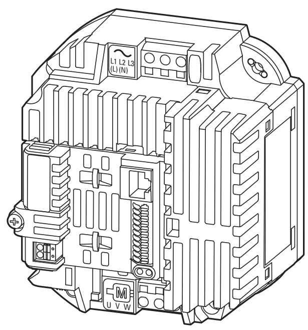
PowerXL™

DB1
Variable Frequency Drives

Installation Manual



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

Translation of the original operating manual
All editions of this document other than those in German language are translations of the original operating manual.

1. Edition 2017, publication date 09/17
2. Edition 2018, publication date 08/18
See revision protocol in the "About this manual" chapter.

Authors: Heribert Joachim, Jan Berchtold
Editor: René Wiegand

Danger!
Dangerous electrical voltage!

Before commencing the installation

- Disconnect the power supply of the device.
- Ensure that devices cannot be accidentally retriggered.
- Verify isolation from the supply.
- Ground and short-circuit.
- Cover or enclose neighbouring units that are live.
- Follow the engineering instructions (IL) of the device concerned.
- Only suitably qualified personnel in accordance with EN 50110-1/-2 (VDE 0105 Part 100) may work on this device/ system.
- Before installation and before touching the device ensure that you are free of electrostatic charge.
- The functional earth (FE) must be connected to the protective earth (PE) or to the potential equalizing. The system installer is responsible for implementing this connection.
- Connecting cables and signal lines should be installed so that inductive or capacitive interference do not impair the automation functions.
- Install automation devices and related operating elements in such a way that they are well protected against unintentional operation.
- Suitable safety hardware and software measures should be implemented for the I/O connection so that a cable or wire breakage on the signal side does not result in undefined states in the automation device.
- Ensure a reliable electrical isolation of the low voltage for the 24 V supply. Only use power supply units complying with IEC 60364-4-41 or HD 384.4.41 S2 (VDE 0100 part 410).
- Deviations of the mains voltage from the nominal value must not exceed the tolerance limits given in the technical data, otherwise this may cause malfunction and dangerous operation.
- Emergency-Stop devices complying with IEC/EN 60204-1 must be effective in all operating modes of the automation devices. Unlatching the emergency switching off devices must not cause restart.
- Built-in devices for enclosures or cabinets must only be run and operated in an installed state, desk-top devices or portable devices only when the housing is closed.
- Measures should be taken to ensure the proper restart of programs interrupted after a voltage dip or failure. This should not cause dangerous operating states even for a short time. If necessary, emergency switching off devices should be implemented.
- Wherever faults in the automation system may cause damage to persons or property, external measures must be implemented to ensure a safe operating state in the event of a fault or malfunction (for example, by means of separate limit switches, mechanical interlocks, etc.).
- During operation, and depending on their degree of protection, variable frequency drives may have live, uninsulated, moving, and/or rotating parts, as well as hot surfaces.
- The impermissible removal of the required cover, improper installation or incorrect operation of the motor or variable frequency drive can cause the failure of the device and serious injury and/or material damage.
- Comply with all applicable national accident prevention regulations (e.g. BGV A3) when working with energized variable frequency drives.
- The electrical installation must be carried out in accordance with the relevant regulations (e.g. with regard to cable cross sections, fuses, PE).
- All transport, installation, commissioning and maintenance work must only be carried out by trained personnel (observe IEC 60364, HD 384 or DIN VDE 0100 and national accident prevention regulations).
- If applicable, systems in which variable frequency drives are installed must be equipped with additional monitoring and protective devices in accordance with the applicable safety regulations, e.g., the German Equipment and Product Safety Act, accident prevention regulations, etc. Making changes to the variable frequency drives by using the operating software is allowed.
- Keep all covers and doors closed during operation.
- When designing the machine, the user must incorporate mechanisms and measures that limit the consequences of a drive controller malfunction or failure (an increase in motor speed or the motor?9s sudden stop) so as to prevent hazards to people and property, e.g.:
  - Additional stand-alone devices for monitoring parameters that are relevant to safety (speed, travel, end positions, etc.)
  - Electrical and non-electrical safety devices (interlocks or mechanical locks) for mechanisms that protect the entire system
  - Due to the possibility of there being capacitors that are still holding a charge, do not touch live device parts or terminals immediately after disconnecting the variable frequency drives from the supply voltage. Heed the corresponding labels on the variable frequency drives

Content

0 About this manual

This MN040031EN manual describes the DB1 variable frequency drivers.

Optional accessories

When an external control unit is being connected, the DB1 variable frequency drivers require type DX-KEY-LED2 and DX-KEY-OLED with software update.
The DX-COM-STICK3 device is required as a parameter memory and for PC communication using Bluetooth.
TheDX-KEY-LED and DX-COM-STICK devices cannot be operated in combination with the DB1 variable frequency drive!

→ "Parameter manual"
A separate manual – MN040034EN ("Parameter Manual") – details how to configure the parameters and provides some application examples for DB1 variable frequency drivers.
This manual is available on the Eaton website at:

http://www.eaton.de/EN/EatonDE/ProdukteundLoesungen/Electrical/Kundensupport/DownloadCenter/index.htm

→ Customer Support → Download Center – Documentation

Enter "MN040034EN" in the **Quick Search** field and click on **Search**.

0.1 Target group

This manual (MN040031EN) is intended for engineers and electricians. Electrical engineering and practical knowledge and skills will be required in order to be able to commission these devices.

We assume that you have a basic knowledge of handling electrical systems and machines, as well as reading technical drawings.

CAUTION
Installation requires qualified electrician

0.2 Change protocol

The following significant amendments have been introduced since previous issues:

Publication date	Page	Keyword	new	modified	deleted
08/18	11	Performance range		✓	
	11	"DrivesConnection mobile" app	✓		
	17	New device types (DB1-12 ... and DB1-34 ...)		✓	
	25	Fan replacement on FS2	✓		
	35	Type F residual current circuit-breakers		✓	
	38	Braking resistors (with DB1-34 ... in FS2)	✓		
	47	Temperature on the cooling surface		✓	
	48	Calculation of power loss P_L	✓		
	51	Installation dimensions, screws, tightening torques for frame size FS2	✓		
	59	Connection cross-section for frame size FS2	✓		
		Cable cross sections (technical data)			✓
		Motor chokes			✓
09/17		First edition			

0.2.1 Presentation conventions

Symbols are used in this manual with the following meanings:

▶ indicates actions to be taken.

0.2.2 Warnings of damage

WARNING
Warns about the possibility of damage.

0.2.3 Warnings of injuries

CAUTION
Warns of hazardous situations that may cause slight injury.

WARNING
Warns of hazardous situations that could result in serious injuries or even death.

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

0.2.4 Helpful hints

→ Indicates useful tips.

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

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

0.3 Documents with additional information

→ More information on the devices described here can be found on the Internet at:

www.eaton.eu/powerxl

as well as in the EATON Download Center:

http://www.eaton.de/EN/EatonDE/ProdukteundLoesungen/Electrical/Kundensupport/DownloadCenter/index.htm

In the **Quick Search** box, enter the document name (such as "MN040031").

0.4 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 field of rotation)
GND	Ground (0-V-potential)
hex	Hexadecimal (base-16 numeral system)
ID	Identifier (unique ID)
IGBT	Insulated gate bipolar transistor
LED	Light emitting diode (LED)
OLED	Organic light emitting diode
PC	Personal computer
PDS	Power drive system
PE ⏚	Protective earth
PES	EMC connection to PE for shielded lines
PNU	Parameter number
REV	Reverse run (anticlockwise field of rotation)
ro	Read Only (read access only)
rw	Read/Write (read/write access)
SCCR	Short circuit current rating
UL	Underwriters Laboratories

0.5 Grid supply voltages

The rated operating voltages stated in the following table are based on the standard values for star networks with a grounded central 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: E.g.: 120 V → 115 V, 240 V → 230 V, 480 V → 460 V.

The broad tolerance range of the DB1 variable frequency drive allows for a permitted voltage drop of 10 % (i. e. U_{LN} - 10 %) and, in the 400-V category, the North American grid voltage of 480 V + 10 % (60 Hz).

The measurements of grid voltage are always based on grid frequencies of 50/60 Hz within a range of 48 to 62 Hz.

→ The permissible power supply for the DB1 series can be found in → section 1.4.3, “Performance characteristics”, page 17.

0.6 Units of measurement

Every physical dimension included in this manual uses international metric 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

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

1 DB1 series

1.1 Introduction

Due to their ease of use and high reliability, DB1 PowerXL™ variable frequency drives are ideal for general applications involving three-phase motors. In addition, an integrated radio interference suppression filter and a flexible interface ensure that the inverters meet a number of important needs in the machine building industry when it comes to the optimization of production and manufacturing processes.

These compact, durable devices with a power range from 0.37 (for 230 V) to 4 kW (for 400 V) are available for protection category IP20.

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

In conjunction with the DX-COM-STICK3 Bluetooth communication stick, and the “DrivesConnect mobile” app (available for Android and iOS operating systems), access via smartphone is also possible.

The extensive accessories additionally increase the flexibility in all areas of application.

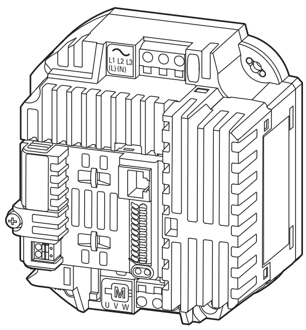


Figure 1: DB1 variable frequency drive, FS1 size

1.2 System overview

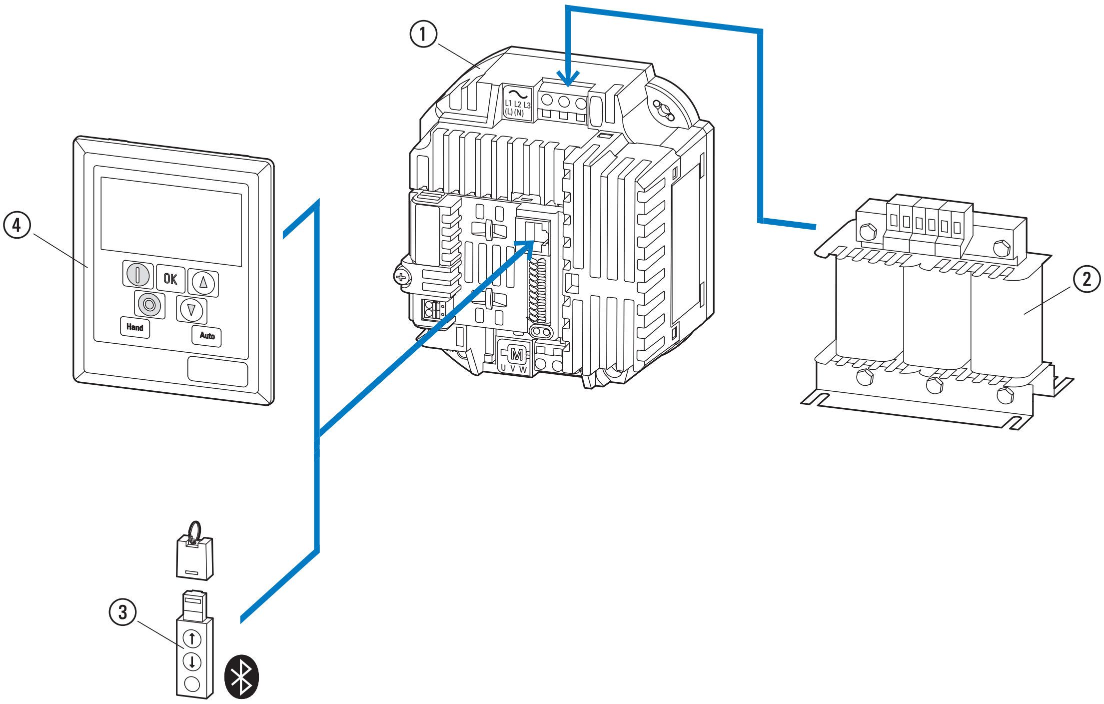


Figure 2: System overview

① DB1… variable frequency drive
② Grid choke DX-LN…
③ DX-COM-STICK3 communication module and accessories (e.g. DX-CBL-… connection cable)
④ DX-KEY-…keypad (external)

1.3 Checking the delivery

→ Before opening the package, please check the rating plate on it to make sure that you have received the variable frequency drive type you ordered.

The DB1 series variable frequency drives are carefully packaged and prepared for delivery. The devices should be shipped only in their original packaging using a suitable means of transportation. Please take note of the labels and instructions on the packaging, as well as the manual for the unpacked device.

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

The packaging must contain the following parts:

- 10x DB1 series variable frequency drive units,
- an instruction leaflet IL040044ZU

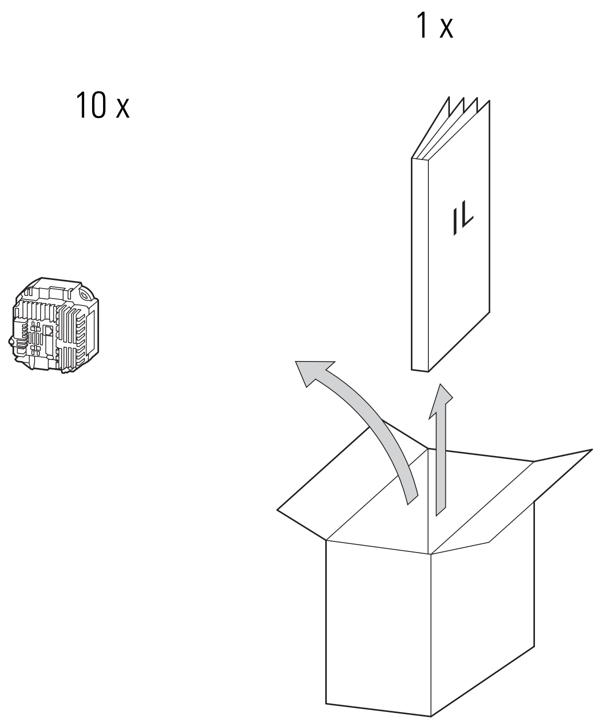


Figure 3: Equipment supplied

1.4 Rating data

1.4.1 Rated values on the nameplate

The device-specific rated values of the DB1 variable frequency drive are listed on the device’s rating plate.

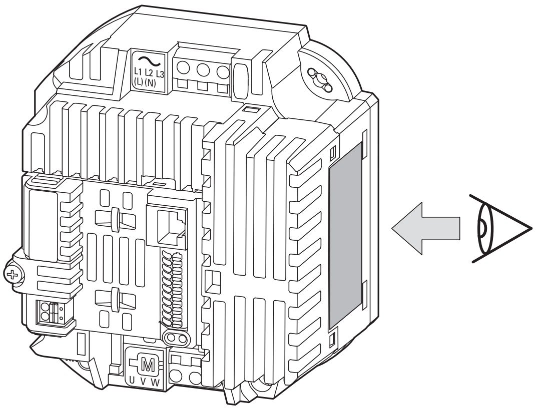
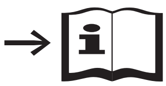


Figure 4: Rating plate location

Rating plate inscription

The label on the rating plate has the following meaning (example):

Description	Meaning
DB1-342D2FN-N2CC	Part number: DB1 = DB1 series variable frequency drive 3 = Three-phase grid connection / three-phase motor connection 4 = Grid voltage category 400 V 2D2 =2.2 A Rated operational current (2-point-2, output current) F = Integrated radio interference suppression filter N = No integrated brake chopper N = no LED display 2C = Protection category IP20/Coldplate C = Coated boards
Input	Rated values of grid connection Three-phase AC voltage (U_e 3~ AC) voltage 380 - 480 V, frequency 50/60 Hz, input phase current (3.5 A)
Output	Load side (motor) rated values: Three-phase AC voltage (0 - U_e), output phase current (2.2 A), output frequency (0 - 500 Hz) Assigned motor output: 0.75 kW at 400 V/1 HP at 460 V for a four-pole, internally or surface-cooled three-phase asynchronous motor (1500 min^{-1} at 50 Hz/1800 rpm at 60 Hz)
Serial No.:	Serial number
IP20	Housing protection type: IP20, UL (cUL) Open type
Software	Software version (2.0)
25072016	Date of manufacture: 7/25/2016
Max. Amb. 60 °C	Maximum permissible ambient air temperature (60 °C)
	Variable frequency drives are electrical equipment. Read the manual (in this case MN040031EN) before making any electrical connections and commissioning.

1.4.2 Type code

The catalog no. or part no. for the DB1 series of variable frequency drives is made up of four sections.

Series – Power unit – Model – Version

The following figure shows it in greater detail:

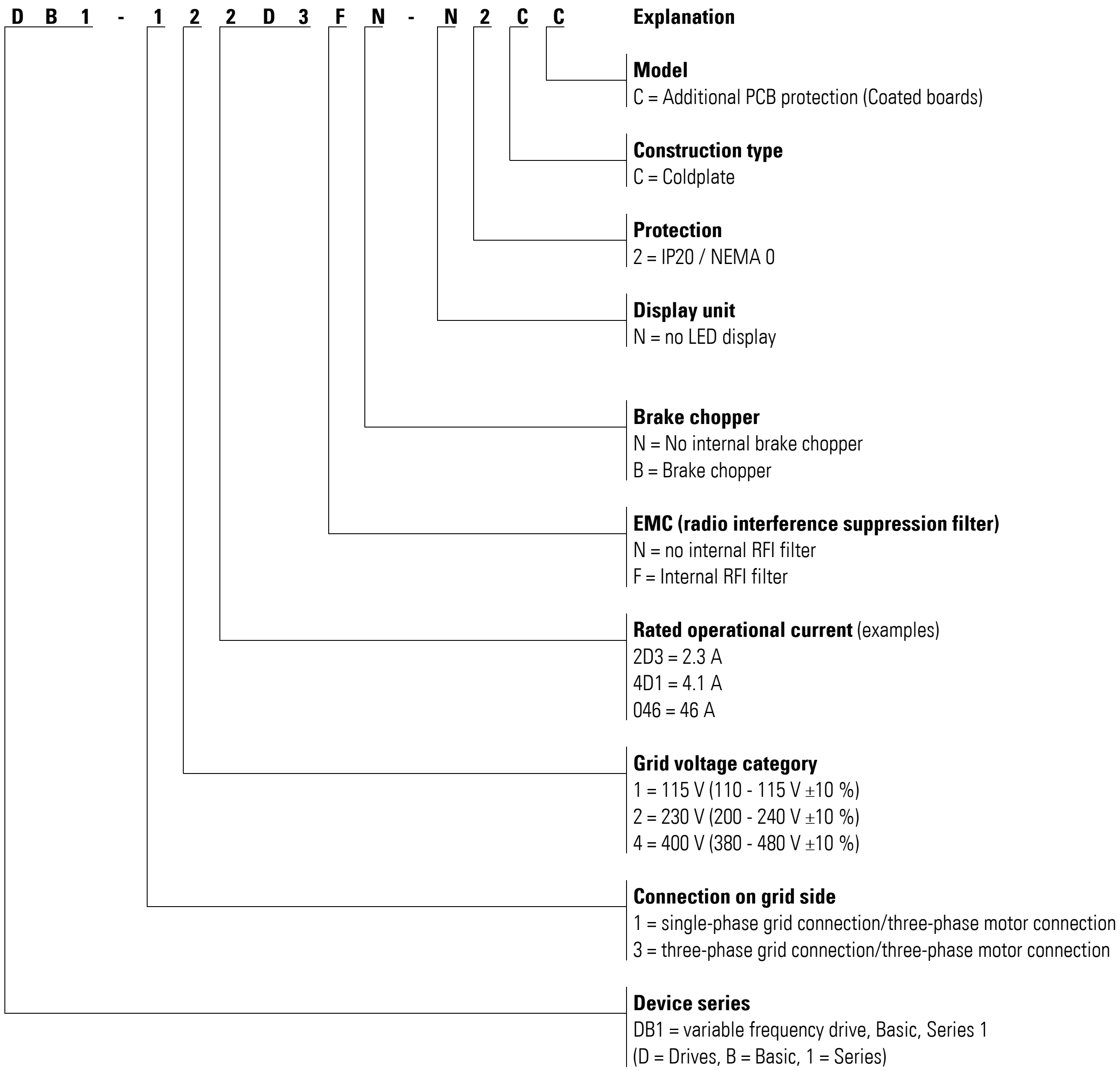


Figure 5: Type code

1.4.3 Performance characteristics

The rated current I2e3 indicated in the tables below is the maximum permitted permanent current under optimum cooling conditions (→ section 3.3.2, "Cooling measures", page 47).
Where cooling is reduced, this value may be lower. The amount of the reduction is application-dependent and cannot be globally specified.

1.4.4 DB1-12… series…

Grid supply voltage: 1 AC (220 - 240) V (±10 %)
Motor connection voltage: 3 AC (220 - 240) V

Table 2: DB1-12… series…

Type	Rated current	Assigned motor output		Radio interference filter	Frame	Brake chopper
	I_e	P 230 V, 50 Hz	P (220 - 240) V, 60 Hz)			
	A	kW	HP			
DB1-122D3FN-N2CC	2.3	0.37	1/2	✓	FS1	–
DB1-124D3FN-N2CC	4.3	0.75	1	✓	FS1	–
DB1-127D0FN-N2CC	7	1.5	2	✓	FS1B	–

1.4.5 DB1-34…device series

Grid supply voltage: 3 AC (380 - 480) V (±10 %)
Motor connection voltage: 3 AC (380 - 480) V

Table 3: DB1-34…device series

Type	Rated current	Assigned motor output		Radio interference filter	Frame size	Brake chopper
	I_e	P 400 V, 50 Hz	P (440 - 480) V, 60 Hz			
	A	kW	HP			
DB1-342D2FN-N2CC	2.2	0.75	1	✓	FS1	–
DB1-344D1FN-N2CC	4.1	1.5	2	✓	FS1	–
DB1-344D1FB-N2CC	4.1	1.5	2	✓	FS2	✓
DB1-345D8FB-N2CC	5.8	2.2	3	✓	FS2	✓
DB1-349D5FB-N2CC	9.5	4	5	✓	FS2	✓

1.5 Description

1.5.1 Frame size FS1

The two following drawings show an example of the designation for the frequency inverter DB1 in frame sizes FS1 and FS2.

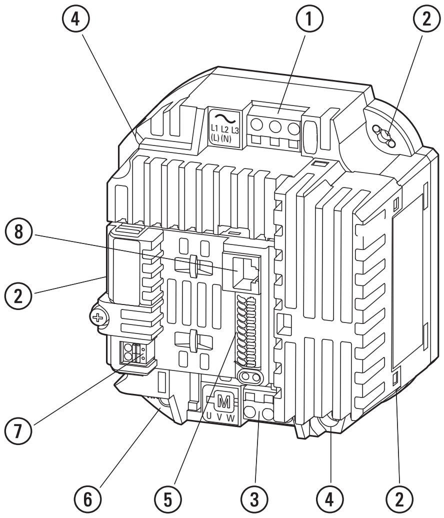


Figure 6: Parts designation - with frame size FS1

① Connection terminals in power unit (grid side)
② Fixing holes
③ Connection terminals in power unit (motor feeder)
④ EMC screw
⑤ Control signal terminals
⑥ Protective ground connector
⑦ Connection terminals for the relay contact
⑧ Communication interface (RJ45)

1.5.2 Size FS2

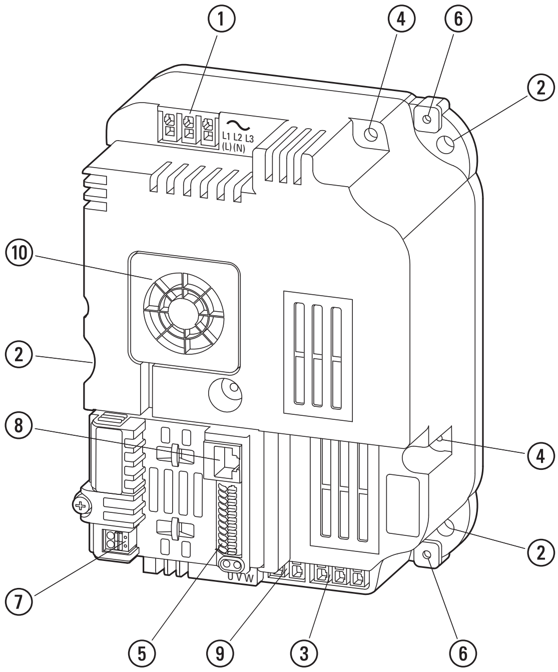


Figure 7: Parts designation - with frame size FS2

① Connection terminals in power unit (grid side)
② Fixing holes
③ Connection terminals in power section (motor feeder)
④ EMC screw
⑤ Control terminals
⑥ Protective ground connector
⑦ Connection terminals for the relay contact
⑧ Communication interface (RJ45)
⑨ Connection terminals in power section (brake chopper)
⑩ Fan

1.6 Voltage classes

The DB1 device series variable frequency drives are divided into two voltage classes:

- 200 V: 200 - 240 V ±10 % → DB1-**12**…
- 400 V: 380 - 480 V ±10 % → DB1-**34**…

- DB1-**12**…
  - single-phase grid connection, rated voltage 230 V
  - U_{LN} = 1~, 200 - 240 V ±10 %, 50/60 Hz
  - I_e = 2.3 - 4.3 A

Motor: 0.37 - 0.75 kW (230 V, 50 Hz), 1/2 - 1 HP (230 V, 60 Hz)

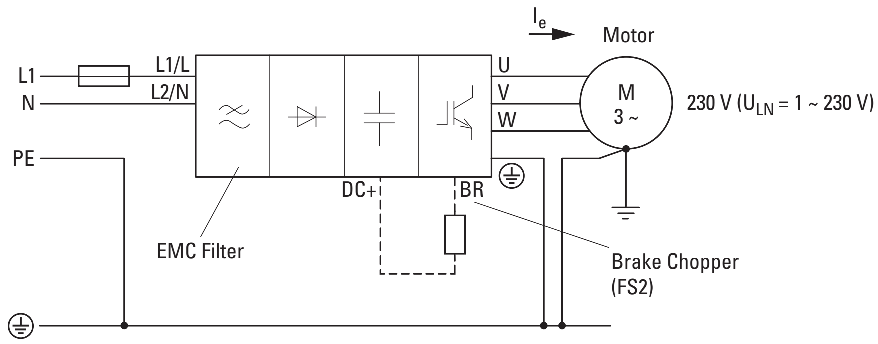


Figure 8: DB1-12…

- DB1-**34**…
  - Three-phase power supply, rated voltage 400/480 V
  - U_{LN} = 3~, 380 - 480 V ±10 %, 50/60 Hz
  - I_e = 2.2 - 4.1 A
  - Motor: 0.75 - 1.5 kW (400 V, 50 Hz), 1 - 2 HP (460 V, 60 Hz)

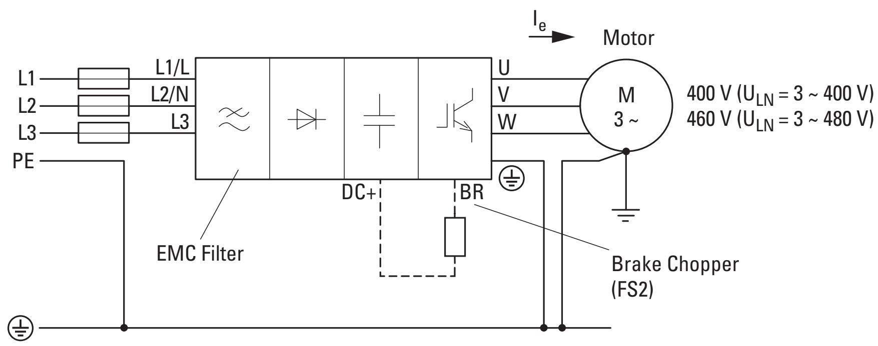


Figure 9: DB1-34…

1.7 Selection criteria

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

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

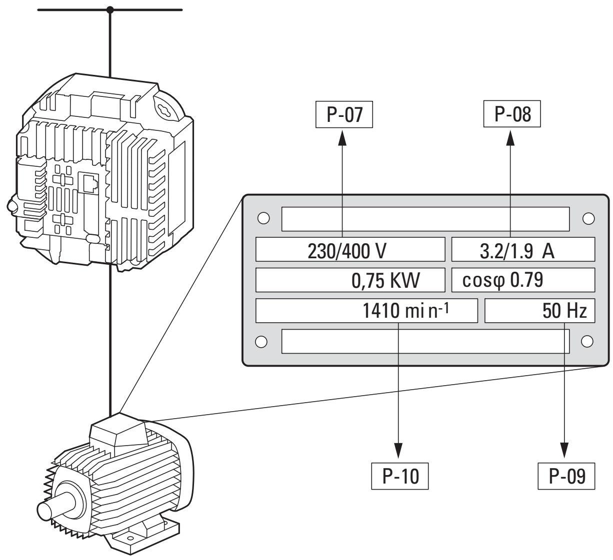


Figure 10:Selection criteria

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

- Grid voltage = rated voltage of the motor (e. g. 3~ 400 V),
- Type of motor (e.g., three-phase asynchronous motor)
- Rated motor current (recommended value, depends on the circuit type and the power supply)

→ The DB1 series variable frequency drives are designed for installation on external cooling surfaces.
The rated currents I_e are permitted up to ambient temperatures of 60 °C. Cooling must be designed accordingly during project planning (→ section 3.3.2, "Cooling measures", page 47).
The lower the ambient temperature, the more favorable the cooling ratios.

Example based on figure 10

- Grid voltage: 3~ 400 V, 50 Hz
- Star connection (400)
- Rated Current: 1.9 A (400 V)
- Max. ambient temperature 60 °C

→ variable frequency drive to be selected: DB1-342D2FN-N2CC

- DB1-**34**…: 3-phase grid terminal, rated voltage: 400 V
- DB1-…**2D2**…: 2.2 A – The variable frequency drive's rated current (output current) guarantees that the motor will be supplied with the required rated current (1.9 A).

1.8 Performance reduction (derating)

A power reduction on the DB1 variable frequency drive or limitation of the maximum permanent output current (I_2) is generally required if the installation altitude is greater than 1,000 m during operation.

Derating for installation altitude

Permissible altitude		Derate:
without derating	with derating	
1,000 m	up to 2,000 m	1% per 100 m above 1,000 m

1.9 Correct use

The DB1 variable frequency drives are electrical devices for controlling variable speed drives with three-phase motors. They are designed for installation in machines or for use in combination with other components within a machine or system.

The DB1 variable frequency drives are not domestic appliances. They are designed only for industrial use as system components.

If the variable frequency drive is installed in a machine, it may not be commissioned until it has been determined that the machine involved meets the safety and protection requirements set out in the Machinery Safety Directive 2006/42/EC (e.g. by complying with EN 60204). The user is responsible for ensuring the machine's usage is in compliance with EC Directives.

The CE labels applied to the DB1 variable frequency drives confirm that the devices comply with the Low Voltage Directive (2014/35/EU), the Electromagnetic Compatibility (EMC) Directive (2014/30/EU), and the RoHS Directive (2011/65/EU) when the typical drive configuration is applied.

In the described system configurations, DB1 variable frequency drives are suitable for use in public and non-public grids.

A DB1 variable frequency drive can only be connected to IT networks (networks without a ground potential link) under certain conditions, because filter capacitors within the device connect the network to the ground potential (housing). With non-grounded networks, this can lead to hazardous situations or damage to the device (insulation monitoring is required).

→ You must not connect any voltage or capacitive loads to the output (terminals U, V, W)

- of the DB1 variable frequency drive:
  (e.g. phase compensation capacitors),
- nor multiple variable frequency drives in parallel,
- nor make a direct connection to the input (bypass).

→ Always observe the technical data and connection requirements! For additional information, refer to the equipment rating plate or label on the variable frequency drive and to the documentation. Any other usage constitutes improper use.

1.10 Maintenance and inspection

DB1 series variable frequency drives will be maintenance-free as long as the general rated values are adhered to and the specific technical data (see annex) for the relevant ratings are taken into account. Please note, however, that external influences may affect the operation and lifespan of a DB1 variable frequency drive.

Because of this, we recommend inspecting the devices on a regular basis and carrying out the following maintenance activities at the specified intervals.

Table 4: Recommended maintenance for DB1 variable frequency drives

Maintenance measures	Maintenance frequency
Clean cooling vents	as needed
Check that the fan is working properly	6 - 24 months (depending on the environment)
Check the filter in the control panel doors (see manufacturer's specifications)	6 - 24 months (depending on the environment)
Check all ground connections to make sure they are intact	On a regular basis, at periodic intervals
Check the tightening torques of the terminals (control terminals, power terminals)	On a regular basis, at periodic intervals
Check connection terminals and all metallic surfaces for corrosion	6 - 24 months; when stored, no more than 12 months later (depending on the environment)
Motor cables and shield connection (EMC)	According to manufacturer specifications, no later than 5 years
Charge capacitors	12 months (→ section 1.12, "Charging the internal DC link capacitors")

Replacement or repair of individual components of DB1 variable frequency drives is not supported!

If the DB1 variable frequency drive is damaged by external influences, repair is not possible.

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

1.10.1 Replacement of the device fan for frame FS2

With DB1 frequency inverters in frame FS2, the installed device fan can be replaced.
The fan is inserted and can be removed from the top of the device.

The following illustrations show the procedure for replacement.

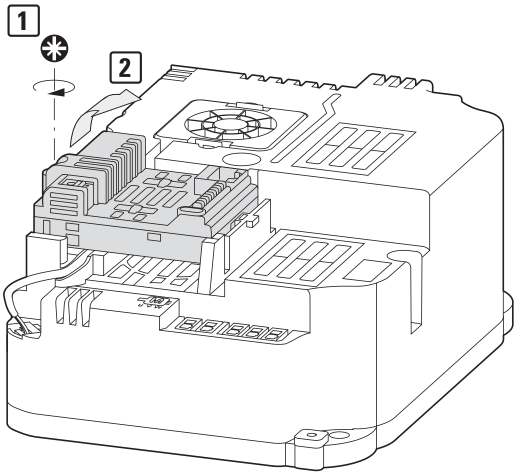


Figure 11:Remove the fan cover

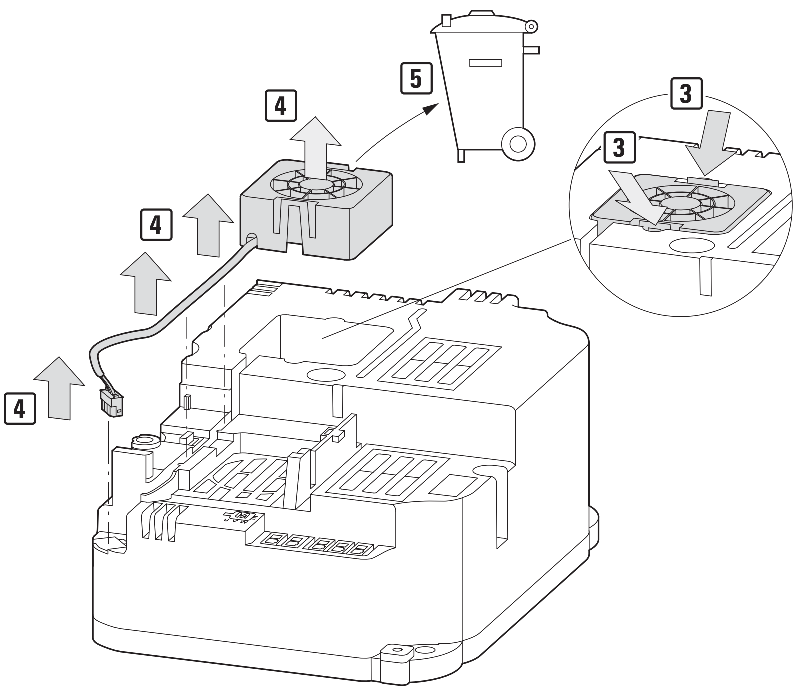


Figure 12:Remove the old fan

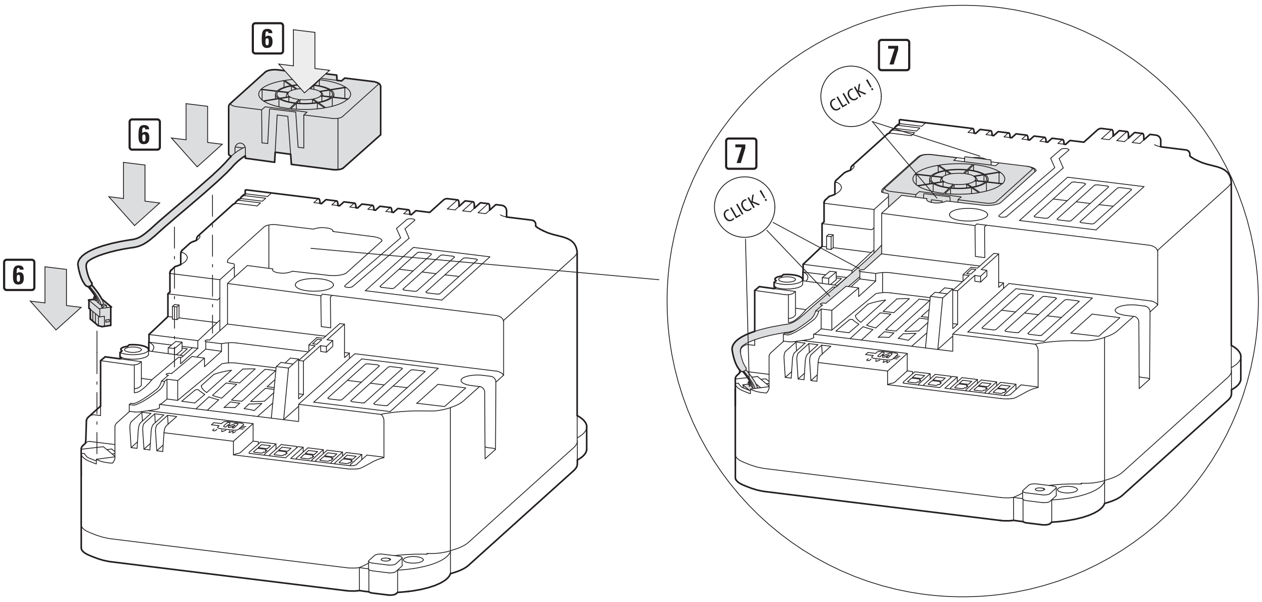


Figure 13:Install the new fan

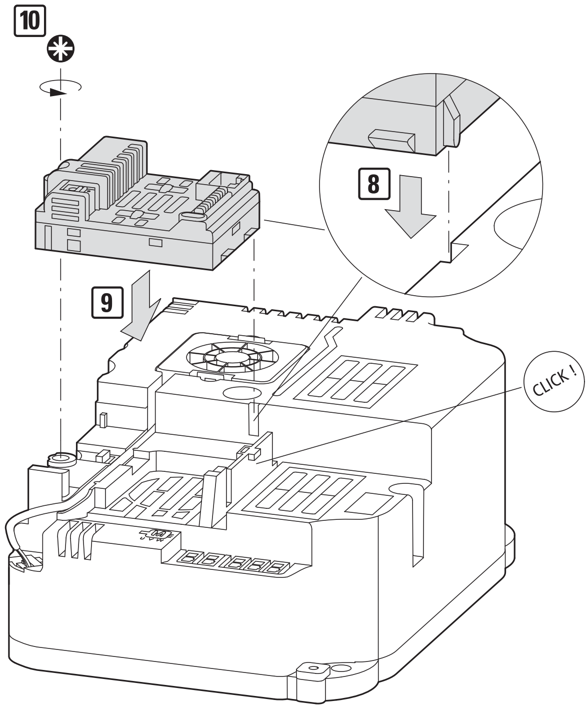


Figure 14:Put on the control board

1.11 Storage

If the DB1 variable frequency drive is stored before use, suitable ambient conditions must be ensured at the site of storage:

- Storage temperature: -40 - +60 °C,
- relative average air humidity: < 95 %, non-condensing
- To prevent damage to the variable frequency drive's internal DC link capacitors, it is recommended that the variable frequency drive is not stored for more than 12 months (→ section 1.12, "Charging the internal DC link capacitors")

1.12 Charging the internal DC link capacitors

After long storage times or long down times without a power supply (> 12 months), the capacitors in the intermediate circuit must be recharged to prevent damage. To do this, the DB1 variable frequency drive must be supplied with power, from a controlled DC power supply unit, via two grid connection terminals (e.g. L1 and L2).

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

- DB1-12…: approx. 324 V DC at U_e = 230 V AC
- DB1-34…: approx. 560 V DC at U_e = 400 V AC

1.13 Service and warranty

In the unlikely event that you have a problem with your DB1 variable frequency drive, please contact your local sales partner.

When you call, please have the following data ready:

- the detailed type description of the variable frequency drive (see rating plate),
- the date of purchase,
- a detailed description of the problem which has occurred with the variable frequency drive.

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

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

Break-Down Service

Please contact your local office:

http://www.eaton.eu/aftersales

or

Hotline After Sales Service

+49 (0) 180 5 223822 (de, en)

AfterSalesEGBonn@eaton.com

2 Engineering

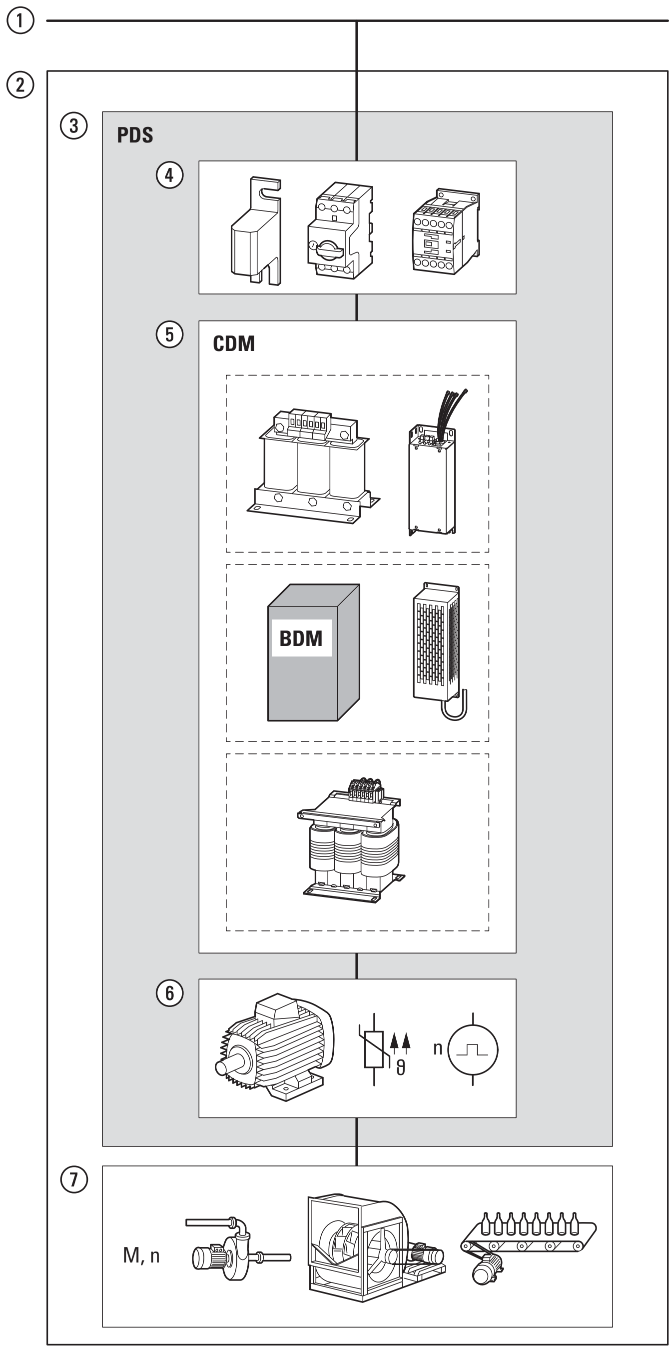
2.1 Introduction

This chapter describes in part the most important features in the power circuit of a drive system (PDS = Power Drive System), which you should take into consideration in your project planning.

It contains instructions that must be followed when determining which device to use with which rated motor output, as well as when selecting protection devices and switchgear, selecting cables, cable entries, and operating the DB1 variable frequency drive.

All applicable laws and local standards must be complied with when planning and carrying out the installation. Not following the recommendations provided may result in problems that will not be covered by the warranty.

An example for a magnet system



① Electrical supply system
(mains connection, mains supply, mains voltage, frequency, voltage balance, THD, compensation systems)

② Overall system – consisting of motor and load systems

③ PDS (Power Drive System)

④ Safety and switching
(disconnecting devices, fuses, cable cross-sectional areas, residual current circuit-breakers, mains contactors)

⑤ CDM = Complete drive module
Variable frequency drive with auxiliary equipment (mains and motor chokes, radio interference suppression filter, brake resistor)
BDM = Basic drive module:
DB1 variable frequency drive

⑥ Motor and sensor
(Temperature, motor speed)

⑦ Load system:
Driven system equipment

Figure 15: Magnet system example (overall system as its own system or as part of a larger system)

2.2 Electrical power network

2.2.1 Mains connection and configuration

DB1 series variable frequency drives can be connected to and run on all star point-grounded AC supply systems (TN-S, TN-C, TT, please refer to IEC 60364) without any limitations.

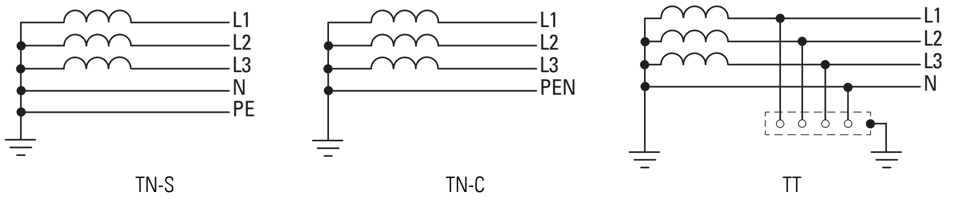


Figure 16: AC supply systems with earthed center point

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

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

→ Operation on non-earthed networks (IT) requires the use of suitable insulation monitoring relays (e. g. pulse-grounded measurement method).

→ In networks with an earthed phase conductor, the maximum phase-earth voltage must not exceed 300 V AC.

The DB1 variable frequency drives can be connected to an asymmetrically grounded network or an IT network (not grounded, insulated).

In this case, the EMC screw must be removed in order to switch off the internal radio interference suppression filter.

→ Measures for electromagnetic compatibility are mandatory in a power drive system, to meet the legal standards for the EMC- and Low Voltage Directives.
Good earthing measures are a prerequisite for the effective use of further measures such as a 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 from voltage phase balance: maximum ±3 %
- Deviation from rated frequency value: maximum ±4 %

The broad tolerance range of the DB1 variable frequency drive observes both the European (EU: U_{LN} = 230 V/400 V, 50 Hz) and the American (USA: U_{LN} = 240 V/480 V, 60 Hz) standard voltages in this case:

- 230 V, 50 Hz (EU) and 240 V, 60 Hz (USA) at DB1-12…
  200 V -10 % - 240 V +10 % (180 V -0 % - 264 V +0 %)
- 400 V, 50 Hz (EU) and 480 V, 60 Hz (USA) at DB1-34…
  380 V -10 % - 480 V +10 % (342 V -0 % - 528 V +0 %)

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

2.2.3 Voltage balance

Unbalanced voltages and deviations from the ideal voltage shape may occur in three-phase AC supply systems if the conductors are loaded unevenly and if large output loads are connected directly. These supply voltage unbalances may cause the diodes in the variable frequency drive’s rectifier bridge converter to be loaded unevenly, resulting in premature diode failure.

→ In the project planning for the connection of three-phase supplied variable frequency drives (DB1-3…), consider only AC supply systems whose permissible asymmetric divergence in the mains voltage is ≦ +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.

→ For the rated mains contactors for DB1 variable frequency drives, please refer to → section 2.5, “Mains chokes”, page 36.

2.2.4 Total Harmonic Distortion (THD)

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

→ In order to reduce the THD value (up to 30 %, it is recommended to use a DX-LN… mains choke (→ section 2.5, "Mains chokes", page 36).

2.2.5 Reactive power compensation devices

Compensation on the power supply side is not required for the variable frequency drives of the DB1 series. From the AC power supply network they take only very little reactive power of the fundamental harmonics (cos φ ~ 0.98).

→ In the AC supply systems with non-choked reactive current compensation devices, current oscillations, (harmonics), parallel resonances and undefined conditions can occur.
In the project planning for the connection of variable frequency drives to AC supply systems with undefined circumstances, consider using mains chokes.

2.3 Cable cross-sections

The mains cables and motor cables must be sized as required by local standards and by the load currents that will be involved.

The PE conductor's cross-sectional area must be the same as the phase conductors' cross-sectional area. The connection terminals marked with ⏚ must be connected to the earth-current circuit.

> *WARNING*
> The specified minimum PE conductor cross-sections (EN 61800-5-1) must be maintained.

→ → section 3.4, "Correct EMC installation", page 52 goes over the EMC requirements for the motor cables.

A symmetrical, fully screened (360°), low-impedance motor cable must be used. The length of the motor cable depends on the RFI class and the environment.

For US installations, UL-listed cables (AWG) should be used exclusively. These cables must have a temperature rating of 70 °C (158 °F), and will often require installation inside a metal conduit (please consult the applicable local standards).

2.4 Safety and switching

2.4.1 Disconnecting device

→ Install a manual disconnecting device between the mains connection and the DB1 variable frequency drive. This disconnecting device must be designed in such a way that it can be interlocked in its open position for installation and maintenance work.

In the European Union, this disconnecting device must be one of the following devices in order to comply with European Directives as per standard EN 60204-1, "Safety of machinery":

- An AC-23B utilization category disconnector (EN 60947-3),
- A disconnector with an auxiliary contact that in all cases will disconnect the load circuit before the disconnector's main contacts open (EN 60947-3),
- A circuit-breaker designed to disconnect the circuit as per EN 60947-2.

In all other regions, the applicable national and local safety regulations must be complied with.

2.4.2 Fuses

The DB1 variable frequency drive and the corresponding supply cables must be protected from thermal overload and short-circuits.

→ The fuse ratings and cable cross-sectional areas (wire gauges) for the connection on the mains side will depend on the DB1 variable frequency drive's input current I_{LN}.

→ For the recommended fuse sizing and assignments, please refer to → section 5.4, "Fuses", page 87.

The fuses will protect the supply cable in the event of a short-circuit, limit any damage to the variable frequency drive, and prevent damage to upstream devices in the event of a short-circuit in the variable frequency drive.

2.4.3 Residual current device (RCD)

When using variable frequency drives (DB1-**3**…) that work with a three-phase power supply (L1, L2, L3), ensure that only type B sensitive residual current devices are used.

When using variable frequency drives that work with a single-phase power supply (L, N) (DB1-**1**2…), typeF residual current devices (RCD) may be used.

> *WARNING*
> Residual-current devices (RCD) may only be installed between the supply system (AC mains supply) and the DB1 variable frequency drive – they must never be installed in the output to the motor.

The leakage currents' magnitude will generally depend on:

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

Other protective measures against direct and indirect contact can be used for DB1 variable frequency drives, including isolating them from the supply system with the use of a transformer.

2.4.4 Mains contactors

The mains contactor enables an operational switching on and off of the supply voltage for the variable frequency drive and switching off in case of a fault. The mains contactor is designed based on the mains-side input current I_{LN} of the variable frequency drive for utilization category AC-1 (IEC 60947) and the ambient air temperature at the location of use.

→ While planning the project, please make sure that inching operation is not done via the mains contactor of the variable frequency drive on frequency-controlled drives, but through a controller input of the variable frequency drive.
The mains voltage on the DB1 variable frequency drive can be switched on a maximum of once every 30 seconds (normal operation).

→ For UL-compliant installation and during operation, the mains side switching devices must allow for a 1.25 times higher input current.

→ For the rated mains contactors for DB1 variable frequency drives, please refer to → section 5.5, "Grid contactors", page 89.

2.5 Mains chokes

Mains chokes reduce the Total Harmonic Distribution (THD) and mains feedback. The apparent current on the mains side is then reduced by around 30 %.

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

→ It is not necessary to use mains chokes in order to run the DA1 variable frequency drive.
However, we recommend using a mains choke if the electrical supply system's quality is not known:

- Large voltage peaks (e.g., when switching large loads directly)
- Correction systems (without series inductors)
- Power supplied via conductor bar or slip ring systems (e.g. overhead cranes)

While planning the project, consider that a mains choke is only assigned to a single variable frequency drive for decoupling.
When using an adapting transformer (assigned to a single variable frequency drive), a mains choke is not necessary.
Mains chokes are designed based on the mains-side input current I_{LN} of the variable frequency drive.

→ When the frequency inverter is operating at its rated current limit, the mains choke causes a reduction of the frequency inverter's greatest possible output voltage U_2 to about 96 % of the mains voltage U_{LN}.

→ For the rated mains chokes for DB1 variable frequency drives, please refer to → section 5.6, "Mains chokes", page 91.

2.6 Radio interference suppression filter

The DB1 variable frequency drives are equipped with internal radio interference suppression filters. Combined with a 360° shielded motor conductor grounded on both sides, this enables compliance with the EMC limit value in Category C1, First Environment (IEC/EN61800-3) in the event of line-bound electromagnetic interference. This requires installation in accordance with EMC requirements, as well as not exceeding permissible motor cable lengths.

- 1 m in Category C1 in First Environment
- 3 m in Category C2 in First and Second Environment
- 10 m in Category C3 in Second Environment

→ Longer motor conductors can still comply with the EMC limit values for line-bound interference if external EMC filters are used.

→ In the case of power drive systems (PDS) with variable frequency drives, electromagnetic compatibility (EMC) measures must already be taken into account during the engineering stage, as making changes during assembly and installation and retroactively fixing things will be more expensive.

2.7 Brake resistors

In certain operating conditions, the motor may run as a generator in certain applications (regenerative braking operation).

Examples include:

- Lowering in hoisting gear and conveyor applications
- Controlled speed reduction in the case of large load inertias (flywheels)
- A fast speed reduction in dynamic travel drives

When the motor operates as a generator, its braking energy will be fed into the variable frequency drive’s DC link via the inverter. DC link voltage UDC will be increased as a result. If the voltage value is too high, the DB1 variable frequency drive will disable its inverter. After this, the motor will coast uncontrolled.

If there is a braking chopper and a connected braking resistance R_B, the braking energy fed back into the variable frequency drive can be dissipated in order to limit the DC link voltage.

DC1-S…B-A… variable frequency drives with a frame size of FS2 feature an integrated brake chopper. The brake resistors are connected to the internal braking transistor with terminals DC+ and BR so that they will be connected in parallel to the DC link. The function of the brake chopper must be activated in parameter P-34 (= 1, 2, 3, 4).

The switch-on occurs automatically during operation, when the DC link voltage rises to the level of the switch-on voltage due to the regenerated braking energy.

Device Type	Power supply	Voltage class	Brake chopper on	Brake chopper off
DB1-344D1FB-N2CC DB1-34508FB-N2CC DB1-349D5FB-N2CC	3-phase	400 V	780 V	756 V

2.8 Switch-disconnectors

Switch-disconnectors are used as repair and maintenance switches in industrial, trade, and building service management applications. At the output of variable frequency drives, they are primarily used to locally switch off motors (pumps, fans) that pose a risk of unintended starting during maintenance or repairs. In order to provide greater safety, these switch-disconnectors can be locked out with the use of padlocks, meaning they have characteristics comparable to those of main switches as defined in EN 60204.

Eaton T0…/MSB/…, P1…/MSB/…, and P3…/MSB/… enclosed switch-disconnectors are designed for local installation with an IP65 degree of protection. The internal screening plate ensures that screened motor cables can be easily connected in a way that meets EMC requirements.

For more information and technical data on T0…/MSB/…, P1…/MSB/…, and P3…/MSB/… switch-disconnectors, please refer to instruction leaflets IL008020ZU and IL008037ZU.

The switch-disconnectors on the output side of DB1 variable frequency drives need to be sized based on utilization category AC-23A (IEC/EN 60947-3) for the assigned rated motor current and the corresponding rated operating voltage.

When a motor is being switched off, the DB1 variable frequency drive's output (inverter) must be disabled (the FWD/REV enable signal must be switched off) before the contacts are opened.

WARNING

Switching off during operation in vector mode (P-60 = 0 / 2 / 3 / 4) is not permissible and may result in damage to the switch-disconnector and the variable frequency drive.

2.9 Three-phase motors

DB1 variable frequency drives can be used to drive the following three-phase AC motors with sensorless control:

- Three-phase asynchronous motor (DAM),
- Permanent magnet motor (PM),
- Brushless DC motors (BLDC),
- Synchronous reluctance motor (SyncRM).

When delivered, the DB1 variable frequency drive is set with U/f modulation for the assigned motor output of a three-phase asynchronous motor.

→ Vector mode, as well as running PM, BLDC, or SyncRM motors, will need for parameters P-60 and P-61 on DB1 variable frequency drives to be configured accordingly.

2.9.1 Motor selection

→ Check whether your chosen DB1 variable frequency drive, in terms of its cooling, is compatible with the assigned three-phase AC motor in terms of voltage (mains and motor voltage) and the rated current.

Configurations such as the ones used in outrunner motors and slip-ring motors also fall under the three-phase asynchronous motor category (which in turn is also referred to as the “squirrel-cage rotor” or “standard motor” category). These motors can also be run with DB1 variable frequency drives, but will normally require additional engineering, modifying the various parameters, and detailed information from the motor manufacturer.
General recommendations for motor selection:

- Only use motors of at least class F temperature rating (155 °C maximum constant temperature).
- Choose 4-pole motors where possible (with synchronous speeds of: 1500 min^{-1} at 50 Hz or 1800 min^{-1} at 60 Hz).
- Take the operating conditions into account for S1 operation (IEC 60034-1).
- Do not oversize the motor, i.e., the motor should not be more than one rating level higher than the rated motor output.
- In the case of undersized motors, the motor output for continuous operation should not be more than one rating level lower than the rated rating level (in order to ensure that the motor will be protected).
- When running tests or commissioning a system with significantly lower motor outputs, the motor’s rated operational current must be adjusted using parameter P-08 (“rated motor current”).

2.9.2 Circuit types with three-phase motors

Based on the mains voltage (U_{LN} = output voltage U_2) and the rated data on the motor's nameplate (rating plate), the stator winding of a three-phase motor can be configured as a star or delta circuit.

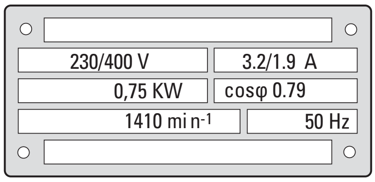


Figure 17: Example of a nameplate (rating plate) for a three-phase asynchronous motor

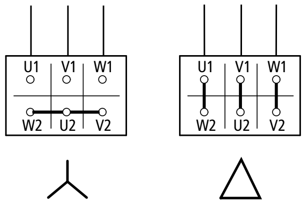


Figure 18: Configuration types:Star-connected circuit (left), Delta circuit (right)

Examples based on figures Figure 17 and Figure 18

Motor with star circuit configuration,
Mains voltage: 3~ 400 V; Output voltage: 3~ 400 V

→ DB1-342D2…

Motor with delta circuit configuration,
Mains voltage: 1~ 230 V; Output voltage: 3~ 230 V

→ DB1-124D3…

Motor connection

DB1 variable frequency drive	as per IEC	as per UL
U	U1 (-U2)	T1 (-T4)
V	V1 (-V2)	T2 (-T5)
W	W1 (-W2)	T3 (-T6)

2.9.3 Permanent magnet motor (PM motor)

PM motors are three-phase motors that are excited by permanent magnets and have a speed that is directly proportional to the supply frequency. Together with a high-pole-count, three-phase stator winding, the permanent magnets on the rotor make it possible to produce large torques at low speeds, which in turn makes it possible to forgo the use of a gearbox in many applications.

By combining high efficiency and good power factor characteristics with a lightweight and compact construction, PM motors make for a compelling choice when compared to asynchronous motors. Accordingly, these high-efficiency motors are primarily found in roller and press drives, agitator and mill drives, drives for extruder screws, and drives used by the crane industry for a variety of applications.

→ In order to use vector control with permanent magnet motors, the values for parameters P-60, P-61, and P-62 on DB1 variable frequency drives need to be changed:

- Change the value for P-60 to 2 (“PM motor speed control”).
- Set P-61 to 1 (“Motor Identification”).
  Automatic auto-tuning to determine the motor parameter during downtime.
- P-62 (“MSC gain”).
  Adjust the gain factor for the speed controller.

2.9.4 Brushless DC motor (BLDC motor)

Contrary to what their name might seem to imply, brushless DC motors (BLDC, also referred to as “EC motors”) do not have the same configuration as a DC motor, but are instead put together the same way as three-phase synchronous motors. The three-phase AC current winding generates a rotating magnetic field, which carries the permanently energized rotor with it.

The rotor position is determined during sensorless vector control by way of the counter-voltage (counter electromotive force) generated in the stator coils. This means that the variable frequency drive’s output voltage must always be live in all three phases (block voltage control), even when the rotor is stationary. If this condition is met, short current pulses will be generated when the system is stationary – these pulses will not move the motor, but they will have an effect on the rotor’s magnetic field.

The control response for BLDC motors is to a large extent the same as that for a shunt DC motor. BLDC motors are primarily used in drive systems for machine tools, servo drives in conveyor systems, and compressors and metering pumps.

→ In order to use vector control with brushless DC motors, the values for parameters P-60, P-61, and P-62 on DB1 variable frequency drives need to be changed:

- Change the value for P-60 to 3 ("Brushless DC motor speed control").
- Set P-61 to 1 ("Motor Identification").
  Automatic auto-tuning to determine the motor parameter during downtime.
- P-62 ("MSC gain").
  Adjust the gain factor for the speed controller.

2.9.5 Synchronous reluctance motor (SyncRM)

Synchronous reluctance motors have the same configuration as a three-phase asynchronous motor. In order to prevent eddy currents, their rotor is made of a soft magnetic material such as electrical steel, and in general terms can have one of two different sheet cross-sections.

In the case of reluctance motors intended to be run as grid-connected systems, the rotor additionally features a rotor cage (similar to that used in asynchronous motors). This cage makes it possible for the motor to start asynchronously on the grid until it synchronizes ("falls into step") to it and is able to follow the rotating field.

In the case of reluctance motors with a rotor that features salient poles with flux directing sections and flux barrier sections, a variable frequency drive with sensorless vector control is required (DC1-…E1). This combination makes it possible to have a rotor speed that is synchronous with the rotating field and achieve optimum operation even when there are load changes. The losses in the rotor are virtually negligible here.

Compared to a standard asynchronous motor, this synchronous reluctance motor is more effective and achieves international efficiency standard IE4. These are primarily used in rotating equipment in process engineering involving pumps, fans, compressors, and turbines, as well as mixers, centrifuges, and conveyor systems.

→ In order to use vector control with synchronous reluctance motors, the values for parameters P-60, P-61, and P-62 on DB1 variable frequency drives need to be changed:

- Change the value for P-60 to 4
  ("SyncRel motor speed control").
- Set P-61 to 1 ("Motor Identification").
  Automatic auto-tuning to determine the motor parameter during downtime.
- P-62 ("MSC gain"):
  Adjust the gain factor for the speed controller.

2.9.6 Connecting EX motors

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

- A DB1 variable frequency drive can be installed in an Ex housing within an Ex-area or in a control cabinet outside of 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 variable frequency drive – e.g., whether motor reactors (dV/dt limiting) are required – must be taken into account.
- Temperature monitors in the motor windings (thermistor, Thermo-Click) must not be connected directly to the variable frequency drive, but instead must be connected through a relay approved for the Ex area (e.g. EMT6).

3 Installation

3.1 Introduction

This chapter provides a description of how to fit and how to connect the DB1 series variable frequency drive.

→ While installing and/or fitting the frequency inverter, cover all ventilation slots in order to ensure that no foreign bodies can enter the device.

→ Perform all installation work only with the indicated, appropriate tools and do not apply any force.

→ For further information about how to install the DB1 variable frequency drive in different frame sizes, please see the IL040044ZU instruction leaflet.

3.2 Mounting position

DB1 variable frequency drives have a compliant coating on their printed circuit boards (coated boards). This provides enhanced protection from moisture and contamination.

Unless covered by the required additional measures, using the device in the following environments is strictly prohibited:

- Explosion-proof areas
- Environments with harmful substances:
  - Oils and acids
  - Gases and fumes
  - Dust
  - Radiation interference
- Environments with mechanical vibration and impact loads that go beyond the requirements in EN 61800-5-1.
- Areas in which the variable frequency drive takes care of safety functions required to guarantee machine and personnel protection.

3.3 Assembly

The installation guidance provided here takes into account building the devices into suitable housing with protection rating IP20 in accordance with standard EN 60529 or other essential provisions that apply regionally.

- The enclosures must be made of a material with high thermal conductivity.
- If a control panel with ventilation openings is used, the openings must be located above and below the variable frequency drive in order to allow for proper air circulation. Air should enter from the bottom and be expelled through the top.
- If the environment outside the control panel contains dirt particles (e.g. dust), a suitable particle filter must be placed on the ventilation openings and forced ventilation must be used.
  The filters must be maintained and cleaned as necessary.
- An appropriate enclosed switch cabinet (without ventilation openings) must be used in environments containing high levels of humidity, salt, or chemicals.

3.3.1 Installation position

The DB1 variable frequency drive range can be built in where desired.
In doing so, you must ensure that the cooling system used in the installation position is capable ofremoving lost heat without this causing the permitted temperature on the variable frequency drive cooling surface to be exceeded.

3.3.2 Cooling measures

In order for variable frequency drive DB1 to operate reliably, sufficient cooling is crucial. An essential aspect of efficient cooling is its thermal resistance, including optimal thermal transfer between the cooling surface of the DB1 variable frequency drive and the cooling system (e.g. heat sink, mounting plate, or machine housing).
A heating plate is required for this purpose, and the correct torque (2 Nm) must also be used for the fixing screws (3 x M4x20).

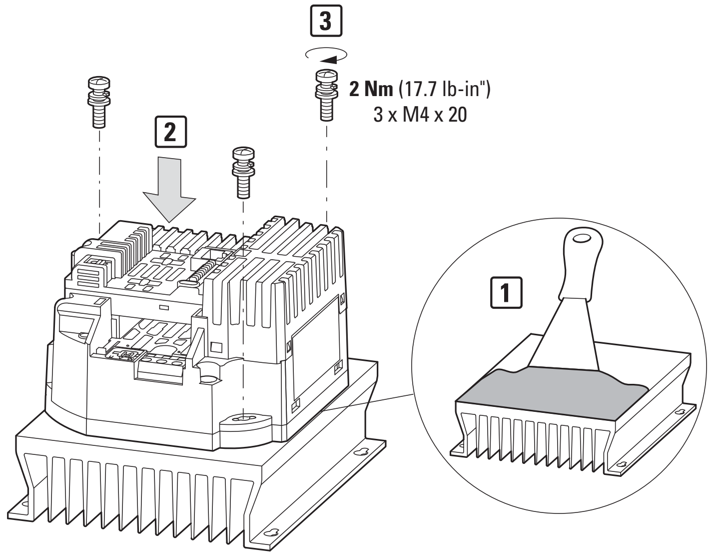


Figure 19: Cooling measures

The permitted temperature on the cooling surface of the drive depends on the switching frequency set using P-17.
The variable frequency drive automatically reduces the switching frequency as soon as a certain temperature is exceeded (see table below).

Table 5: Temperature on the cooling surface

Temperature on the cooling surface	Response
65 °C	Automatic switching of the switching frequency from 32 kHz to 24 kHz
70 °C	Automatic switching of the switching frequency from 24 kHz to 16 kHz
80 °C	Automatic switching of the switching frequency from 16 kHz to 12 kHz
85 °C	Automatic switching of the switching frequency from 12 kHz to 8 kHz
94 °C	Shutdown due to over-temperature when P-17 ≧ 8 kHZ
97 °C	Shutdown due to over-temperature when P-17 ≧ 4 kHZ

The required maximum thermalresistance R_{th} of the cooling system depends on the power loss P_L of the variable frequency drive and the difference between the temperature T_{CP} on the variable frequency drive cooling surface and the ambient temperature T_{AMB} in the control cabinet. The greater the temperature difference, the less cooling is required.

$$R_{th} = \frac{T_{CP} - T_{AMB}}{P_L}$$

The power loss P_L is calculated from the efficiency η_F of the variable frequency drive and the power delivered to the motor.
The power delivered to the motor is calculated from the motor voltage U_M, the motor current I_M and the motor's power factor cos φ.

Overall, one obtains for the power loss P_L:

$$P_L = \sqrt{3} \cdot U_M \cdot I_M \cdot \cos\varphi \cdot (1 - \eta_F)$$

The thermal resistance value calculated in this way must also be effective. If, for example, a heat sink is used with the calculated thermal resistance and with a larger cooling surface than that of the variable frequency drive, it is assumed that the effective thermal resistance is greater in this case. In this instance, you should contact the manufacturer of the heat sink.

In other cases, existing surfaces such as a mounting plate should be used as cooling surfaces. If the thermal resistance is unknown, measurements can determine whether the existing cooling type is sufficient. During these measurements, the temperature on thevariable frequency drive cooling surface must be measured under normal operating conditions (ambient temperature, motor load, closed control cabinet doors).
The temperature rise will be delayed due to the thermal time constant. If the temperature exceeds the maximum permitted value, the measurements must be interrupted and cooling improved.
The DB1 variable frequency drive self-monitors its internal temperature and switches off if required.

The value calculated above for thermal resistance R_{th} is the maximum permitted value in the relevant application. The lower the thermal resistance, the lower the temperature on the cooling surface and inside the variable frequency drive.

During installation, it is important to ensure that the cooling air can circulate adequately and that there are no hotspots.

Table 6: Temperature at the cooling surface, thermal resistance, efficiency

Device type	Switching frequency	Permissible temperature T_{cp} at the cooling surface	Maximum thermal resistance	Efficiency
DB1-122D3FN-N2CC	4 kHz	95 °C	2.5 K/W	96.00 %
	8 kHz	90 °C	2.2 K/W	95.90 %
	12 kHz	85 °C	1.9 K/W	95.90 %
	16 kHz	80 °C	1.6 K/W	95.70 %
	24 kHz	70 °C	1.3 K/W	95.70 %
	32 kHz	65 °C	1.0 K/W	95.60 %
DB1-124D3FN-N2CC	4 kHz	95 °C	1.2 K/W	96.00 %
	8 kHz	90 °C	1.0 K/W	95.90 %
	12 kHz	85 °C	0.9 K/W	95.90 %
	16 kHz	80 °C	0.7 K/W	95.70 %
	24 kHz	70 °C	0.6 K/W	95.70 %
	32 kHz	65 °C	0.5 K/W	95.60 %
DB1-127D0FN-N2CC	4 kHz	95 °C	0.5 K/W	95 %
	8 kHz	90 °C	0.4 K/W	94.7%.
	12 kHz	85 °C	0.3 K/W	94.4 %
	16 kHz	80 °C	0.3 K/W.	94.1 %
	24 kHz	70 °C	0.2 K/W	93 .4%
DB1-342D2FN-N2CC	4 kHz	95 °C	2.3 K/W	97.70 %
	8 kHz	90 °C	1.7 K/W	97.30 %
	12 kHz	85 °C	1.3 K/W	96.80 %
	16 kHz	80 °C	1.2 K/W	97.00 %
	24 kHz	70 °C	0.8 K/W	96.50 %
	32 kHz	65 °C	0.6 K/W	96.00 %
DB1-344D1FN-N2CC	4 kHz	95 °C	1.1 K/W	97.70 %
	8 kHz	90 °C	0.8 K/W	97.30 %
	12 kHz	85 °C	0.6 K/W	96.80 %
	16 kHz	80 °C	0.6K/W	97.00 %
	24 kHz	70 °C	0.4 K/W	96.50 %
	32 kHz	65 °C	0.3 K/W	96.00 %
DB1-344D1FB-N2CC	4 kHz	95 °C	0.64 K/W	97.60 %
	8 kHz	90 °C	0.49 K/W	97.20 %
	12 kHz	85 °C	0.37 K/W	96.80 %
	16 kHz	80 °C	0.28 K/W	96.40 %
	24 kHz	70 °C	0.18 K/W	95.40 %

Device type	Switching frequency	Permissible temperature T_{cp} at the cooling surface	Maximum thermal resistance	Efficiency
DB1-345D8FN-N2CC	4 kHz	95 °C	0.64 K/W	97.60 %
	8 kHz	90 °C	0.49 K/W	97.20 %
	12 kHz	85 °C	0.37 K/W	96.80 %
	16 kHz	80 °C	0.28K/W	96.40 %
	24 kHz	70 °C	0.18 K/W	95.40 %
DB1-349D5FN-N2CC	4 kHz	95 °C	0.33 K/W	97.30 %
	8 kHz	90 °C	0.26 K/W	96.90 %
	12 kHz	85 °C	0.2 K/W	96.50 %
	16 kHz	80 °C	0.15 K/W	96.00 %
	24 kHz	70 °C	0.1 K/W	94.90 %

3.3.3 Mounting

DB1 variable frequency drives are fastened to the cooling surface using three screws.

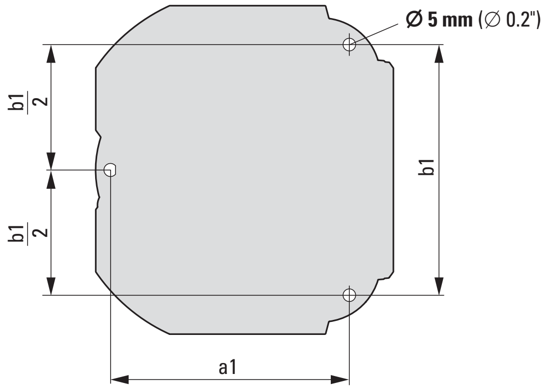


Figure 20: Mounting dimensions

→ It is essential to apply the correct tightening torque to the fixing screws, as this ensures optimum heat transfer between the variable frequency drive cooling surface and the external cooling system.

Table 7: Installation dimensions, screws, tightening torques

Frame size	a1		b1		Screw		Tightening torque	
FS	mm	in	mm	in	Quan-tity	Size	Nm	lb-in
FS1, FS1B	95	3.74	99	3.90	3	M4x20	4	35.4
FS2	125	4.92	189	6.26	3	M4x20	4	35.4

3.4 Correct EMC installation

The responsibility to comply with the legally stipulated thresholds and thereby ensuring electromagnetic compatibility is the responsibility of the end user or system operator. They must also take measures to minimize or remove emitted interference in the environment concerned. They must also utilize means to increase the interference immunity (immission) of the devices or the systems.

→ In a drive system (PDS) with variable frequency drives, you should consider electromagnetic compatibility (EMC) during project planning, since changes or improvements to the installation site, which are required during the installation or mounting, normally imply additional and higher costs.

The technology and system of a variable frequency drive causes high frequency leakage currents during operation. Because of this, all grounding elements must be low-impedance elements connected across a large surface area.

In the case of any leakage currents greater than 3.5 mA, IEC/EN 61800-5-1 requires that

- the cable cross-section of the protective conductor must be ≧ 10 mm^2,
- the protective conductor must be open-circuit monitored, or
- a second ground conductor must be fitted.

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

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

→ Ground all conductive components and enclosures in a drive system with the shortest possible cable with the largest possible diameter (Cu-braid).

WARNING
In a home environment this product can cause high-frequency interference, which may require remedial action.

3.4.1 EMC measures in the switching cabinet

In order to have an installation that meets EMC requirements, make sure to connect all the metallic parts in the devices and in the control panel to each other across a large area and in a way that will make it possible to conduct high frequencies. Mounting plates and control panel doors should be connected to the panel by means of short drain wires with an electrical contact established across a large surface area.

→ Do not make connections to painted surfaces (electrolytic oxidation, yellow chromated).

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

→ If routed in parallel, cables carrying high frequencies (e.g. shielded motor cables) and clean cables (e.g. grid supply cables, control and signal cables) should be installed at a distance of at least 100 mm from each other in order to avoid electromagnetic interference. You should also use separate cable entries if there is a major difference in voltage. If control cables and power cables need to cross, they should always do so at a right angle (90°).

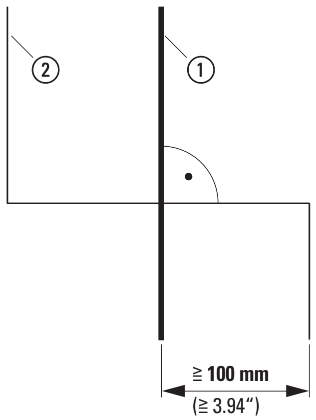


Figure 21: Cable routing

→ Never lay control or signal cables ② in the same duct as power cables ①.
Analog signal cables (measured values, set points, and correction values) must be routed inside shielded conduits.

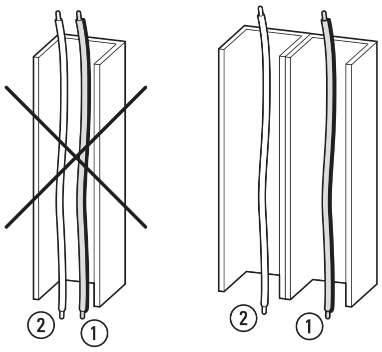


Figure 22: Separate routing

① Power cable: Grid voltage, motor connection

② Control and signal lines, field bus connections

3.4.2 Grounding

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

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

All protective conductors must be routed in a star-shaped layout extending from the central grounding point, and all of the drive system's conductive components must be connected.

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

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

3.4.2.1 Protective ground

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

3.4.2.2 Motor grounding

The motor grounding must be connected to one of the grounding terminals on the variable frequency drive, as well as to the central ground point on the power drive system (PDS). Ground connections to a neighboring steel element in the building (e.g., beam, ceiling joist), a ground rod in the ground, or a grid ground bus must meet the requirements set out in the applicable national and regional industrial safety regulations and/or regulations for electrical systems.

3.4.3 Shielding

Cables that are not shielded work like antennae (sending, receiving).

→ For a correct EMC protected connection, cables emitting interference (e.g. motor cables) and susceptible cables (analog signal and measurement values) must be shielded and laid separately from each other.

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

→ Use only shielding with tin or nickel-plated copper braiding. Screens made from steel braids or metal conduits are either not suitable, or suitable only to a limited extent (depending on the EMC environment).

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

3.4.4 General installation diagram

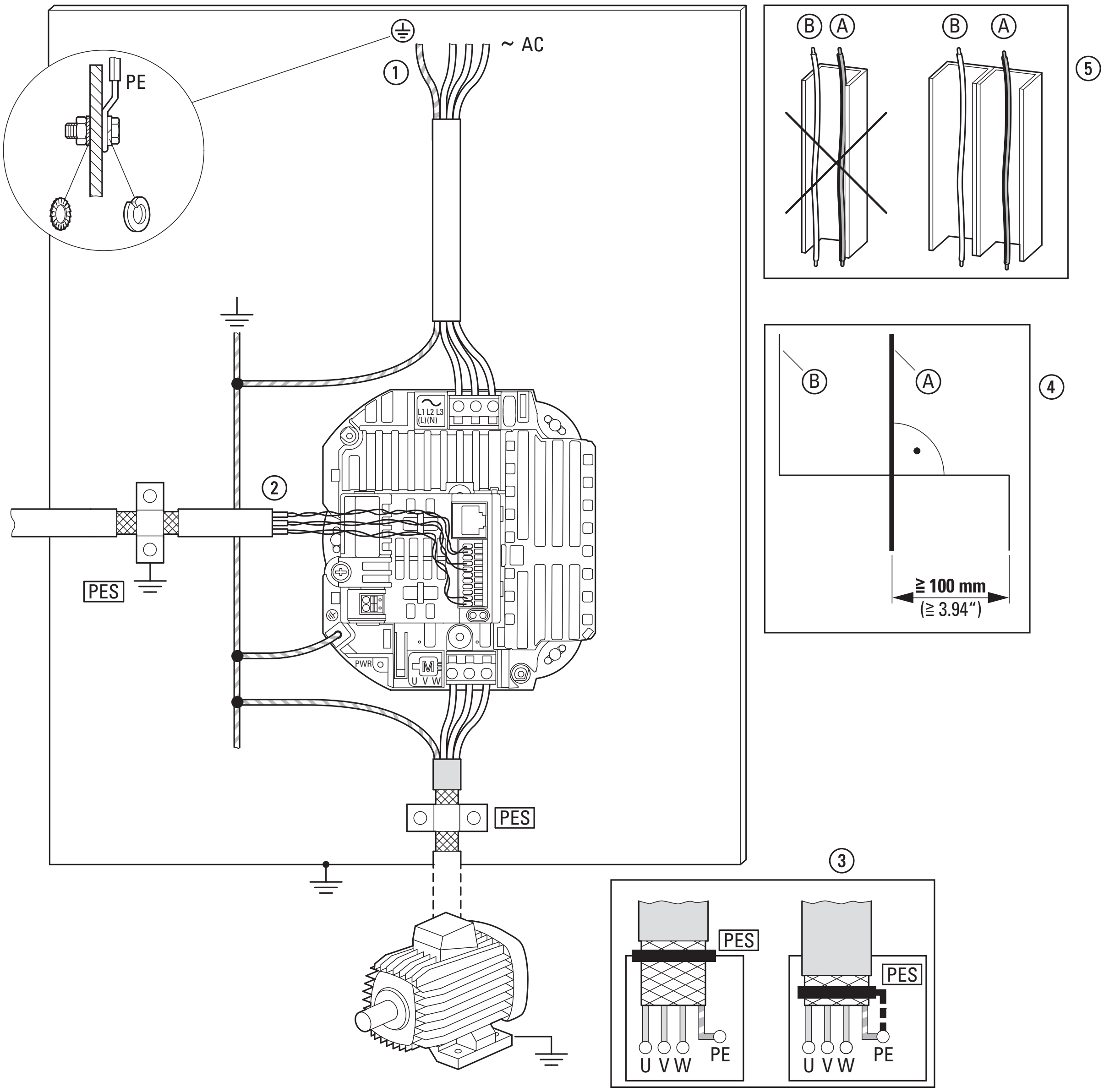


Figure 23: Correct EMC installation

① Grid connection: Supply voltage, central grounding connection for control panel and machine
② Control connection: Connecting the digital and analog control lines and communicating through an RS45 plug-in connection
③ Motor connection: EMC-compliant connection (PES) between the shielded motor cable and the motor's terminal box, using metal screw fitting or with a cable clip in the terminal box.
④ Cable Routing: Power cables (A) and control cables (B) routed separately and at a distance from each other. If different voltage levels need to cross, they should do so at a right angle as far as possible.
⑤ Cable routing: Do not route power cables and control cables parallel to each other in the same cable duct. If they need to be routed in parallel, they should be in separate metal cable ducts (EMC-requirements).

3.5 Electrical Installation

CAUTION

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

DANGER

Electric shock hazard - risk of injuries!
Carry out wiring work only if the unit is disconnected.

WARNING

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

WARNING

The ground leakage currents in the DB1 variable frequency drives can be greater than 3.5 mA (AC).
According to product standard IEC/EN 61800-5-1, an additional grounding conductor must be connected or the existing grounding conductor must have a cross-section of at least 10 mm^2.

DANGER

The components in the variable frequency drive's power unit 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!

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

3.5.1 Connection to thepower unit

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

- L1/L, L2/N, L3, PE for the grid-side supply voltage.
  The phase sequence is not relevant here.
- U, V, W, PE for the connection to the motor
- BR, DC+, PE for external braking resistance (only for frame size FS2)

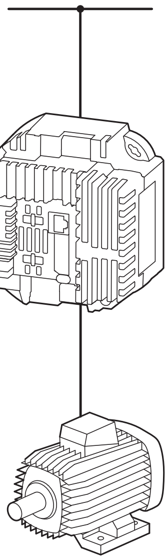


Figure 24: Connections in power unit (schematic)

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

> *WARNING*
> The variable frequency drive must always be grounded via a grounding conductor (PE).

3.5.1.1 Stripping lengths

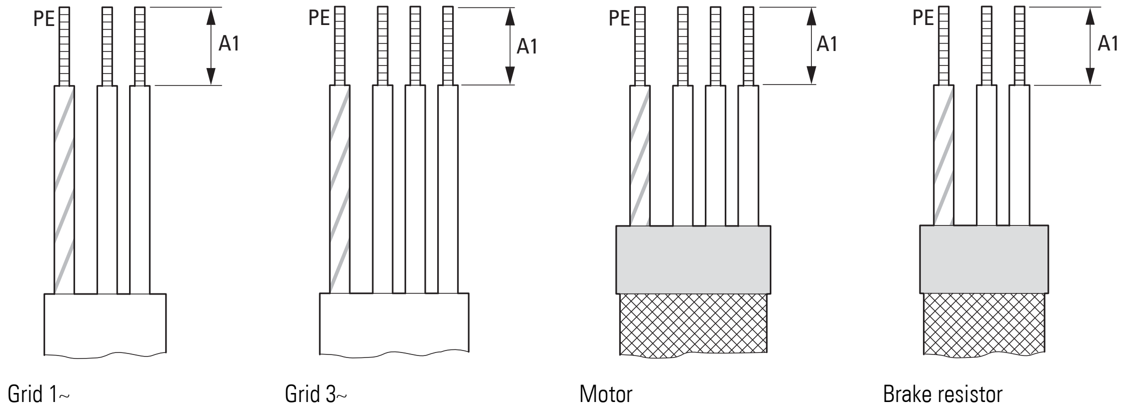


Figure 25: Stripping lengths in the power unit

Grid = Electrical power network (supply voltage)
Motor = Motor connection
Brake resistor (connection to brake chopper – not applicable for frame size FS1)

The power unit has terminals with cage clamp connections.

Table 8: Connector cross sections

Frame size	A1		Connector cross section, solid		Connector cross section, stranded		Connector cross section, fine-strand with ferrule	
	mm	in	mm²	AWG	mm²	AWG	mm²	AWG
FS1, FS1B	8 - 9	0.31 - 0.35	0.08 - 2.5	28 - 12	0.08 - 2.5	28 - 12	0.25 - 1.5	n/a
FS2	10 - 12	0.39 - 0.47	0.2 - 6	24 - 10	0.2 - 6	24 - 10	0.25 - 2.5	n/a

n/a = not allowed

3.5.1.2 Connecting the motor cable

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

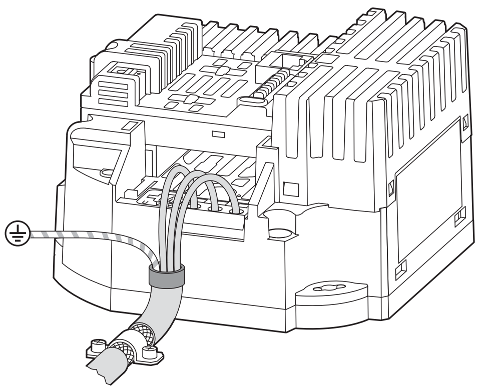


Figure 26: Connection on motor side

- Connect the screening, on both sides and across a large area (360° overlap), to the protective ground (PE) ⏚.
  The power screening's protective ground (PES) connection should be in the immediate vicinity of the variable frequency drive and directly on the motor terminal box.
- Prevent the screen ground shielding from becoming unbraided, i.e. by pushing the separated plastic covering over the end of the shielding or using a rubber grommet on the end of the shielding. Connect the shielding braid at the (PES) end across a large area.
  Alternatively, you can twist the screen braid and connect it to the protective ground using a cable lug. In order to prevent EMC interference, this twisted shielding connection should be as short as possible (recommended value for the twisted cable screen: b ≧ 1/5 a).

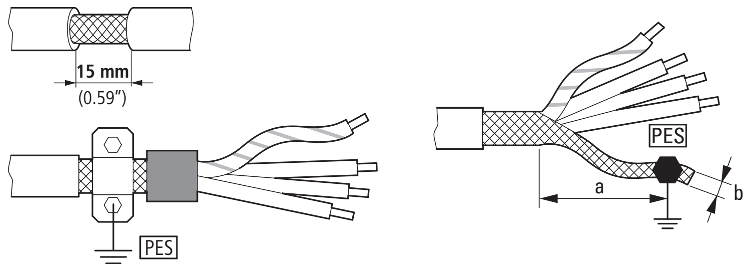


Figure 27: Screened connection cable in motor circuit

Screened, four-wire cable is recommended for the motor cables.
The green-yellow wire in these cables must be used to connect the motor's and variable frequency drive's PE terminals, thereby minimizing the loads on the cable screen (high equalizing currents).

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

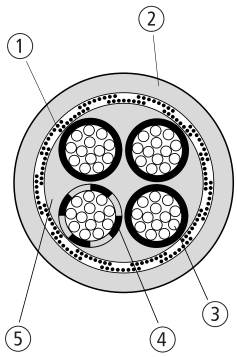


Figure 28: Four-core, shielded motor supply cable

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

If there are additional sub-assemblies in a motor feeder (such as motor contactors, overload relays, motor chokes, sine filters or terminals), the shielding of the motor cable can be interrupted close to these sub-assemblies and connected to the mounting plate (PES) with a large area connection. Free, i.e., non-shielded connection cables should not be any longer than about 300 mm, (maximum 500 mm).

3.5.2 Connection to control section

Push-in terminals are used to connect the control section.

ESD measures

Discharge yourself from static on a grounded surface before touching the control terminals and the circuit board, to prevent damage through electrostatic discharge.

WARNING

Do not connect an external voltage source to control terminal 1 (+24 V)!

→ The relay contact (terminals with the contact) may have been wired to a higher-level control circuit that has a dangerous voltage (e.g., 110 V AC, 230 V AC) even when the variable frequency drive is disconnected, (e.g. 110 V AC, 230 V AC).

→ When using more than one control voltage, we recommend using separate cables.

Example:
24 V DC at control signal terminals 1, 2, 3, 4, 6, and 8 and
110 V AC or 230 V AC at the relay contact.

3.5.2.1 Terminal capacities and stripping lengths

Table 9: Terminal capacities and stripping lengths

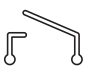
	Stripping length		Connector cross section, solid		Connector cross section, fine stranded		Connector cross section, fine stranded with ferrule	
	mm	in	mm²	AWG	mm²	AWG	mm²	AWG
Control terminals	6 - 7	0.25	max. 0.5	max. 20	max. 0.5	max. 20	n/a	n/a
Relay connection	8 - 9	0.3	max. 1.5	max. 14	max. 1.5	max. 14	n/a	n/a

n/a = not permitted

3.5.2.2 Control terminal connection information and functions

The functions that are set in the 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 clamp		Signal	Description	Factory default setting
1	+24 V	Control voltage for DI1 - DI4, output (+24 V)	maximum load 100 mA, Reference potential 0 V **Caution:** Do not connect an external voltage source!	–
2	DI1	Digital Input 1	+8 - +30 V (High, $R_i > 6$ kΩ)	Start enable FWD
3	DI2	Digital Input 2	+8 - +30 V (High, $R_i > 6$ kΩ)	Start enable REV
4	D13 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) switchable using parameter P-16	Fixed frequency FF1
5	+10 V	Reference voltage, Output (+10 V)	Maximum load: 10 mA,	–
6	AI1 DI4	Analog Input 1 Digital Input 4	• digital: +8 - +30 V (High) • Analog: 0 - +10 V ($R_i > 72$ kΩ) 0/4 - 20 mA ($R_B = 500$ Ω) switchable using parameter P-16	Frequency Reference (fixed frequency)
7	0 V	Reference potential	0 V = connection terminal 9	–
8	A01 D01	Analog output 1 Digital output 1	• digital: 0 - +24 V, maximum 20 mA • analog: 0 - +10 V, maximum 20 mA switchable using parameter P-25	Output frequency
9	0 V	Reference potential	0 V = connection terminal 7	–
10		Modbus+		
11		Modbus-		
		Relay output RO1	Potential-free N/O contact 250 V/6A AC1 30 V/5A DC1	RUN

→ The input and output functions can be adjusted by setting the parameters accordingly (→ "Parameter Manual" MN040034EN).

Terminals 4 (DI3/AI2), 6 (AI1/DI4), and 8 (AO1/DO1) can be assigned with both digital and analog signals in this process.

The relevant signal switchover will occur automatically as selected in the corresponding parameters.

- Terminal assignment of inputs: P-12 and P-15
- Relay output function: P-18
- Function of the digital/analog output at terminal 8: P-25
- Format of the input signal from analog input 1: P-16
- Format of the input signal from analog input 2: P-47

3.5.2.3 Connection example

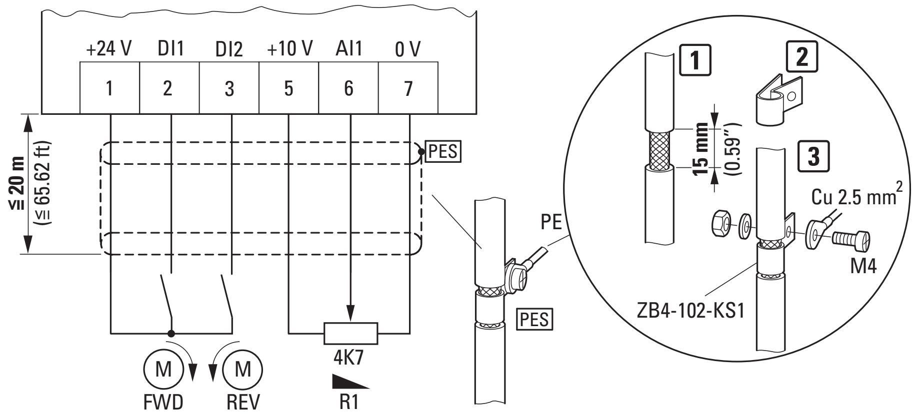


Figure 29: Simple connection example

- Two operating directions:
  - FWD = clockwise rotating field
  - REV = anticlockwise rotating field
- R1: External reference value potentiometer, frequency reference value 0 - f_{max} (P-01)

The control cables should be shielded and twisted for the external connection. The screening is applied on one side in the proximity of the variable frequency drive (PES).

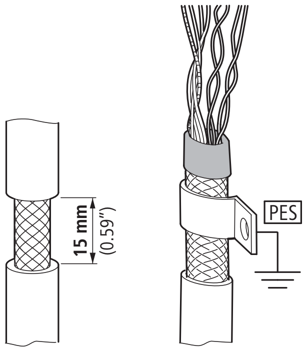


Figure 30: Shield is connected at one end (PES) close to the variable frequency drive.

Alternatively, in addition to the broad area cable clamp, you can twist the screen braid at the end and connect it to the protective ground with a cable lug. To prevent EMC disturbance, this twisted shielding connection should be made as short as possible.

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

We recommend connecting the loads connected to the relay contact as follows:

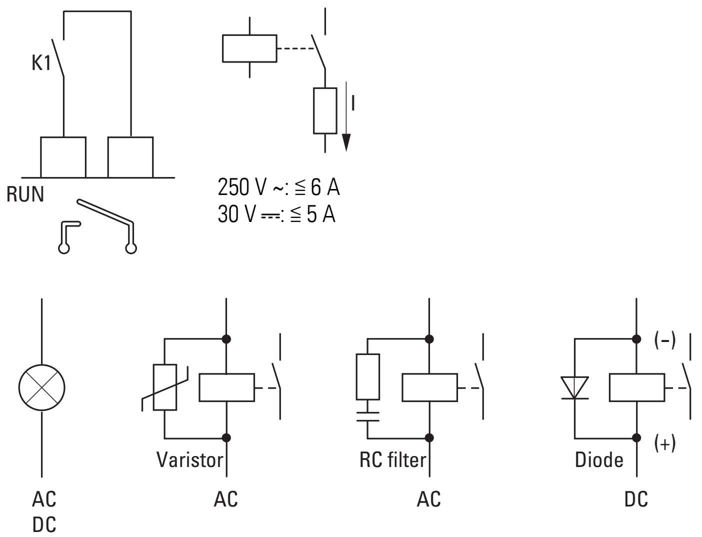


Figure 31: Connection examples with suppressor circuit

3.5.2.4 RJ 45 interface

The RJ45 interface of the DA1 allows a direct connection to communication assemblies and field bus switch-ons.

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

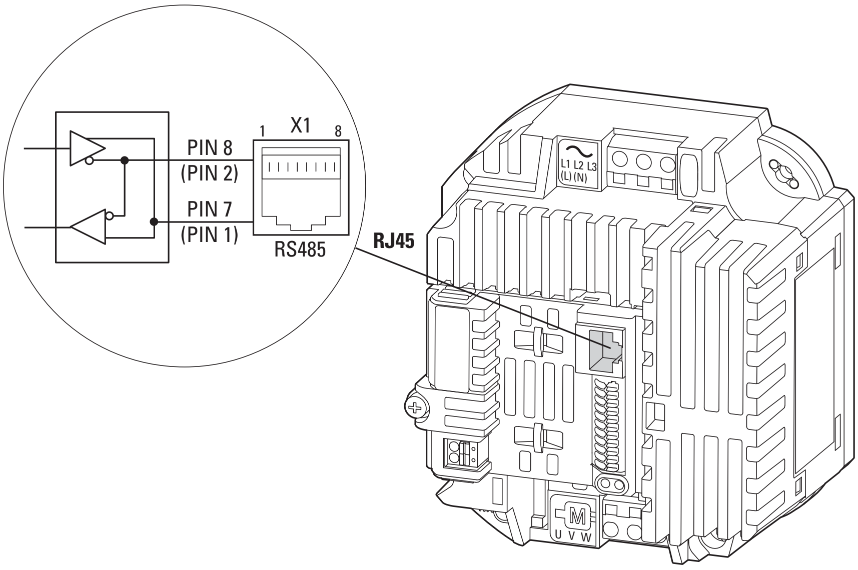


Figure 32: RJ45 interface

Table 11: Configuration of the RJ45 interface

Pin	Meaning
1	CANopen -
2	CANopen +
3	0 V
4	OP-Bus -
5	OP-Bus +
6	+24 V
7	Modbus RTU (A), RS485-
8	Modbus RTU (B), RS485+

→ The way the RJ45 interface works is described in the following manuals:

- MN040018: "Modbus RTU – Communication manual for DA1, DC1, DE1 variable frequency drives"
- MN040019: "CANopen – Communication manual for DA1, DC1, DE11 variable frequency drives"

→ DB1 variable frequency drives have no internal bus termination resistor.
Use EASY-NT-R as needed.

3.5.3 Thermistor connection

As a way of protecting against thermal overload in the motor, motor thermistors and motor temperature switches (Thermo-Click) can be connected to control signal terminal 4 (DI3 = digital input 3).
In parameter P-15, setting EXTFLT (external fault) must be chosen for DI3 and in parameter P-47, value 6 (Ptc-th) must be enabled in order to do this.

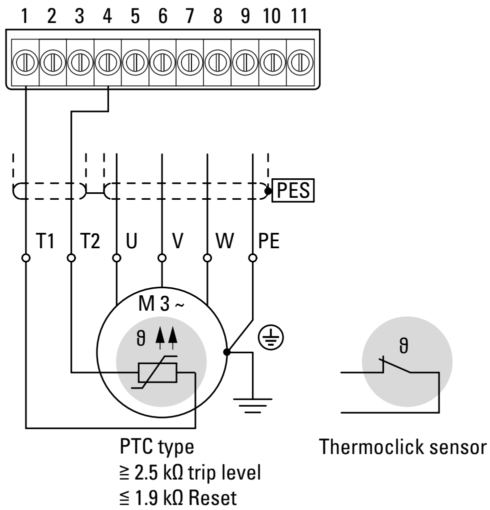


Figure 33: Thermistor connection

Thermistors and temperature switches must be PTC-based (PTC characteristics; positive temperature coefficient).
These are triggered at a resistance value of approx. 2.5 kΩ - 3 kΩ, and a reset is triggered at approx. 1.9 kΩ - 1 kΩ.

3.6 Block diagrams

The following block diagrams show all the connection terminals on a DB1 variable frequency drive and their functions under their factory settings.

3.6.1 DB1-12…

Grid voltage U_{LN}: single-phase, 200 (-10%) - 240 (+10%) V, 50/60 Hz

Motor Voltage U_2: Three-phase, U_2 = U_{LN}, 0 - 50/60 Hz (max. 500 Hz)

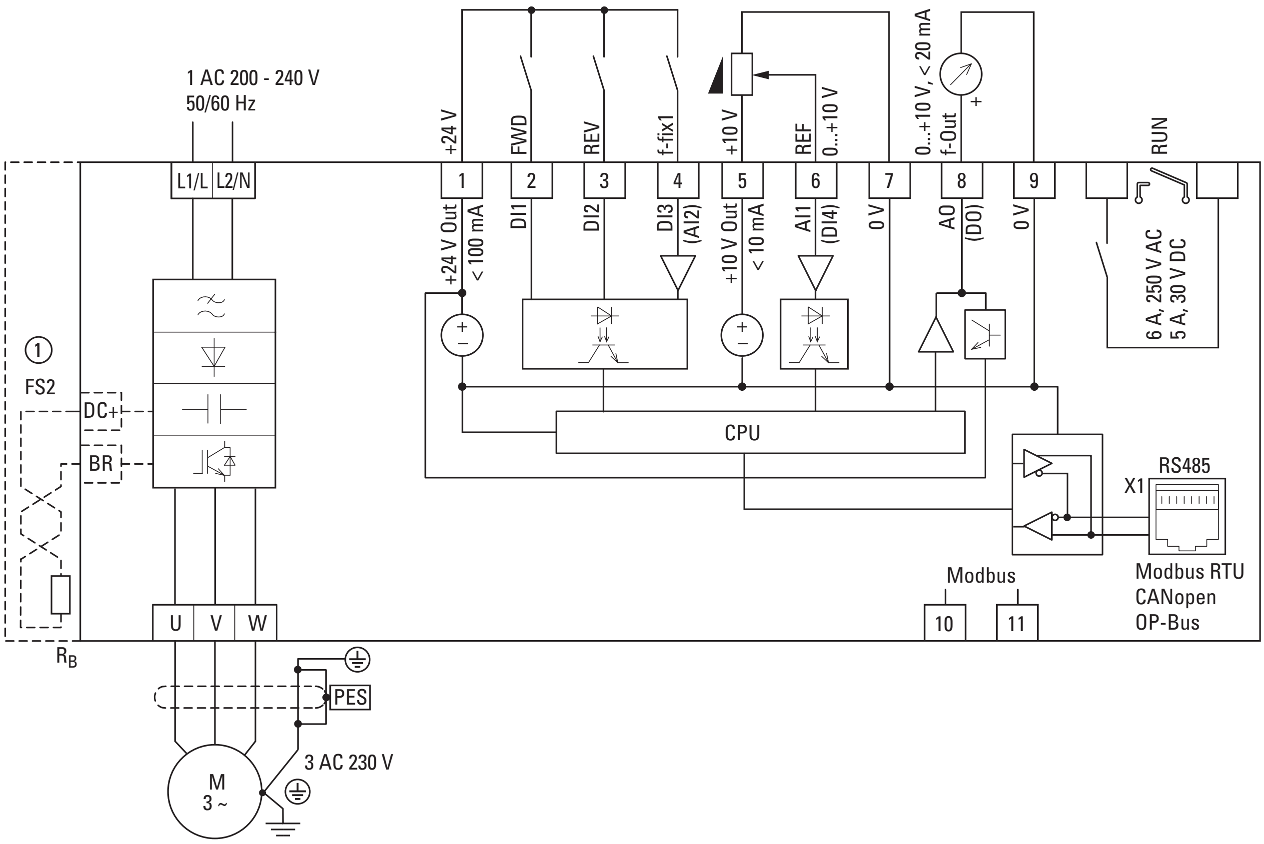


Figure 34: Block diagram DB1-12…

Variable frequency drive with single-phase grid connection and three-phase motor connection

① Devices with frame size FS2 allow the connection of braking resistors (DC+, BR).

3.6.2 DB1-34…

Grid voltage U_{LN}: 3-phase, 380 (-10 %) - 480 (+10 %) V, 50/60 Hz

Motor voltage U_2: Three-phase, $U_2 = U_{LN}$, 0 - 50/60 Hz (max. 500 Hz)

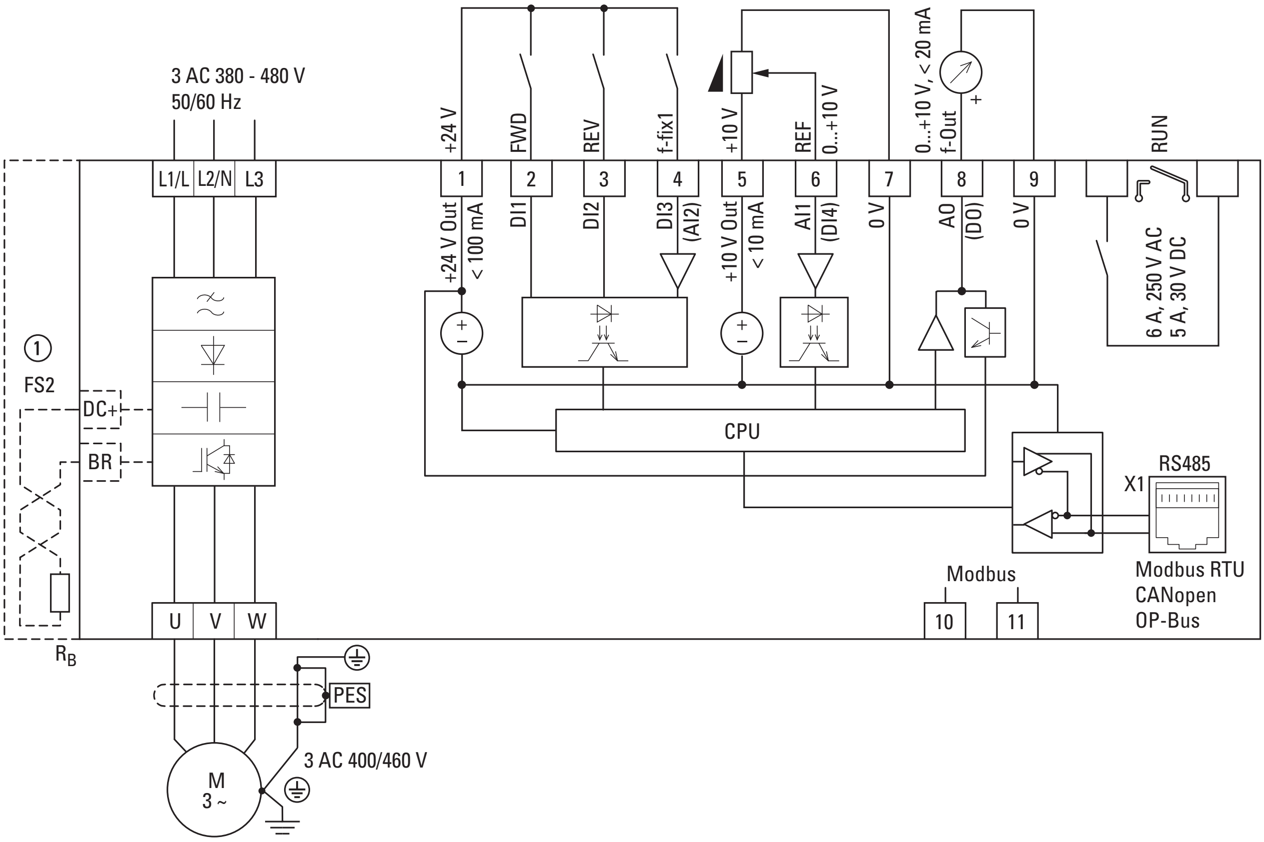


Figure 35: Block diagram DB1-34…

Variable frequency drive with three-phase grid connection and three-phasemo-tor connection

① Devices in frame size FS2 allow the connection of braking resistors (DC+, BR).

3.7 Insulation testing

The variable frequency drives of the DB1 series are tested, delivered and require no additional testing.

> **CAUTION**
> On the control signal and the connection terminals of the variable frequency drive, no leakage resistance tests may be performed with an insulation tester.

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

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

Testing the motor cable insulation

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

The insulation resistance must be greater than 1 MΩ.

Testing the grid cable insulation

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

The insulation resistance must be greater than 1 MΩ.

Testing the motor insulation

▶ Separate the motor cable from the motor (U, V, W) and open the bridge circuit (star or delta) in the motor terminal box.
Measure the insulation resistance of the individual motor windings.
The measured voltage must at least match the rated operating voltage of the motor but must not exceed 1,000 V.

The insulation resistance must be greater than 1 MΩ.

→ Take the instructions from the motor manufacturer into account when testing the insulation resistance.

3.8 Protection against electric shock

Ensuring protection against electric shock when using DB1 variable frequency drives, as per IEC/EN 61800-5-1

Manufacturer's declaration for the initial validation under IEC/HD 60364-6

Fault protection as per IEC/HD 60364-4-41 (DIN VDE 0100-410 (VDE 0100-410)) for the circuit on the output side of the aforementioned equipment is ensured based on the following requirements:

- The installation instructions in this documentation have been followed.
- The applicable standards in the IEC/HD 60364 (DIN VDE 0100 (VDE 0100) series have been observed.
- The consistency of all associated protective conductors and potential equalization cables, including their connection points, has been ensured.

Provided that the above requirements are met, the above apparatus meets the requirements in IEC/HD 60364-4-41 (DIN VDE 0100-410 (VDE 0100-410): 2007-06, section 411.3.2.5) when applying the “automatic power supply shutdown” protective measure.

The note is based on the following information:

In the event of a short-circuit with negligible impedance to a protective conductor or to ground, the aforementioned equipment reduces the output voltage within the times as per Table 41.1 or otherwise within 5 seconds – whichever applies – in accordance with IEC/HD 60364-41 (DIN VDE 0100-410; VDE 0100-410):2007-06).

4 Operation

4.1 Checklist for commissioning

Before starting to operate the frequency converter, use the checklist below to make sure that all the following requirements are met:

Number	Operation	Note
1	Mounting and wiring have been carried out as required by the instruction leaflet (→ IL040044ZU).	
2	Any wiring and line section waste, as well as all the tools used, have been removed from the frequency converter's proximity.	
3	All cables have been correctly installed.	
4	The lines connected to the output terminals of the variable frequency drive (U, V, W, DC+, BR) are **not** short-circuited and **not connected** to ground (PE).	
5	The frequency converter has been grounded properly (PE).	
6	All electrical connections in the power unit (L1/L, L2/N, L3, U, V, W, DC+, BR, PE) have been connected properly, taking into account the protection level and have been dimensioned in for the requirements.	
7	Each phase of the supply voltage (L or L1, L2, L3) is fitted with a protective device.	
8	The variable frequency drive and the motor are matched to the grid voltage. (→ section 1.4.1, "Rated values on the nameplate", page 14) The connection type (star, delta) of the motor is tested.	
9	The quality and volume of cooling air are in line with the environmental conditions required for the variable frequency drive and the motor.	
10	All connected control cables comply with the corresponding stop conditions (e.g. switch in OFF position and set point value = zero).	
11	The parameters that were preset at the factory have been checked with the list of parameters (→MN040034EN).	
12	The direction of action of a connected machine will allow the motor to start.	
13	All EMERGENCY STOP and protection functions are in the proper state.	

4.2 Operational hazard warnings

Please observe the following notes.

DANGER

Commissioning is only to be carried out by qualified professionals.

DANGER

Dangerous electrical voltage!

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

DANGER

The components in the variable frequency drive's power unit are energized whenever the supply voltage (grid voltage) is connected. For instance: the L1/L, L2/N, L3, DC+, BR, U/T1, V/T2, W/T3 power terminals.
The control signal terminals are insulated from the grid power voltage.
There can be a dangerous voltage on the relay terminals even if the variable frequency drive is not connected to grid voltage (e.g. when installing relay contacts in control systems with voltage > 48 V AC/60 V DC).

DANGER

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

Pay attention to hazard warnings!

DANGER

Following a shutdown (fault, grid failure), the motor may start automatically (when the grid voltage is switched back on) if the automatic restart function has been enabled (→ parameter P-31).

WARNING

Any contactors and switching devices on the grid side must not be opened while the motor is in operation.
Inching operation using the grid contactor is not permitted.
Contactors and switchgear (repair and maintenance switches) on the motor side must not be opened while the motor is in operation.
Inching operation of the motor with contactors and switching devices on the variable frequency drive output is not permitted.

WARNING

Make sure that no danger will be caused by starting the motor.
Disconnect the machine being powered if there is a danger of it operating in an incorrect 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. Otherwise the motors could be damaged.

4.3 Commissioning (default settings)

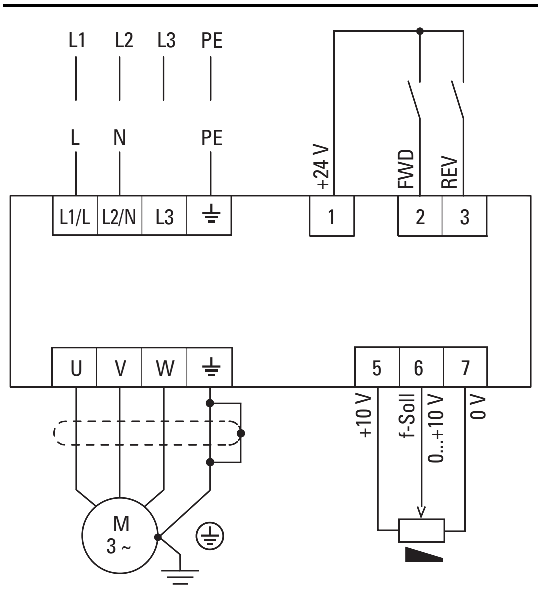
Commissioning as described in this chapter relates to a device with default settings.

If the parameter settings need to be changed due to the application in question, this can be performed using the optional keypad DX-KEY-LED2 or DX-KEY-OLED or using the DrivesConnect parameter configuration software.

→ The function and setting options for the parameters are described in "Parameter Manual" MN040034EN.
In addition, the Manual also provides information on operating the keypad as well as potential error messages that may occur and the causes for them.

Simplified connection example

DB1



Terminal	Description	
L1/L	Single-phase grid connection (DB1-12…)	Three-phase grid connection (DB1-34…)
L2/N		
L3	–	
⏚	Ground connection	
1	Control voltage +24 V (output, maximum 100 mA)	
2	FWD, Start enable clockwise rotating field	
3	REV, Start enable left rotating field	
U	Connection for three-phase AC motor (three-phase motor)	
V		
W		
⏚		
5	Control voltage +10 V (output, maximum 10 mA)	
6	Frequency reference value f-set point (Input 0 - +10 V)	
7	Reference potential (0 V)	

The set point potentiometer should have a fixed resistor of at least 1 kΩ up to a maximum of 10 kΩ (connection of terminals 5 and 7).
A standard, fixed set point of 4.7 kΩ is recommended in this case.

→ Make sure that the enable contacts (FWD/REV) are open before switching on the grid power.

By applying the specified power supply to the grid connection terminals (L1/L, L2/N, L3), the switching power supply unit will generate the control voltage in the DC link voltage. At this point, the variable frequency drive will be ready for operation (correct operating status) and in Stop mode.

The start enable is done by actuating one of the digital inputs with +24 V:

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

▶ The output frequency (0 - 50 Hz) and, as a result, the speed of the connected three-phase motor (0 - n_{motor}) can be adjusted by using the set point potentiometer via terminal 6 (0 - +10 V proportional voltage signal). The output frequency will then be changed after a delay according to the specified acceleration and deceleration times. In the default settings, these times are set to 5 seconds each.

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

Figure 36 shows an example of the timing when an enable signal RUN (FWD or REV) is turned on, and the maximum set point voltage (+ 10 V) is applied to control terminal 6. The speed of the motor follows the output frequency, depending on the load torque and moment of inertia (slip), from zero to n_{max}. The acceleration time is set in parameter P-03.

If the enable signal (FWD or REV) is switched off during operation, the inverter will be disabled immediately (STOP) and the output frequency will be set to zero. The motor then runs in an uncontrolled manner (coast down), see ① below.
If both enable signals (FWD and REV) are applied, the variable frequency drive will perform a quick stop using the time set in parameter P-24.

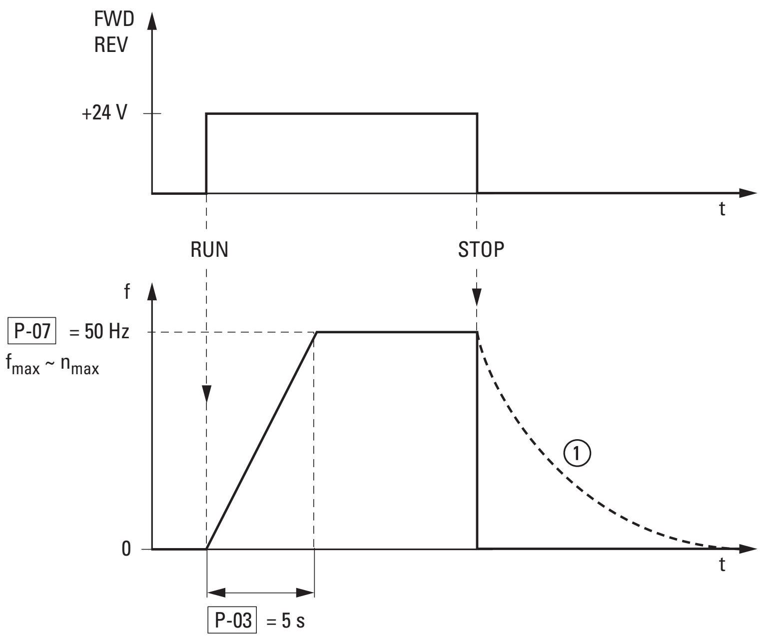


Figure 36: Start-stop command at maximum set point voltage, acceleration ramp 5 s

5 Technical data

5.1 Generalrated operational data

Technical data	Symbol	Unit	Value
General			
Standards and Provisions			General requirements: EN 61800-2 EMC: EN 61800-3: Safety: EN 61800-5-1
Certifications and manufacturer's declarations on conformity			CE, UL, cUL
Production quality			RoHS, ISO 9001
Climate resistance	p_w	%	< 95 %, mean relative humidity (RH), non-condensing, non-corrosive, no dripping water (EN 61800-2)
Ambient temperature range			
Operation	ϑ	°C	-10 – +60 – depending on the cooling system
Storage	ϑ	°C	-40 - +60 (frost-free and condensation-free)
Vibration level (not evaluated during operation)			
Shock test			
Pulse shape			Half sine
Peak acceleration			15 g
Duration			11 ms
Vibration test			
Frequency range	f	Hz	10 - 150 10 - 57.55: 0.075 mm peak-peak shift 57.55 - 150: 1 g peak acceleration
Vibration measurement			1 octave/minute
Electrostatic discharge (ESD, EN 61000-4-2:2009	U	kV	±4, contact discharge ±8, air discharge
Fast transient burst (EFT/B, EN 61000-4-4: 2004)	U	kV	±1, at 5 kHz, control signal terminal ±2, at 5 kHz, motor connection terminals, Single-phase grid connection terminals

Technical data	Symbol	Unit	Value
Overvoltage (surge, EN 61000-4-5: 2006)			
(200 - 240) V	U	kV	±1, phase to phase/neutral conductor ±2, phase/neutral conductor to ground
(380 - 480) V	U	kV	±2, phase to phase ±2, phase to ground ±4, Fail Safe
Voltage stability (flash, EN 61800-5-1: 2007)			
(200 - 240) V	U	kV	1.5
(380 - 480) V	U	kV	2.5
Radio interference class (EMC)			
Maximum screened motor cable length with integrated radio interference suppression filter			
Category C1 (line-conducted)	l	m	1
Category C2	l	m	3
Category C3	l	m	10
Installation site			optional – depends on the cooling system
Altitude	h	m	0 - 1,000 above sea level, > 1,000 with 1 % load rating reduction every 100 m, max. 2,000
Level of protection			IP20 (NEMA 0)
protection from accidental contact			BGV A3 (VBG4, finger and back-of-hand proof)
Main circuit / power unit			
Feed			
Rated operational voltage			
DB1-12…	U_e	V	1~ 230 (200 V -10 % - 240 V +10 %)
DB1-34…	U_e	V	3~ 400 (380 V -10 % - 480 V +10 %)
Grid frequency	f	Hz	48 - 62
Phase imbalance		%	max. 3
Maximum short-circuit current (supply voltage)	SCCR	kA	100
Grid switch-on frequency			Maximum of one time every 30 seconds
Grid network configuration (AC supply system)			TN and TT network with directly grounded star point
Inrush current	I	A	$< I_{LN}$

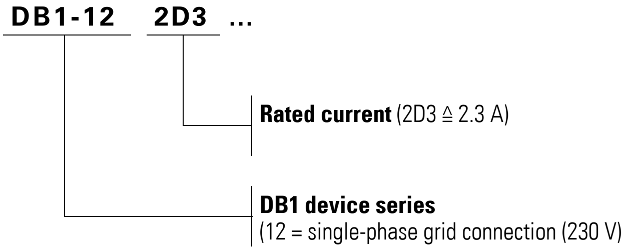
Technical data	Symbol	Unit	Value
Motor feeder			
Output voltage	U_2	V	3~ 0 - U_e
Assigned motor output			
at 230 V, 50 Hz	P	kW	0.37 - 1.5
at 400 V, 50 Hz	P	kW	0.75 - 4
Output frequency			
Range, parameterizable	f_2	Hz	0 - 5 x Motor Nom Frequency (P-09), max. 500 Hz
Resolution		Hz	0.1
Rated operational current	I_e	A	2.2 - 9.5
Overload current for 60 s every 600 s	I_L	%	150
Overload current for 3.75 s every 600 s	I_L	%	175
Switching frequency (double modulation)	f_{PWM}	kHz	max. 32
Operational mode			
Rpm control (speed accuracy)			±20%, with slip compensation
Vector control			±1% load range: 0 % - 100 %
Torque response time	t_r	ms	1 - 8
Torque linearity			±5 % (10 % - 90 % of rpm range, 20 - 100% of torque load range)
Response time (release IGBT)	t_r	ms	< 10
DC-braking			
Time before start	t	s	0 - 25, in the event of a stop
Motor pick-up control function			all frame sizes

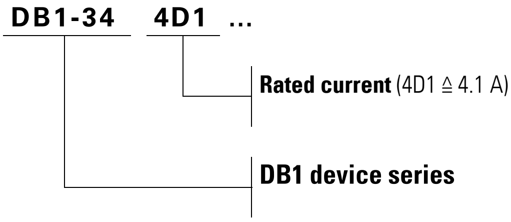
Technical data	Symbol	Unit	Value
Control section			
Control voltage			
Output voltage (control terminal 1)	U_C	V DC	24
Load rating (control terminal 1)	I_1	mA	100
Reference voltage (control terminal 5)	U_S	V DC	10
Load rating (control terminal 5)	I_5	mA	10
Digital input (DI)			
Quantity			2 - 4
Logic (level)			increase (NPN)
Reaction time	t_r	ms	< 8
Input voltage range High (1)	U_C	V DC	8 - 30
Input voltage range Low (0)	U_C	V DC	0 - 4
Analog Input (AI)			
Quantity			0 - 2
Resolution			12 Bit
Accuracy		%	< 1 full scale
Reaction time	t_r	ms	< 16
Input voltage range	U_S	V	0/-10 - +10, DC (R_i > 100 kΩ)
Input current range	I_S	mA	0/4 - 20 (R_{BB} ~ 500 Ω)
Relay output (RO1)			
Quantity			1 relay
Relay contact			Normally Open contact
Switching capacity			
AC	I	A	6 (250 V AC)
DC	I	A	5 (30 V AC)
Digital Output (DO)			
Quantity			0 - 1
Output voltage	U_{Out}	V	+24
Load rating (control terminal 8)	I_8	mA	20 max.
Analog Output (AO)			
Quantity			0 - 1
Output voltage (control terminal 8)	U_{Out}	V	0 - +10
Output current (control terminal 8)	I_8	mA	0 - 20, 4 - 20
Loading capacity (control terminal 8)	I_8	mA	20 max.
Resolution		Bit	10
Accuracy		%	< 1 to the end value
Interface (RJ45)			OP bus, Modbus RTU, CANopen, RS485
Response time (after valid command)	t_r	ms	< 8 (Modbus, CANopen) < 8 (OP bus: Master slave, 60 ms cycle)

5.2 Specific rated data

The following tables list the specific rated data for the individual DB1 series based on the corresponding rated current.

Examples





5.2.1 DB1-12… device series

Size	Symbol	Unit	2D3	4D3	7D0
Rated current	I_e	A	2.3	4.3	7.0
Overload current for 60 s every 600 s	I_L	A	3.45	6.45	10.5
Overload current for 3.75 s every 600 s	IL	A	4.03	7.53	12.25
Apparent power at rated operation 230 V	S	kVA	0.53	0.99	1.61
Apparent power at rated operation 240 V	S	kVA	0.55	1.03	1.68
Assigned motor rating					
at 230 V, 50 Hz	P	kW	0.37	0.75	1.5
at (220 - 240) V, 60 Hz	P	HP	0.5	1	2
Power side (primary side):					
Number of phases			single-phase or two-phase		
Rated voltage	U_{LN}	V	200 - 10 % - 240 + 10 %, 50/60 Hz 180 - 264 ±0%, 48 - 62 Hz ±0%		
Input current (phase current)	I_{LN}	A	3.7	7.5	14
Switching frequency (pulse frequency)					
Factory default setting	f_{PWM}	kHz	8	8	8
Adjustable range	f_{PWM}	kHz	4 - 32	4 - 32	4 - 32
Maximum leakage current (touch current) to ground (PE) at U_{LN}: 240 V, without motor	I_{Touch}	mA	< 3.5	< 3.5	< 3.5
Power loss (% n_N/% M_N)					
90 / 100 @ 4 kHz	P_L	W	–	57	113
90 / 100 @ 8 kHz	P_L	W	–	60	116
90 / 100 @ 12 kHz	P_L	W	–	47	119
90 / 100 @ 16 kHz	P_L	W	–	59	110
90 / 100 @ 24 kHz	P_L	W	–	59	115
90 / 100 @ 32 kHz	P_L	W	–	60	119
90 / 50 @ 8 kHz	P_L	W	–	32	74
50 / 100 @ 8 kHz	P_L	W	–	41	87
50 / 50 @ 8 kHz	P_L	W	–	23	56
50 / 25 @ 8 kHz	P_L	W	–	18	45
10 / 100 @ 8 kHz	P_L	W	–	27	95
10 / 50 @ 8 kHz	P_L	W	–	18	46
10 / 25 @ 8 kHz	P_L	W	–	13	50
in no-load state, (device not enabled)	P_L	W	5 W	5 W	5 W
Frame size			FS1	FS1	FS1B

5.2.2 DB1-34…device series

Size	Symbol	Unit	2D2	4D1	4D1	5D8	9D5
Rated current	I_e	A	2.2	4.1	4.1	5.8	9.5
Overload current for 60 s every 600 s	I_L	A	3.3	6.15	6.15	8.7	14.25
Overload current for 3.75 s every 600 s	I_L	A	3.85	7.18	7.18	10.15	16.63
Apparent power at rated operation 400 V	S	kVA	0.88	1.64	1.64	2.32	3.8
Apparent power at rated operation 480 V	S	kVA	1.06	1.97	1.97	2.78	4.56
Assigned motor rating							
at 400 V, 50 Hz	P	kW	0.75	1.5	1.5	2.2	4
at 480 V, 60 Hz	P	HP	1	2	2	3	8
Grid side (primary side):							
Number of phases			3	3	3	3	3
Rated voltage	U_{LN}	V	380 V - 10 % - 480 V + 10 %, 50/60 Hz 342 - 528 ±0%, (48 - 62) Hz ±0%				
Input current (phase current)	I_{LN}	A	3.5	5.6	5.6	7.5	10.2
Switching frequency (pulse frequency)							
Factory default setting	f_{PWM}	kHz	8	8	8	8	8
Adjustable range	f_{PWM}	kHz	4 - 32	4 - 32	4 - 32	4 - 32	4 - 32
Maximum leakage current to ground (touch current), at U_{LN}: 400 V, without motor	I_{Touch}	mA	< 3.5	< 3.5	< 3.5	< 3.5	< 3.5
Loss of performance (% n_N/% M_N)							
90 / 100 @ 4 kHz	P_V	W	–	46	48	75	128
90 / 100 @ 8 kHz	P_L	W	–	53	57	82	148
90 / 100 @ 12 kHz	P_L	W	–	63	69	99	169
90 / 100 @ 16 kHz	P_L	W	–	59	78	115	191
90 / 100 @ 24 kHz	P_L	W	–	69	99	143	244
90 / 100 @ 32 kHz	P_L	W	–	80	–	–	–
90 / 50 @ 8 kHz	P_L	W	–	36	38	62	94
50 / 100 @ 8 kHz	P_L	W	–	50	51	72	126
50 / 50 @ 8 kHz	P_L	W	–	35	37	55	84
50 / 25 @ 8 kHz	P_L	W	–	29	–	45	67
10 / 100 @ 8 kHz	P_L	W	–		47	62	108
10 / 50 @ 8 kHz	P_L	W	–	30	37	54	75
10 / 25 @ 8 kHz	P_L	W	–	27	–	40	61
during no-load state, (device not enabled)	P_L	W	6	6	6	6	6
Frame size			FS1	FS1	FS2	FS2	FS2

5.3 Dimensions and frame size

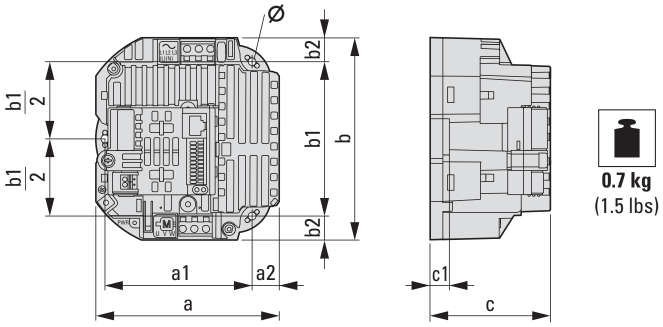


Figure 37: Dimensions

Table 12: Dimensions and weights

Frame size	a mm (in)	a1 mm (in)	a2 mm (in)	b mm (in)	b1 mm (in)	b2 mm (in)	c mm (in)	c1 mm (in)	Ø mm (in)	m kg (lbs)
FS1	118 (4.65)	95 (3.74)	18 (0.71)	130 (5.12)	99 (3.90)	15 (0.59)	74 (2.91)	12 (0.47)	5 (0.20)	0.7 (1.5)
FS1B	118 (4.65)	95 (3.74)	18 (0.71)	130 (5.12)	99 (3.90)	15 (0.59)	85 (3.35)	12 (0.47)	5 (0.20)	0.9 (2.0)
FS2	144 (5.67)	125 (4.92)	12.4 (0.49)	183 (7.6)	159 (6.26)	17 (0.67)	90 (3.54)	8.6 (0.34)	7 (0.28)	1.15 (2.2)

1 in = 1’’ = 25.4 mm, 1 mm = 0.0394 in

5.4 Fuses

The Eaton circuit-breakers and fuses listed below are examples and can be used without additional measures. If you use other circuit-breakers and fuses, make sure to take their protective characteristics and operational voltage into account. When using other circuit-breakers, it may be necessary to also use fuses depending on the circuit-breaker’s model, design, and settings. There may also be limitations concerning the short-circuit capacity and the supply grid's characteristic, and these must also be taken into account when selecting circuit-breakers and/or fuses.

Table 13: Safety features

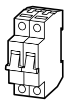
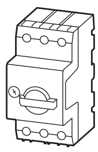
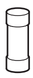
	Symbol	Description
①		**Circuit-breaker** FAZ-B…/1N: 1 pole + N FAZ-B…/2: 2 pole FAZ-B…/3: 3 pole Rated operating voltage: 230/400 V AC Switching capacity: 15 kA
②		**Motor protection switch** PKM0…, PKZM4…: 3 pole Rated operating voltage: 690 V AC Switching capacity: • PKM0: 150 kA to 12 A and 50 kA to 32 A • PKZM4: 50 kA
③		**Fuse** Rated operating voltage: 500 V AC Switching capacity: 50 kA Frame size: DII, E27 / DIII, E33 Fuse base: S27, S33
④		**Fuse Class J** Rated operating voltage: 600 V AC Switching capacity: 300 kA Fuse Bases: • up to 30 A: J60030… • 35 - 60 A: J60060… • 70 - 100 A: JM60100…

Table 14: Specified fuses

Device Type	Input current	Fuse or miniature circuit-breaker					
	I_{LN}	IEC (Type B or gG)				UL (Class CC or J) 1)	
	A	A	Eaton type			A	Eaton type
Voltage class 230 V **Grid voltage (50/60 Hz) U_{LN} 200 (-10%) – 240 (+10%) V** **U_e 230 V AC, single-phase / U_2 230 V AC, three-phase**							
			①	①, 2-phase	④		⑤
DB1-122D3…	3.7	10	FAZ-B10/1N	FAZ-B10/2	10D27	6	LPJ-6SP
DB1-124D3…	7.5	10	FAZ-B10/1N	FAZ-B10/2	10D27	10	LPJ-10SP
DB1-127D0…	14	20	FAZ-B20/1N	FAZ-B20/2	20D27	20	LPJ-20SP
Voltage class 400 V **grid voltage (50/60 Hz) U_{LN} 380 (-10%) – 480 (+10%) V** **U_e 400 V AC, three-phase / U_2 400 V AC, three-phase**							
			①	②	③		④
DB1-342D2…	3.5	6	FAZ-B6/3	PKM0-6.3	6D27	6	LPJ-6SP
DB1-344D1…	5.6	10	FAZ-B10/3	PKM0-10	10D27	10	LPJ-10SP
DB1-345D8…	7.5	16	FAZ-B16/3	PKM0-16	16D27	10	LPJ-10SP
DB1-349D5…	10.2	16	FAZ-B16/3	PKM0-16	16D27	15	LPJ-15SP

1) Maximum short-circuit current of the supply grid: 100 kA RMS

5.5 Grid contactors

→ The grid contactors listed here are based on the variable frequency drive's rated input-side grid current I_{LN} without an external mains choke.
These are selected based on thermal current $I_{th} = I_e$ (AC-1) at the indicated ambient temperature.

WARNING
Inching operation is not permissible via the grid contactor.
(Pause time ≧ 30 s between switching off and on).

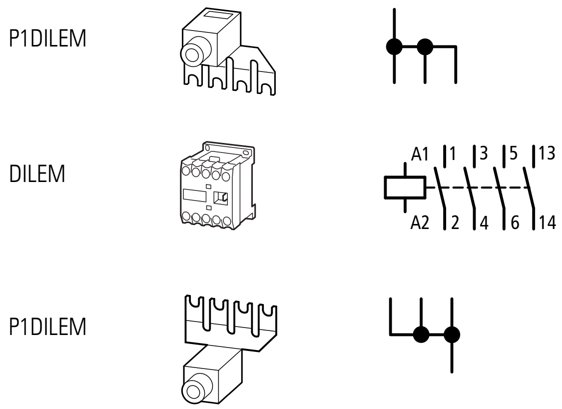
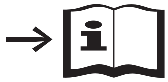


Figure 38: Grid contactor with single-phase connection (DB1-12…)

Table 15: Grid contactors

Device Type	Input current	Grid contactor (thermal current AC-1)			
	I_{LN} A	Type (max. 50 °C and IEC)	I_{th} A	Type (max. 40 °C and UL)	I_{th} A
Voltage class 230 V grid voltage (50/60 Hz) U_{LN} 200 (-10%) – 240 (+10%) V U_e 230 V AC, single-phase / U_2 230 V AC, three-phase					
DB1-122D3…	3.7	DILEM-…+P1DILEM	50	DILEM-…+P1DILEM	50
DB1-124D3…	7.5	DILEM-…+P1DILEM	50	DILEM-…+P1DILEM	50
DB1-127D0…	14	DILEM-…+P1DILEM	50	DILEM-…+P1DILEM	50
Voltage class 400 V grid voltage (50/60 Hz) U_{LN} 380 (-10%) – 480 (+10%) V U_e 400 V AC, three-phase / U_2 400 V AC, three-phase					
DB1-342D2…	3.5	DILEM-…	20	DILEM-…	20
DB1-344D1…	5.6	DILEM-…	20	DILEM-…	20
DB1-345D8…	7.5	DILEM-…	20	DILEM-…	20
DB1-349D5…	10.2	DILEM-…	20	DILEM-…	20

5.6 Mains chokes



For more information and technical data on DX-LN… mains chokes, please refer to installation leaflet IL00906003Z.

DX-LN1…

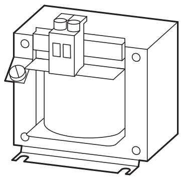


Figure 39: DEX-LN1… mains chokes (single-phase)

Table 16: Assigned mains chokes (single-phase)

Device Type	Input current	Mains choke, single-phase (U_{LN} max. 260 V +10%, 50/60 Hz ±10%)			
	I_{LN}	Type	I_e	Type	I_e
	A	(max. 50 °C)	A	(max. 40 °C)	A
Voltage class 230 V grid voltage (50/60 Hz) U_{LN} 200 (-10%) – 240 (+10%) V U_e 230 V AC, single-phase / U_2 230 V AC, three-phase					
DB1-122D3…	3.7	DX-LN1-006	5.5	DX-LN1-006	6
DB1-124D3…	7.5	DX-LN1-009	8.1	DX-LN1-009	9
DB1-127D0…	14	DX-LN1-018	16.4	DX-LN1-018	18

DX-LN3…

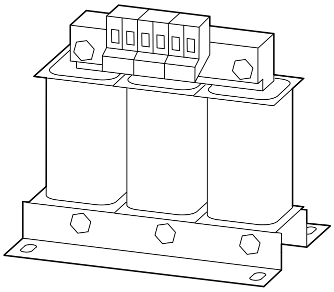


Figure 40: Mains chokes DEX-LN3… (three-phase)

Table 17: Assigned Mains chokes (three-phase)

Device Type	Input current	Mains choke, three-phase (U_{LN} max. 500 V +10%, 50/60 Hz ±10%)			
	I_{LN}	Type	I_e		I_e
	A	max. 50 °C	A		A
Voltage class 400 V grid voltage (50/60 Hz) U_{LN} 380 (-10%) – 480 (+10%) V U_e 400 V AC, three-phase / U_2 400 V AC, three-phase					
DB1-342D2…	3.5	DX-LN3-004	3.7	DX-LN3-004	4
DB1-344D1…	5.6	DX-LN3-006	5.7	DX-LN3-006	6
DB1-345D8…	7.5	DX-LN3-010	9.5	DX-LN3-010	10
DB1-349D5…	10.2	DX-LN3-016	15.2	DX-LN3-016	16

5.7 Brake resistors

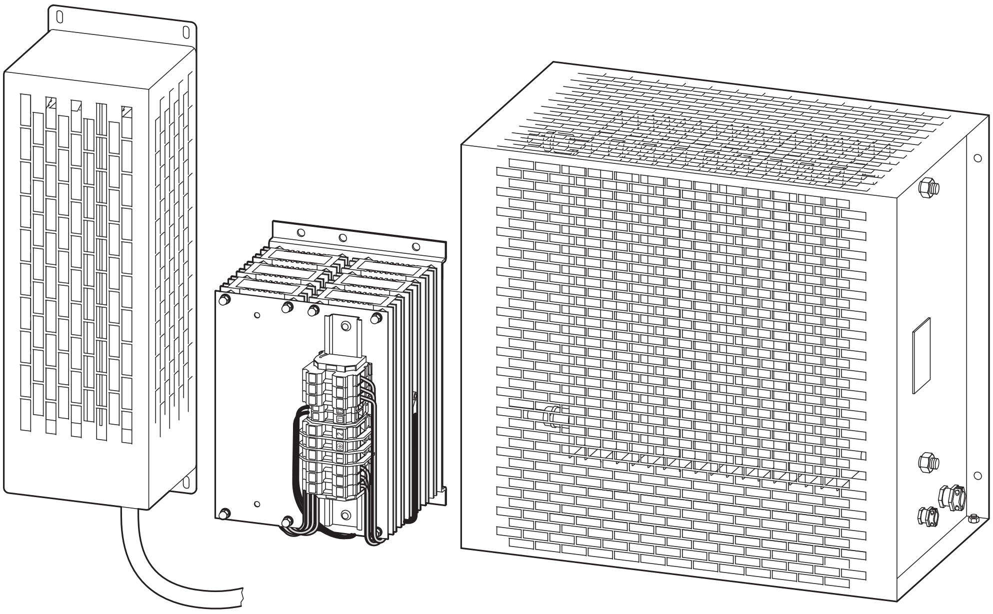


Figure 41: Examples of DX-BR… brake resistor designs

> *WARNING*
> You must never go below the specified minimum resistance R_{Bmin}.

> **CAUTION**
> Brake resistors get extremely hot during operation!

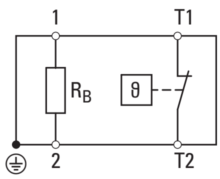
The following tables provide examples of DX-BR… series brake resistors rated for individual DB1-34… variable frequency drives with frame size FS2. They are specified according to the “High duty” and “Low duty” classification, for intermittent braking, with a cycle time t_C of 120 seconds, corresponding to a pulse power P_{Peak}, which corresponds to the maximum braking output P_{max} of the variable frequency drive with the rated motor output.

Load groups (simplified classification)

- **Low duty**: Low load with short braking duration and low duty factor (up to about 25 %), for, e.g. horizontal conveyors and handling equipment for bulk cargo and general cargo, crane trolleys, sliding doors, and continuous flow machinery (centrifugal pumps, fans).
- **High duty**: High load with long braking time and high duty factor (at least 30 %), e.g., for elevators, downhill conveyors, winders, centrifuges, flywheel motors, and large fans.

→ All brake resistors feature a temperature switch for protection against thermal overload.

This dry contact (N/C) can be directly integrated into the DB1 variable frequency drive's control section and work as an external error message (DI3, parameter P15 = 3, 6, 7, 13).



→ For more information and technical data on the DX-BR… series brake resistors listed here, please refer to the corresponding instruction leaflet for the individual models: IL04012024Z, IL04011ZU, IL04014ZU, IL04015ZU and IL04021ZU.

Table 18: Braking resistance – DB1 voltage class 400 V

Device Type	Frame size	Resistance value			Braking resistance (Low duty)					Braking resistance (High duty)				
					Type					Type				
		R_{Bmin}	R_{Brec}	P_{max}		R_{Brec}	P_{max}	ED	t_{Bresis}		R_{Brec}	P_{max}	ED	t_{Bresis}
		Ω	Ω	kW		Ω	kW	%	s		Ω	kW	%	s
Voltage class 400 V grid voltage (50/60 Hz) U_{LN} 380 (-10%) – 480 (+10%) V U_e 400 V AC, three-phase / U_2 400 V AC, three-phase														
DB1-344D1FB-N2CC	FS2	100	250	1.5	DX-BR210-200	210	0.2	13	16	DX-BR100-600	100	0.6	40	48
DB1-34508FB-N2CC	FS2	100	175	2.2	DX-BR200-0K4	200	0.4	18	22	DX-BR050-720	50	0.72	33	39
DB1-349D5FB-N2CC	FS2	100	100	4	DX-BR150-0K5	150	0.5	13	15	DX-BR025-1440	25	1.44	36	43

Resistance values:

R_{Bmin} = minimum acceptable resistance value;
R_{Brec} = recommended resistance value
P_{max} = rated power for Low duty and High duty classifications

6 Accessories

Table 19: PowerXL accessories

Type	Description	Document
DX-KEY-LED2 DX-KEY-OLED	External control unit	AP040022, IL04012020Z
DX-COM-STICK3-KIT	Parameter copying stick for establishing a Bluetooth connection to PC software, smartphone app	MN040003, IL040051ZU
DX-CBL-PC-3M0	Wired communication between variable frequency drive and PC	MN040003 IL040025ZU
DX-SPL-R145-2SL1PL	RJ45, 8-pin, splitter, 2 sockets, 1 plug on short connection cable	IL04012023Z
DX-SPL-RJ45-3SL	RJ45, 8-pin, splitter, 3 sockets	IL04012023Z
drivesConnect	PC parameter configuration software for variable frequency drive with integrated oscilloscope function	MN040003

AP = Application Note
MN = Manual
IL = Instruction Leaflet

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