanical braking energy produced during extended periods of dynamic operation or when braking large moments of inertia into heat.

9.7 Mains chokes

Allocating the mains chokes is done according to the rated input currents of the frequency inverter (without upstream main choke).
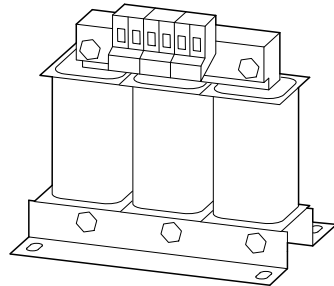
Figure 92: main chokes DEX-LN…

→ When the frequency inverter is operating at its rated current limit, the mains choke with a u_K value of around 4 % causes a reduction of the frequency inverter's maximum possible output voltage (U_2) 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 frequency inverters and upstream-connected switching devices.
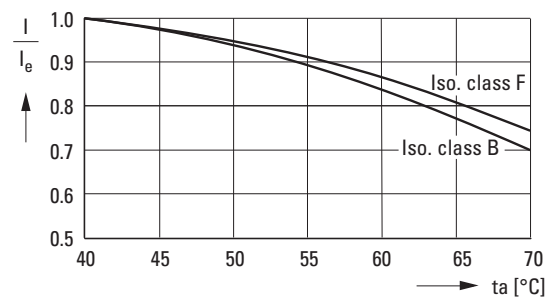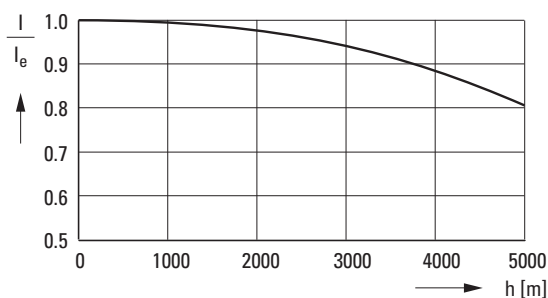
Figure 93: Derating values for deviating installation altitudes and ambient air temperatures

→ 📖 Further information and technical data on the mains chokes of the DX-LN… series is provided in instructional leaflet IL00906003Z.

Table 25:   Compatible DX-LN1… single-phase main chokes

Device type DC1…	Rated input current	Assigned motor reactor			
		Part no.	Rated operational current	Frequency	
	I_{LN} [A]		I_e [A]	f [Hz]	U_{LNmax} [V]
DC1-122D3…	5	DX-LN1-006	5.8	50/60 ±10 %	260 +0 %
DC1-S24D3…	6				
DC1-124D3…	8.5	DX-LN1-009	8.6	50/60 ±10 %	260 +0 %
DC1-S14D3…	8.5				
DC1-S27D0…	9.3	DX-LN1-013	13	50/60 ±10 %	260 +0 %
DC1-1D2D3…	11				
DC1-S1011…	12.5				
DC1-127D0…	13.9	DX-LN1-018	18	50/60 ±10 %	260 +0 %
DC1-S14D3…	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 26:   Compatible DX-LN3… three-phase main chokes

Device type DC1…	Rated input current	Assigned motor reactor			
		Part no.	Rated operational current	Frequency	
	I_{LN} [A]		I_e [A]	f [Hz]	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 %
DC1-32018…	18.8	DX-LN3-025	25	50/60 ±10 %	550 +0 %
DC1-34018…	18.1				
DC1-34024…	24.7				

9.8 Motor reactors

The motor reactor is in the output of the frequency inverter. Its rated operational current must always be greater than/equal to the rated operational current of frequency inverter.
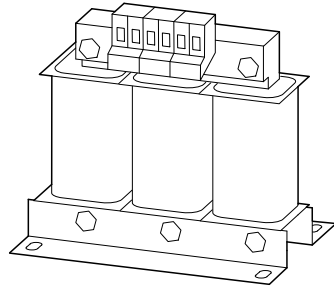
Figure 94:   Motor reactors DX-LM3…
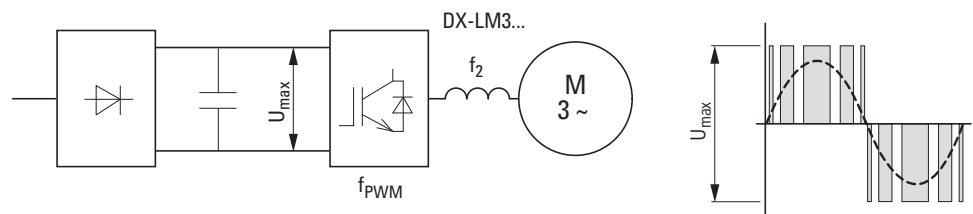
➡️   When multiple motors are connected in parallel in the motor reactor, the rated operational current of the motor reactor must be greater than the total current of all motors.
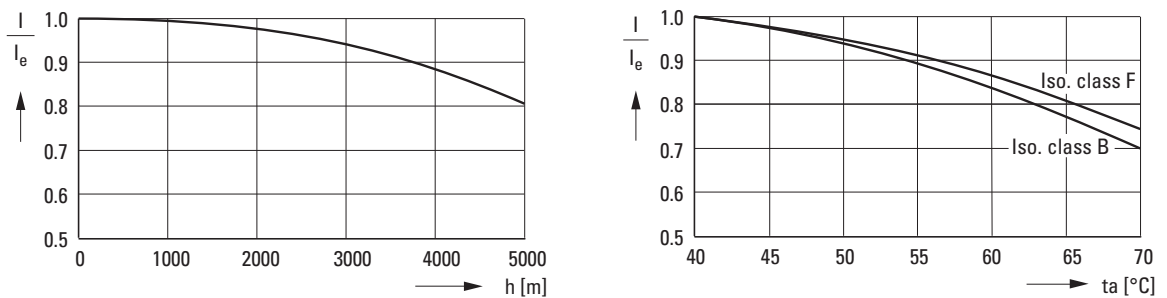
Figure 95:   Derating values for deviating installation altitudes and ambient air temperatures

→ℹ️📖   Further information and technical data on the motor reactors of the DX-LM3… series is provided in instructional leaflet IL00906003Z.

Table 27: Allocation of the motor reactors for frequency inverters of the 230-V class

| Device type | Rated operational current | Assigned motor reactor | | Assigned motor power | | | |
| | | at ambient temperature to +50 °C | Rated operational current | (230 V, 50 Hz) | | (220 - 240 V, 60 Hz) | |
	I_e [A]		I_e [A]	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 ±0 %
• Maximum permissible frequency: 200 Hz
• Maximum permissible pulse frequency (f_{PWM}): 12 kHz

Table 28: Compatible motor reactors for 400-V class frequency inverters

| Device type | Rated operational current | Assigned motor reactor | | Assigned motor power | | | |
| | | at ambient temperature to +50 °C | Rated operational current | (400 V, 50 Hz) | | (440 - 480 V, 60 Hz) | |
	I_e [A]		I_e [A]	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 ±0 %
• Maximum permissible frequency: 200 Hz
• Maximum permissible pulse frequency (f_{PWM}): 12 kHz

9.9 Sinusoidal filter
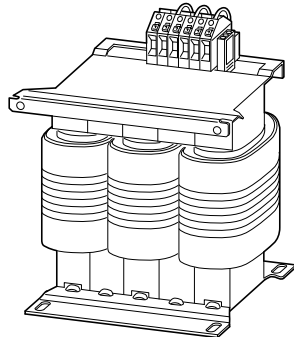
Figure 96:　　　　Sinusoidal filter DX-SIN3…

The DX-SIN3… sinusoidal filter removes high-frequency components from the frequency inverter's output voltage (U_2). This reduces conducted and radiated interference. The sinusoidal 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.
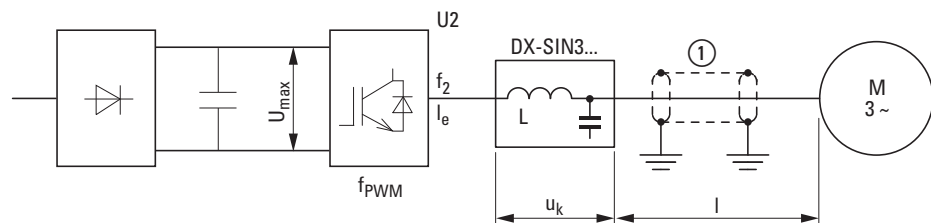
Figure 97:　　　Maximum permissible motor cable lengths
① Screened motor cable: $U_2 \leqq 230$ V → $\leqq 200$ m (656.17 ft); $U_2 \leqq 500$ V → $\leqq 150$ m (492.13 ft)
　Unscreened motor cable: $U_2 \leqq 230$ V → $\leqq 300$ m (924.25 ft); $U_2 \leqq 500$ V → $\leqq 200$ m (656.17 ft
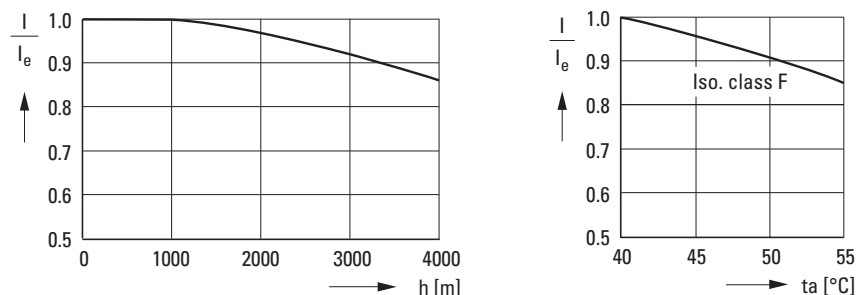
Figure 98:　　　Derating values for deviating installation altitudes and ambient air temperatures

For more information and technical data regarding DX-SIN3… series sinusoidal filters, please consult instructional leaflet IL00906001Z.

Table 29:   Assignment of sinusoidal filters

Device type	Rated operational current I_e for DC1 [A]	Assigned sinusoidal 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:
Sinusoidal 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}

Alphabetical index