Hardware and Engineering

DF5-...
Frequency Inverters

05/04 AWB8230-1412GB

Think future. Switch to green.

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Warning!
Dangerous electrical voltage!

Before commencing the installation

- Disconnect the power supply of the device.
- Ensure that devices cannot be accidentally restarted.
- Verify isolation from the supply.
- Earth and short circuit the device.
- Cover or enclose any adjacent live components.
- Follow the engineering instructions (AWA) for the device concerned.
- Only suitably qualified personnel in accordance with EN 50110-1/-2 (VDE 0105 Part 100) may work on this device/system.
- Before installation and before touching the device ensure that you are free of electrostatic charge.
- The functional earth (FE) must be connected to the protective earth (PE) or the potential equalisation. The system installer is responsible for implementing this connection.
- Connecting cables and signal lines should be installed so that inductive or capacitive interference does not impair the automation functions.
- Install automation devices and related operating elements in such a way that they are well protected against unintentional operation.
- Suitable safety hardware and software measures should be implemented for the I/O interface so that an open circuit on the signal side does not result in undefined states in the automation devices.
- Ensure a reliable electrical isolation of the extra-low voltage of the 24 V supply. Only use power supply units complying with IEC 60364-4-41 (VDE 0100 Part 410) or HD384.4.41 S2.
- Deviations of the mains voltage from the rated value must not exceed the tolerance limits given in the specifications, otherwise this may cause malfunction and dangerous operation.
- Emergency stop devices complying with IEC/EN 60204-1 must be effective in all operating modes of the automation devices. Unlatching the emergency-stop devices must not cause a restart.
- Devices that are designed for mounting in housings or control cabinets must only be operated and controlled after they have been installed and with the housing closed. Desktop or portable units must only be operated and controlled in enclosed housings.
- Measures should be taken to ensure the proper restart of programs interrupted after a voltage dip or failure. This should not cause dangerous operating states even for a short time. If necessary, emergency-stop devices should be implemented.
- Wherever faults in the automation system may cause injury or material damage, external measures must be implemented to ensure a safe operating state in the event of a fault or malfunction (for example, by means of separate limit switches, mechanical interlocks etc.).
- Depending on their degree of protection, frequency inverters may contain live bright metal parts, moving or rotating components or hot surfaces during and immediately after operation.
- Removal of the required covers, improper installation or incorrect operation of motor or frequency inverter may cause the failure of the device and may lead to serious injury or damage.
- The applicable national accident prevention and safety regulations apply to all work carried on live frequency inverters.
- The electrical installation must be carried out in accordance with the relevant regulations (e. g. with regard to cable cross sections, fuses, PE).
- Transport, installation, commissioning and maintenance work must be carried out only by qualified personnel (IEC 60364, HD 384 and national occupational safety regulations).
- Installations containing frequency inverters must be provided with additional monitoring and protective devices in accordance with the applicable safety regulations. Modifications to the frequency inverters using the operating software are permitted.

- All covers and doors must be kept closed during operation.
- To reduce the hazards for people or equipment, the user must include in the machine design measures that restrict the consequences of a malfunction or failure of the drive (increased motor speed or sudden standstill of motor). These measures include:
  - Other independent devices for monitoring safety-related variables (speed, travel, end positions etc.).
  - Electrical or non-electrical system-wide measures (electrical or mechanical interlocks).
  - Never touch live parts or cable connections of the frequency inverter after it has been disconnected from the power supply. Due to the charge in the capacitors, these parts may still be live after disconnection. Fit appropriate warning signs.

Content

About this Manual

This manual describes the DF5 series frequency inverters.

This manual contains the information you need to install, configure and operate the DF5 frequency inverters. It provides a detailed description of the DF5's features, parameters and functions, with examples for the most important applications. All information applies to the specified hardware and software versions.

Abbreviations and symbols

The following abbreviations and symbols are used in this manual:

DS	**D**efault **s**etting
EMC	**E**lectro **M**agnetic **C**ompatibility
ESD	**E**lectro**s**tatic **D**ischarge
HF	**H**igh **F**requency
IGBT	**I**nsulated **G**ate **B**ipolar **T**ransistor
PES	**P**ositive **E**arth connection of the cable screen
PNU	**P**arameter **nu**mber
RFI	**R**adio-**F**requency **I**nterference

All measurements are in millimetres unless otherwise stated.

In some of the illustrations, the enclosure of the frequency inverter and other components affecting equipment safety have been omitted for improved clarity. In practice, the frequency inverter must always be operated with the enclosure and all necessary components that affect equipment safety correctly fitted.

Read the manual thoroughly before you install and operate the frequency inverter. We assume that you have a good knowledge of engineering fundamentals and that you are familiar with electrical systems and the applicable principles and are able to read, interpret and apply the information contained in technical drawings.

▶ Indicates instructions to be followed

→ Indicates useful tips and additional information

Caution!
Warns of the possibility of minor material damage.

Warning!
Warns of the possibility of major material damage and minor injury.

Warning!
Warns of the possibility of major material damage and serious or fatal injury.

To improve legibility, the title of the current section is given at the top of each left-hand page and the current subsection at the top of each right-hand page, except on the title page of each section and the blank pages at the end of each section.

Document changes

Publication date	Page	Keyword	New	Change	Omitted
05/04	104	No-load current replaced by load current		✓	
03/04	All	Three-phase 230 V DF5-320 series added	✓		
	11	Block diagram	✓		
	121	New DEX mains chokes		✓	
	from 126	Default settings for the USA	✓		
12/01	All	(Applies only to German version of manual)		✓	
	45	Change over control mode from control signal terminals (default) to keypad	✓		
	49	Connection examples moved from appendix to section "Using the DF5"		✓	
	104	Magnetization current setting range		✓	
	from 126	Page numbers included in "User-defined parameters"	✓		
03/02	28	Terminal designations Fig. 19		✓	
	from 126	Value range	✓		

1 About the DF5 frequency inverters

System overview

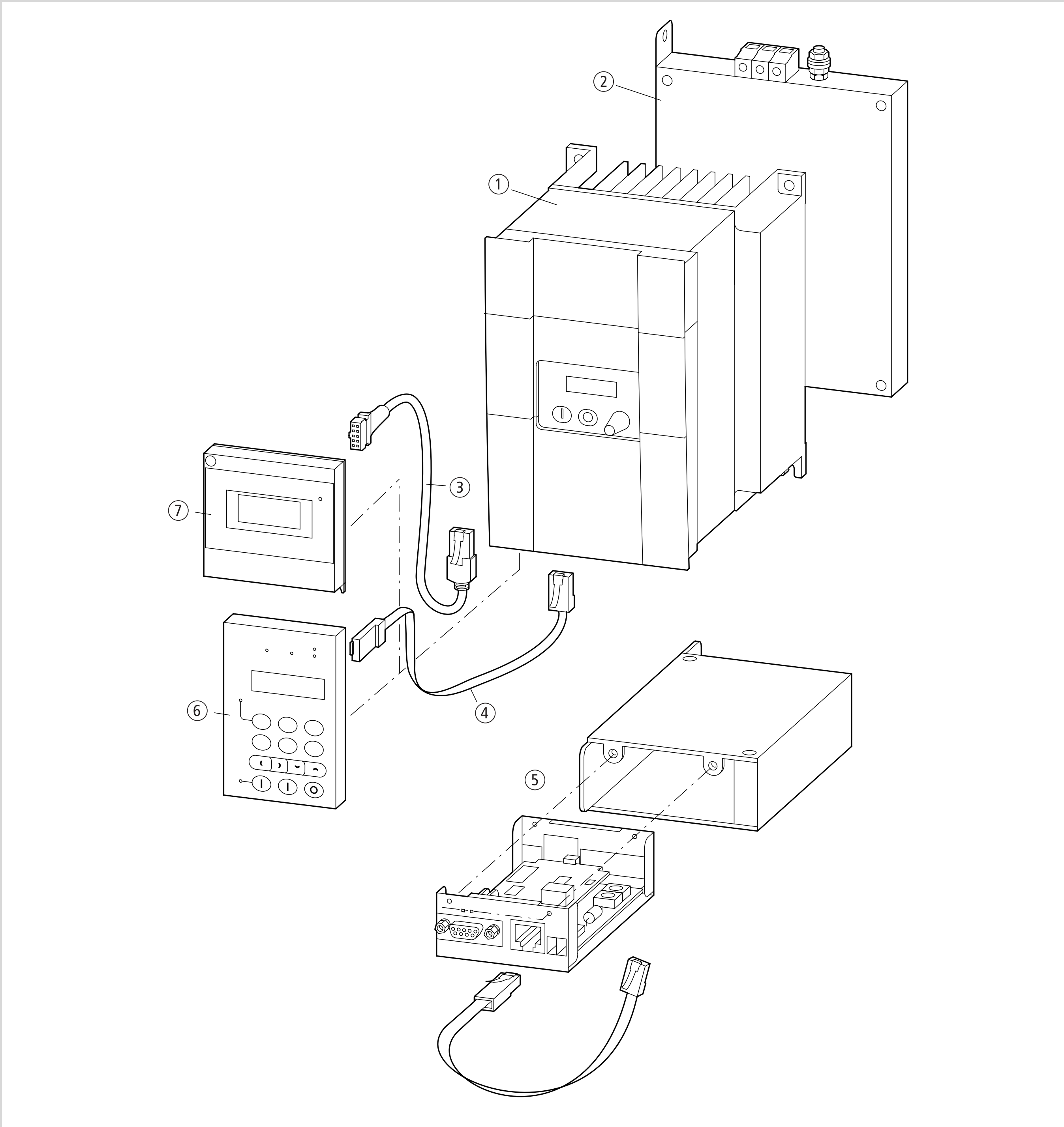


Figure 1: System overview

① DF5-... frequency inverters
② DE5-LZ... RFI filters
③ DE5-CBL-…-ICL connection cables
④ DEX-CBL-...-ICS connection cables
⑤ DE5-NET-DP and DE5-MNT-BX interface module for PROFIBUS DP
⑥ DEX-DEY-10 external keypad
⑦ DE5-KEY-RO3 external display module

Type code

Key to type references and type designation of the DF5 series frequency inverters:

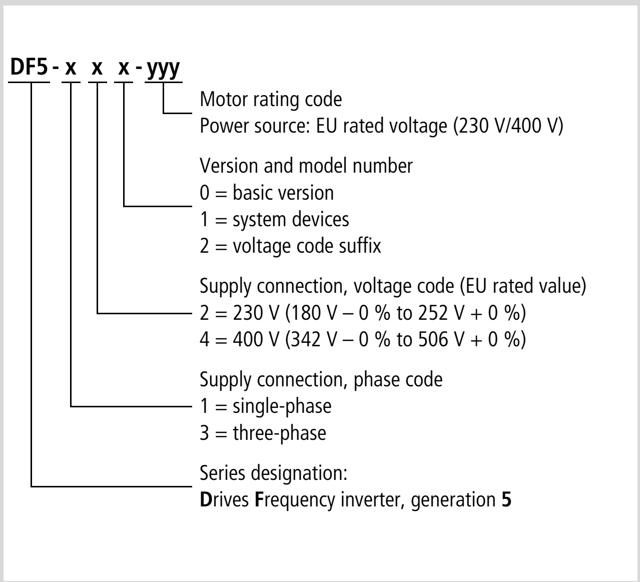


Figure 2: Type codes of the DF5 frequency inverters

Examples:

DF5-320-4K0	The DF5 frequency inverters
	Three-phase mains supply voltage: 230 V
	Assigned motor rating: 4 kW at 230 V
DF5-322-075	The DF5 frequency inverters
	Single-phase or three-phase supply: 230 V
	Assigned motor rating: 0.75 kW at 230 V
DF5-340-5K5	The DF5 frequency inverters
	Three-phase mains supply voltage: 400 V
	Assigned motor rating: 5.5 kW at 400 V

Inspecting the package content

The DF5 series frequency inverters are carefully packaged and prepared for delivery. The device may be transported only in its original packaging with a suitable transport system (see weight details). Observe the instructions and the warnings on the side of the packaging. This also applies after the device has been removed from its packaging.

Open the packaging with suitable tools and inspect the contents immediately on delivery to ensure that they are complete and undamaged. The package should contain the following items:

- One DF5 frequency inverter,
- Installation instructions AWA8230-1935,
- A CD containing:
  - This manual in PDF format and copies in other languages;
  - The parameterization software. Hardware requirements: PC with Windows (98, ME, NT, 2000 or XP) and the DEX-CBL-2M0-PC connecting cable

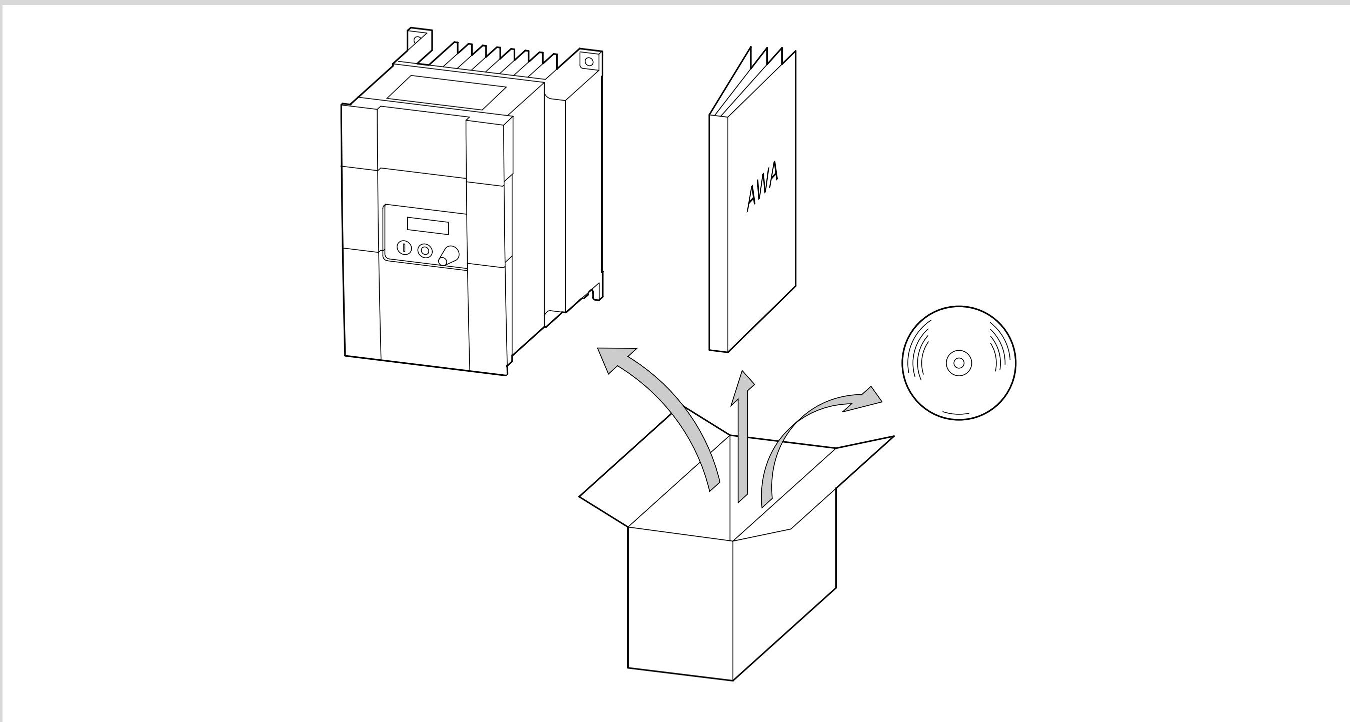


Figure 3: Package content

→ On the nameplate attached to the frequency inverter, check to ensure that the frequency inverter is the type you have ordered.

Layout of the DF5

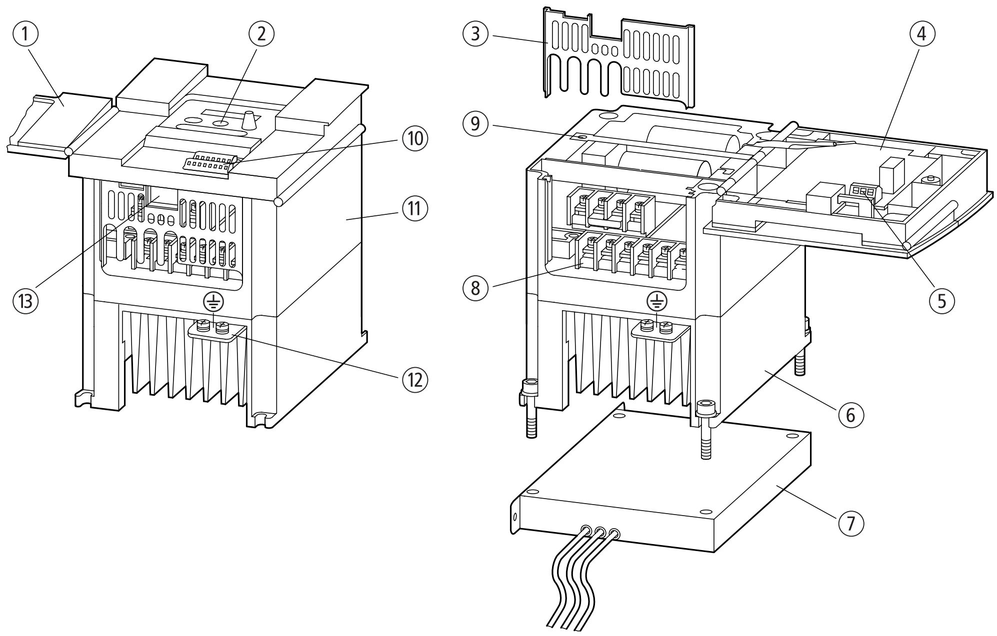


Figure 4: Physical features of the DF5

① Front cover, can be opened without tools
② Built-in keypad
③ Terminal shroud
④ Front cover flap with keypad
⑤ Signalling relay terminals
⑥ Heat sink
⑦ Optional radio interference filter
⑧ Power terminals
⑨ Screw for opening the front enclosure
⑩ Control signal terminals
⑪ Enclosure
⑫ Earth connection (PE)
⑬ Interface connection

Block diagram

The following block diagram shows all terminals of the DF5.

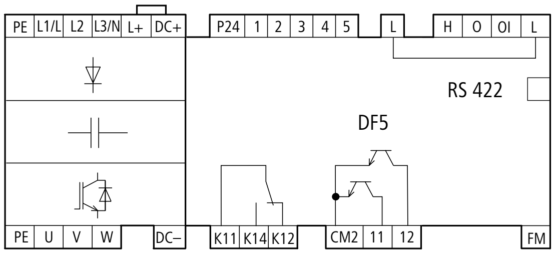


Figure 5: Block diagram of the DF5

Power terminals

L, L1, L2, L3, N Supply (mains) voltage
U, V, W Frequency inverter output
L+, DC+ External DC choke
DC+, DC– Internal DC link
⏚, PE Positive earth

Control signal terminals

P24 Control voltage output, +24 V
1 Digital input
2 Digital input
3 Digital input
4 Digital input
5 Digital input
L Common 0 V reference potential
H Reference voltage output, +10 V
O Analog input, 0 to +10 V
OI Analog input, 4 to 20 mA
L Common 0 V reference potential
FM Analog output, 0 to 10 V
K11 Signalling relay terminal
K12 Signalling relay terminal
K14 Signalling relay terminal
CM2 Externe control voltage input, max. 27 V
12 Transistor output, max. 27 V
11 Transistor output, max. 27 V
RS 422 Interface connection for expansion

Features of the frequency inverters

The DF5 frequency inverters convert the voltage and frequency of an existing three-phase supply to a DC voltage and use this voltage to generate a three-phase supply with adjustable voltage and frequency. This variable three-phase supply allows infinitely adjustable speed control of three-phase asynchronous motors.

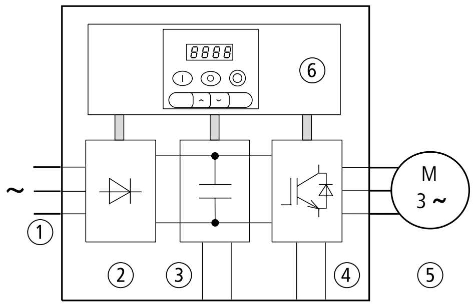


Figure 6: Function chart of the frequency inverter

① Supply via an interference suppressor
Mains voltage U_{LN} (EU rated voltage):
DF5-320 3 AC 230 V, 50/60 Hz
DF5-322 1/3 AC 230 V, 50/60 Hz
DF5-340 3 AC 400 V, 50/60 Hz

② The bridge rectifier converts the AC voltage of the electrical supply to a DC voltage.

③ The DC link contains a charging resistor, smoothing capacitor and switched-mode power supply unit. It enables coupling of the DC bus voltage and the DC current supply:
DC bus voltage (U_{ZK}) = $\sqrt{2} \times$ mains voltage (U_{LN})

④ IGBT power inverter:
The power inverter converts the DC voltage of the internal DC link to a variable three-phase alternating voltage with variable frequency.

⑤ Output voltage (U_2), motor connection:
three-phase, variable AC voltage, 0 to 100 % of the input voltage (U_{LN})
Output frequency (f_2):
variable frequency, 0.5 to 360 Hz
Rated output current (I_{2N}):
1.8 to 22.5 A with about 1.5 times starting current for 60 s, at an operating frequency of 5 kHz and an ambient temperature of 40 °C
Motor connection, assigned shaft power (P_2):
0.18 to 7.5 kW at 230 V
0.37 to 7.5 kW at 400 V

⑥ Programmable control section with keypad and interface

Selection criteria

Select a suitable frequency inverter according to the rated motor current. The rated output current of the frequency inverter must be greater than or equal to the rated current of the motor.

The following drive data is assumed to be known:

- Type of motor (three-phase asynchronous)
- Mains voltage = motor supply voltage (e.g. 3 ~ 400 V)
- Rated motor current (guide value, dependent on the circuit type and the supply voltage)
- Load torque (square-law, constant, with 1.5 times the starting torque)
- Ambient temperature (maximum temperature 40 °C).

→ If several motors are connected in parallel to the output of a frequency inverter, the motor currents are geometrically added, i.e. separately by active and reactive current components. When you select a frequency inverter, make sure that it can supply the total resulting current.

→ If you connect a motor to an operational frequency inverter, the motor draws a multiple of its rated current. When you select a frequency inverter, make sure that the starting current plus the sum of the currents of the running motors will not exceed the rated output current of the frequency inverter.

The rated output current of the frequency inverter can be found in the technical data in the appendix from page 113

Intended use

The DF5 frequency inverters are not domestic appliances. They are designed only for industrial use as system components.

The DF5 frequency inverters are electrical apparatus for controlling variable speed drives with three-phase motors. They are designed for installation in machines or for use in combination with other components within a machine or system.

After installation in a machine, the frequency inverters must not be taken into operation until the associated machine has been confirmed to comply with the safety requirements of Machinery Safety Directive (MSD) 89/392/EEC and meets the requirements of EN 60204. The owner/operator of the equipment is responsible for ensuring that the machine is used in compliance with the relevant EU Directives.

The CE markings on the DF5 frequency inverter confirm that, when used in a typical drive configuration, the apparatus complies with the European Low Voltage Directive (LVD) and the EMC Directives (Directive 73/23/EEC, as amended by 93/68/EEC and Directive 89/336/EEC, as amended by 93/68/EEC).

In the described system configurations, DF5 frequency inverters are suitable for use in public and non-public networks. Depending on their location of use, external filtering may be necessary.

A connection to IT networks (networks without reference to earth potential) is permissible only to a limited extent, since the device's built-in filter capacitors connect the network with the earth potential (enclosure). On earth free networks, this can lead to dangerous situations or damage the device (isolation monitoring is required).

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

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

Observe the technical data and terminal requirements. For additional information, refer to the equipment nameplate or label and the documentation.

Any other usage constitutes improper use.

Service and warranty

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

Please have the following data and information about your frequency inverter to hand:

- Exact frequency inverter type designation (→ nameplate)
- Date of purchase
- Detailed description of the problem which has occurred with the frequency inverter

If some of the information printed on the nameplate is not legible, please state only the information which is clearly legible.

Information concerning the guarantee can be found in the Moeller General Terms and Conditions of Sale.

2 Engineering

This section describes the "Performance features of the DF5" and the requirements and directives covering the following issues:

- Connection to the power supply
- EMC Directives

Performance features of the DF5

Ambient temperatures	
Operation[1)]	T_a = –10 to +40 °C with rated current I_e without derating, up to +50 °C with reduced carrier frequency of 2 kHz and reduced output current to 80 % I_e
Storage	T_a = –25 to +70 °C
Transport	T_a = –25 to +70 °C
Permissible environmental conditions	
Resistance to vibration	Impacts and vibration: Up to 5.9 m/s^2 (0.6 g) at 10 to 55 Hz
Degree of pollution	VDE 0110 Part 2, pollution degree 2
Packaging	Dustproof packaging (DIN 4180)
Climatic conditions	Class 3K3 according to EN 50178 (non-condensing, average relative humidity 20 to 90 %)
Installation altitude	Up to 1 000 m above sea level
Mounting position	Vertically suspended
Free surrounding areas	100 mm above and below device
Electrical data	
Emitted interference	IEC/EN 61800-3 (EN 55011 group 1, class B)
Noise immunity	IEC/EN 61800-3, industrial environment
Insulation resistance	Overvoltage category III according to VDE 0110
Leakage current to PE	Greater than 3.5 mA according to EN 50178
Degree of protection	IP 20
Protection against direct contact	Finger and back-of-hand proof (VBG 4)
Protective isolation against switching circuitry	Safe isolation from the mains. Double basic isolation according to EN 50178
Protective measures	Overcurrent, earth fault (at power-up), overvoltage, undervoltage, overload, overtemperature, electronic motor protection: I^2t monitoring and PTC input (thermistor or temperature contacts)
Open-/closed-loop control	
Modulation method	Pulse width modulation (PWM), *U/f* characteristics control (linear, square-law)
Switching frequency	5 kHz (default), can be changed between 0.5 and 16 kHz
Torque	At startup, 1.5 × M_N for 60 s at assigned motor rating, every 600 s
Output frequency	
Range	0.5 to 360 Hz
Frequency resolution	0.1 Hz, at digital setpoint, maximum frequency/1 000 with analog setpoint value
Error limit at 25 °C ±10 °C	Digital setpoint definition ±0.01 % of the maximum frequency
	Analog setpoint definition ±0.2 % of the maximum frequency
Relay	
Changeover contact	• 250 V AC, 2.5 A (resistive load) • 250 V AC, 0.2 A (inductive load, p.f. = 0.4) • 100 V AC, minimum 10 mA
	• 30 V DC, 3 A (resistive load) • 30 V DC, 0.7 A (inductive load, p.f. = 0.4) • 5 V DC, minimum 100 mA

Internal voltages	
Control	24 V DC, maximum 30 mA
Setpoint definition	10 V DC, maximum 10 mA
Analog and digital actuation	
Analog inputs	• 1 input, 0 to 10 V, input impedance 10 kO • 1 input, 4 to 20 mA, load impedance 250 Ω
Digital inputs/outputs	5 inputs, user-configurable
	2 outputs, open collector (up to 27 V DC, 50 mA)
Monitor output	1 output for motor frequency or current, 10 V, up to 1 mA
Keypad (built-in)	
Operation	6 function keys for controlling and parameterizing the DF5
Display	Four-digit 7-segment display and seven LEDs (for status signals)
Potentiometer	Setpoint definition (0 to 270°)

1) If the frequency inverter is to be installed in a control panel, enclosure or similar installation, the temperature within the enclosure or control panel is considered to be ambient temperature T_a. The use of fans should be considered to ensure that the ambient temperature remains within permissible limits.

Connection to the power supply

The DF5 frequency inverters can not be used in every network configuration without limitations (network configuration according to IEC 364-3).

Mains configurations

Networks with earthed centre point (TT/TN networks):

- DF5 frequency inverters can be used without limitations in TT and TN networks. The ratings of the DF5 frequency inverters must, however, be observed.

→ If many frequency inverters with a single-phase supply are connected to the same supply network, they should be distributed symmetrically over all three phases and the load placed on the common neutral connection (mains r.m.s. current) must be taken into account. If the N-conductor carries the total current of all single-phase devices, its cross-section may have to be increased.

Networks with isolated centre point (IT networks):

- The use of DF5 frequency inverters in IT networks is only permissible to a limited extent. In this case, a suitable device (isolation monitor) to monitor earth faults and isolates the frequency inverter from the mains must be used.

▽ **Caution!**
In the event of an earth fault in an IT system, the capacitors of the frequency inverter which are switched to earth are subjected to a very high voltage, and safe operation of the frequency inverter is no longer guaranteed. To overcome this problem,fit additional isolating transformer to the frequency inverter's supply and earth the transformer's secondary side at its centre point to form, in effect, an individual TN network for the frequency inverter.

Mains voltage, mains frequency

The ratings of the DF5 frequency inverters cover European and American standard voltages:

- 230 V, 50 Hz (EU) and 240 V, 60 Hz (USA) for DF5-320 and DF5-322,
- 400 V, 50 Hz (EU) and 460 V, 60 Hz (USA) for DF5-340

The permissible mains voltage range is:

- 230/240 V: 180 V – 0 % to 252 V + 0 %
- 380/460 V: 342 V – 0 % to 506 V + 0 %

The permissible frequency range is 47 Hz –0 % to 63 Hz +0 %.

The motor rating to mains voltage assignments are listed in the appendix, section "Technical data", page 113.

Interaction with p.f. correction equipment

The DF5 frequency inverters absorb only a small fundamental reactive power from the AC supply. Compensation is therefore unnecessary.

> **Caution!**
> Operation of DF5 series frequency inverters on the mains with p.f. correction equipment is only permitted when this equipment is dampened with chokes.

Fuses and cable cross-sections

The fuse ratings and cable cross-sections required for the network connection depend on the rating of the frequency inverter and the drive's operating mode.

> **Caution!**
> When selecting the cable cross-section, take the voltage drop under load conditions into account. Compliance to further standards (e.g. VDE 0113, VDE 0289) is the responsibility of the user.

The recommended fuses and their assignment to the DF5 frequency inverters are listed in the appendix, section "Mains contactors", page 119.

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

When the device is operated in a UL-approved system, only UL-approved fuses, fuse bases and cables must be used.

The leakage currents to earth (to EN 50178) are greater than 3.5 mA. The connection terminals marked PE and the enclosure must be connected to the earth circuit.

> **Caution!**
> The prescribed minimum cross-sections for PE conductors (EN 50178, VDE 0160) must be observed. Use a PE conductor whose cross-section is as least as large as the terminal capacity of the power terminals.

Protection of persons and domestic animals with residual-current protective devices

Residual-current circuit breakers (RCCBs; also called earth-leakage circuit breakers or ELCBs). Universal current sensitive RCCBs according to EN 50178 and IEC 755.

	Identification on the residual-current circuit-breakers		
Logo	~	≈	⎓ ≈
Type	Alternating-current sensitive (RCCB, Type AC)	Pulse-current sensitive (RCCB, Type A)	Universal (RCCB, Type B)

The frequency inverter has a built-in mains rectifier. When a frame fault occurs, a DC fault current can block the trip of the alternating current sensitive or pulse current sensitive residual-current circuit breaker, thereby preventing its protective function. We therefore recommend the use of:

- pulse-current sensitive RCCBs with a rated fault current ≧ 30 mA for frequency inverters with a single-phase supply.
- universal RCCBs with a rated fault current ≧ 300 mA for frequency inverters with a three-phase supply.

The approximate fault current values of the DF5 frequency inverters and their assigned radio interference filters are listed in the appendix, section "RFI filters", page 122.

Spurious tripping of a residual-current circuit breaker can be caused by the following:

- capacitive compensation currents in the cable screens, particularly with long, screened motor cables,
- simultaneous connection of multiple frequency inverters to the mains supply,
- the use of additional chokes and filters (radio interference filters, line filters).

> **Caution!**
> Residual-current circuit breakers must be installed only on the primary side between the incoming supply and the frequency inverter.

> **Warning!**
> Use only cables, residual-current circuit breakers and contactors with a suitable rating. Otherwise there is a danger of fire.

Mains contactor

The mains contactor is connected to the mains side input cables L1, L2, L3 (depending on its type) and allows the DF5 frequency inverter on the supplying network to be switched on and off during operation and to be disconnected in the event of a fault.

Mains contactors and their assignment to the DF5 frequency inverters are listed in the appendix, section "Mains contactors", page 119.

Current peaks

In the following cases, a relatively high peak current can occur on the primary side of the frequency inverter (i.e. on the supply voltage side), which, under certain conditions, can destroy the frequency inverter's input rectifier:

- Imbalance of the voltage supply greater than 3 %.
- The maximum power output of the point of supply must be at least 10 times greater than the maximum frequency inverter rating (about 500 kVA).
- If sudden voltage dips in the supply voltage are to be expected, for example when:
  - a number of frequency inverters are operated on a common supply voltage
  - a thyristor system and a frequency inverter are operated on a common supply voltage
  - power factor correction devices are switched on or off

In these cases, a mains choke with about 3 % voltage drop at rated operation should be installed.

Mains choke

The mains choke (also called commutating choke or line reactor) is connected to the mains side input cables L1, L2, L3 (depending on type). It reduces the harmonics and therefore – by up to 30 % – the apparent mains current.

A mains choke also limits any current peaks caused by potential dips (e.g. caused by p.f. correction equipment or earth faults) or switching operations on the mains.

The mains choke increases the lifespan of the internal DC link capacitors and therefore the lifespan of the frequency inverter. Its use is also recommended:

- with single-phase supplies (DF5-322),
- with derating (temperatures above +40 °C, sites of installation more than 1000 m above sea level),
- with parallel operation of multiple frequency inverters on a single mains supply point,
- with DC link coupling of multiple frequency inverters (interconnected operation).

Mains chokes and their assignment to the DF5 frequency inverters are listed in the appendix, section "Mains choke", page 121.

Mains filters and radio interference filters

Mains filters are a combination of mains chokes and radio interference filters in a single enclosure. They reduce the current harmonics and dampen high frequency radio interference levels.

Radio interference filters only dampen high frequency radio interference levels.

Caution!
When line filters or radio interference filters are used, the drive unit's leakage current to earth increases. Observe this point when installing residual-current circuit breakers.

EMC Directives

The limit values for emitted interference and immunity for variable speed drives are described in the **IEC/EN 61800-3** product standard.

If you use DF5 frequency inverters in European Union (EU) countries, you must observe the EMC Directive 89/336/EEC. The following conditions must be observed to comply with this Directive:

Supply voltage (mains voltage) for the frequency inverter:

- Voltage fluctuation ±10 % or less
- Voltage imbalance ±3 % or less
- Frequency variation ±4 % or less

If one of the conditions listed here cannot be fulfilled, you must install an appropriate mains choke (→ section "Mains choke" in the appendix, page 121).

EMC interference class

Installed according to the "EMC compliance" in section "Installation" on page 23 and with the use of a radio interference filter, the DF5 frequency inverters conform to the following standards:

- Emitted interference:
  IEC/EN 61800-3 (EN 55011 group 1, class B)
- Noise immunity:
  EN 61800-3, industrial environment

With frequency inverters, performance related and emitted interference increases with the pulse frequency. The frequency at which performance-related interference occurs also increases with longer motor cables. When the assigned radio interference filter is used, the EN 61800-3 standard is complied to as follows:

	Conformity	
	General	**Limited**
First environment (public mains network)	Up to 10 m motor cable lengths with 16 kHz (maximum switching frequency)	Up to 50 m[1)]
	Up to 20 m motor cable lengths with a switching frequency of up to 5 kHz	
Second environment (industrial)	Up to 50 m	Up to 50 m

1) This is a product with limited conformity as defined by IEC/EN 61800-3. This product can cause radio-frequency interference in domestic environments. In this case appropriate protection measures must be implemented by the user.

Noise immunity
Used with the assigned radio interference filters, the DF5 frequency inverters meet the interference immunity requirements of EMC product standard IEC/EN 61800-3 for industrial environments (second environment) and for domestic use (first environment).

A "domestic environment" is defined here as a connection point (transformer feeder) to which domestic households are also connected.

For industrial systems, the EMC Directive requires electromagnetic compatibility with the environment as a whole. The Product Standard regards a typical drive system as a complete unit, i.e. the combination of frequency inverter, cables and motor.

Emitted interference and radio interference suppression
Used with the assigned radio interference filters, the DF5 frequency inverters meet the requirements of the EMC Product Standard IEC/EN 61800-3 for domestic use (first environment) and therefore also for the higher limit values of industrial environments (second environment).

To ensure compliance to the limit values, observe the following points:

- Reduction of performance related interference with line filters and/or radio interference filters including mains chokes
- Reduction of the electromagnetic emission interference by screening motor cables and signal cables
- Compliance with installation requirements (EMC-compliant installation).

3 Installation

The DF5 frequency inverters should be installed in a control panel or in a metal enclosure (e.g. IP 54).

→ During installation or assembly operations on the frequency inverter, all ventilation slots and openings should be covered to ensure that no foreign bodies can enter the device.

Fitting the DF5

The DF5 frequency inverters must be mounted vertically on a non-flammable surface.

Mounting position

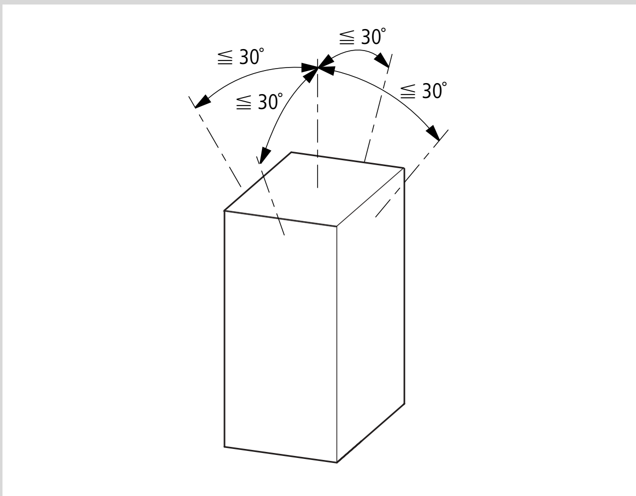


Figure 7: Mounting position

Installation dimensions

A free space of at least 100 mm is required above and below the device to allow air circulation for cooling.

Make sure that the enclosure front cover can be opened and closed freely for connecting the control signal terminals.

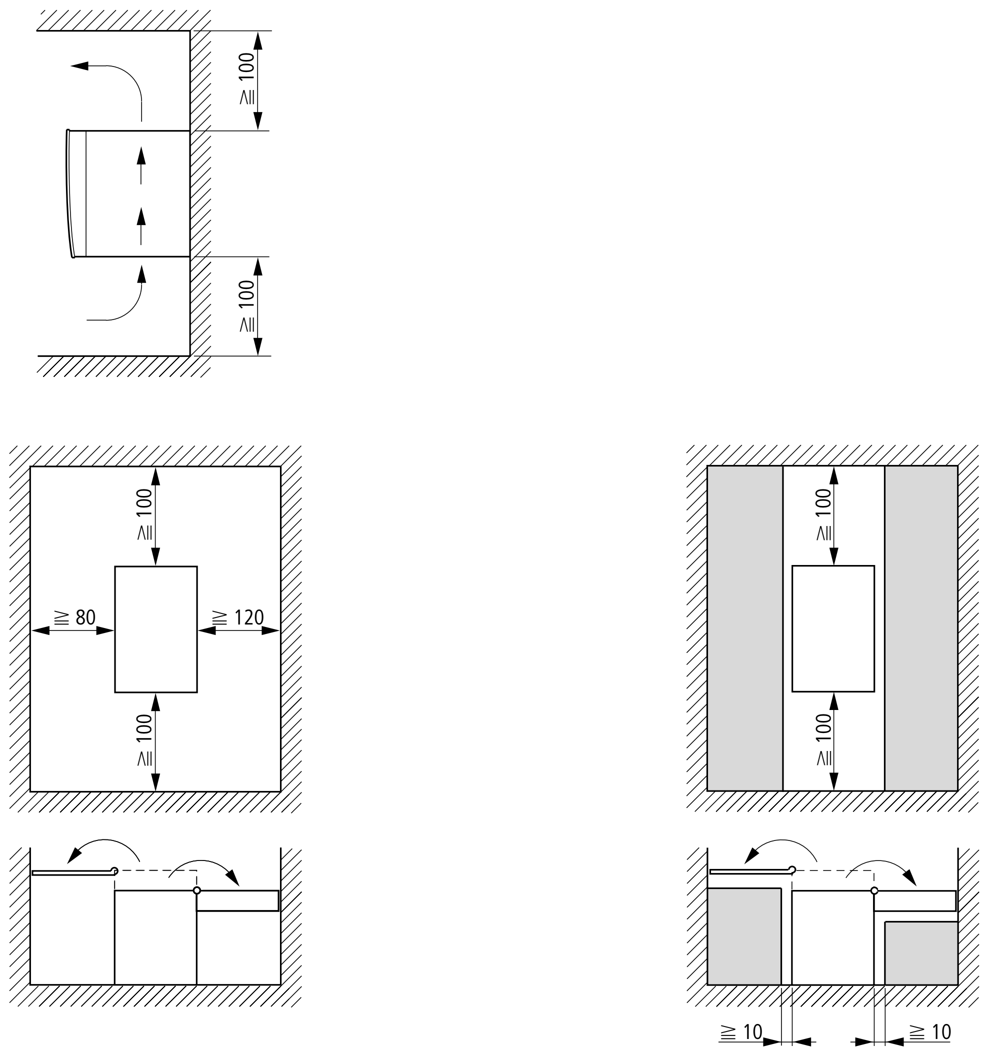


Figure 8: Installation dimensions

Weights and dimensions of the DF5 are listed in the appendix in section "Weights and dimensions" from page 117.

Mounting the DF5

Mount the DF5 frequency inverter as shown in Fig. 9 and tighten the screws to the following torque values (→ Table 1):

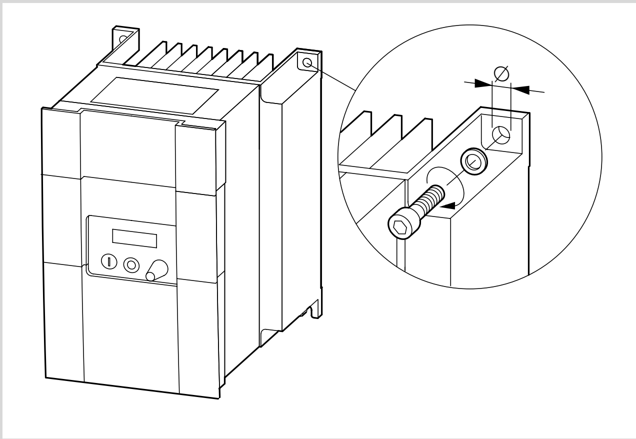


Figure 9: Mounting the DF5

Table 1: Tightening torques of the fixing screws

o [mm]		Nm	ft lb
5	M4	3	2.6
7	M6	4	3.5

EMC compliance

EMC-compliant installation

The frequency inverters operate with fast electronic switching devices e.g. transistors (IGBT). For this reason, radio interference can occur on the frequency inverter's output, which may effect other electronic devices in the direct vicinity, such as radio receivers or measurement instruments. To protect against this radio frequency interference (RFI), the devices should be screened and installed as far away as possible from the frequency inverters.

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

- Installation of the frequency inverter in a metallic, electrically conducting enclosure with a good connection to earth.
- Installation of a radio interference filter on the input of and immediately adjacent to the frequency inverter.
- Use of screened motor cables (short cable lengths).

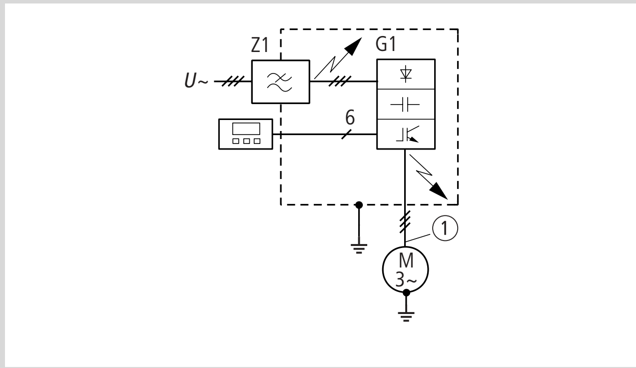


Figure 10: DF5 and radio interference filters in an insulated metal enclosure

Z1: RFI filter

G1: Frequency inverter

① Screened motor cable

▶ Earth the metallic enclosure using a cable which is as short as possible (→ Fig. 10).

Using the radio interference filter

The RFI filter should be installed immediately adjacent to the frequency inverter. The connection cable between the frequency inverter and filter should be as short as possible. Screened cables are required if the cable length exceeds 30 cm.

The mounting surfaces for the frequency inverter and radio interference filter should be as free as possible from paint and oil residue.

The assigned DE5-LZ... radio interference filters (→ section "RFI filters" in the appendix, page 122) can be mounted under (footprint) or next to (book-type) the DF5 frequency inverter.

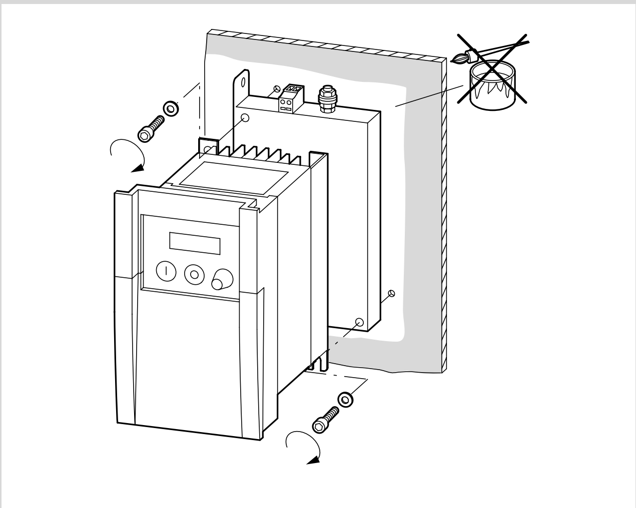


Figure 11: Footprint mounting

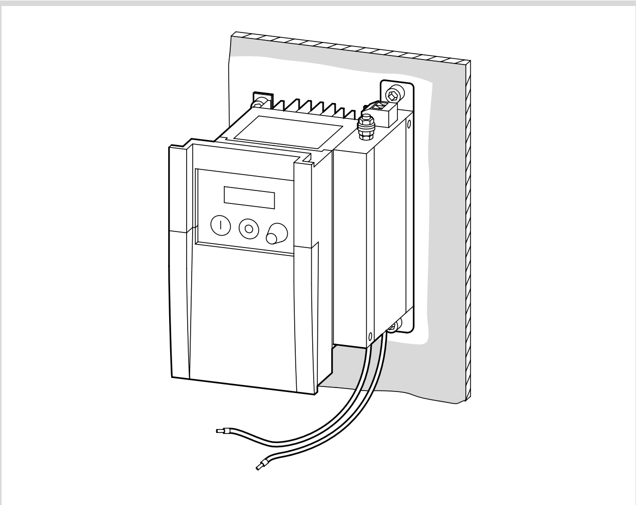


Figure 12: Book-type mounting (on right side in the example)

Radio interference filters produce leakage currents which, in the event of a fault (phase failure, load unbalance), can be larger than the rated values. To prevent dangerous voltages, the filters must therefore be earthed before use. As the leakage currents are high-frequency interference sources, the earthing connections and cables must have a low resistance and large contact surfaces.

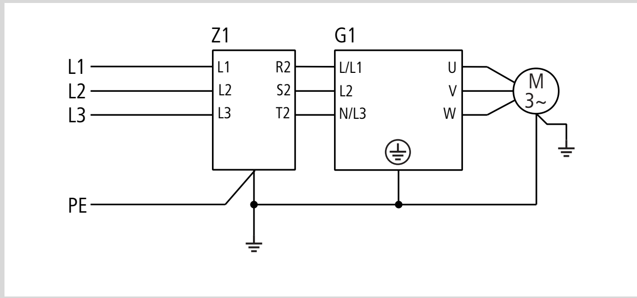


Figure 13: Earthing measures

Z1: RFI filter

G1: Frequency inverter

With leakage currents ≧ 3.5 mA, VDE 0160 and EN 60335, one of the following conditions must be fulfilled:

- the protective conductor has a cross-section ≧ 10 mm^2,
- the protective conductor is monitored to ensure continuity, or
- an additional protective conductor is installed.

For DF5 frequency inverters, use the assigned DE5-LZ… filters.

EMC measures in the control panel

To ensure an EMC-compliant setup, connect all metallic components of the devices and of the control cabinet with each other using a large cross-section conductor with good HF conducting properties. Do not make connections to painted surfaces (Eloxal, yellow-passivized). If there is no alternative, use contact and scraper washers to ensure contact with the base metal. Connect mounting plates to each other, and the cabinet doors with the cabinet using contacts with large surface areas and short HF wires.

The following figure provides an overview of the EMC measures.

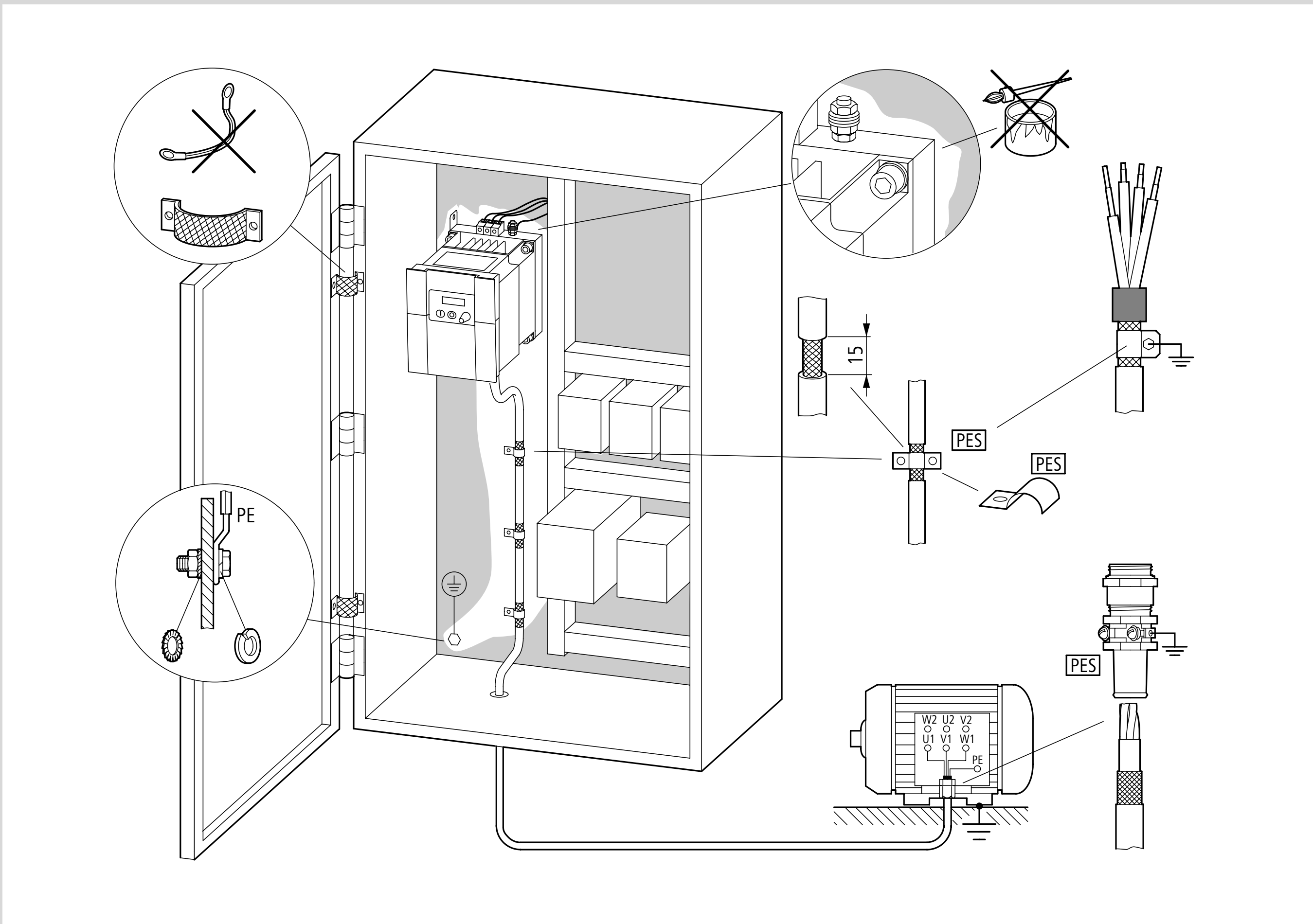


Figure 14: EMC-compliant setup

Fit additional RFI filters or mains filters and frequency inverters as closely as possible to each other and on a single metal mounting plate.

Lay cables in the control cabinet as near as possible to the earth potential. Cables that hang freely act as antennae.

To prevent transfer of electromagnetic energy, lay interference-suppressed cables (e.g. the mains supply line before the filter) and signal lines as far away as possible (at least 10 cm) from HF-conducting cables (e.g. mains supply cable after a filter, motor power cable). This applies especially where cables are routed in parallel. Never use the same cable duct for interference-suppressed and HF cables. Where crossovers are unavoidable, cables should always cross at right angles to each other.

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

Earthing

Connect the base (mounting) plate with the protective earth using a short cable. lay all conducting components (frequency inverter, mains filter, motor filter, mains choke) with an HF wire, and the protective conductor in a star configuration from a central earthing point. This achieves the best results.

Make sure that the earthing measures have been correctly implemented (→ Fig. 15). No other device which has to be earthed should be connected to the earthing terminal of the frequency inverter. If more than one frequency inverter is used, the earthing cables should not form a closed loop.

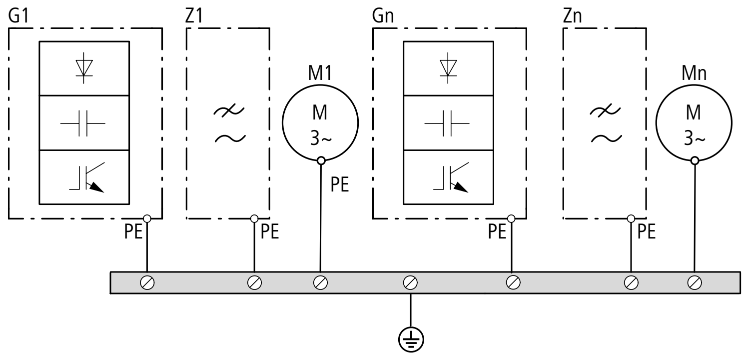


Figure 15: Star-type point-to-point earthing

Screening

Unscreened cables behave like antennae, i.e. they act as transmitters and receivers. To ensure EMC-compliant connection, screen all interference-emitting cables (frequency inverter/motor output) and interference-sensitive cables (analog setpoint and measured value cables).

The effectiveness of the cable screen depends on a good screen connection and a low screen impedance. Use only screens with tinned or nickel-plated copper braiding, braided steel screens are unsuitable. The screen braid must have an overlap ratio of at least 85 percent and an overlap angle of 90°.

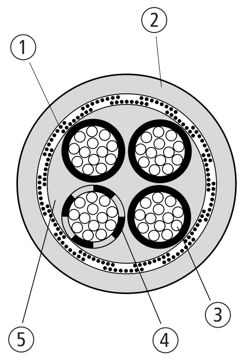


Figure 16: Sample motor cable

1. C screen braid
2. PVC outer sheath
3. Drain wire (copper strands)
4. PVC core insulation
   3 × black, 1 × green/yellow
5. Textile braid and PVC inner

The screened cable between frequency inverter and motor should be as short as possible. Connect the screen to earth at both ends of the cable using a large contact surface connection.

Lay the cables for the supply voltage separately from the signal cables and control cables.

Never unravel the screening or use pigtails to make a connection.

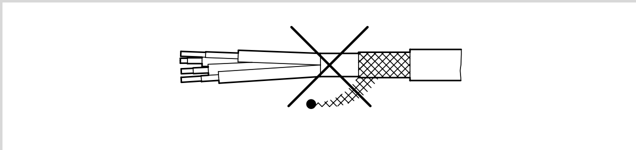


Figure 17: Inadmissible screen grounding (pigtails)

If contactors, maintenance switches, motor protection relays, motor chokes, filters or terminals are installed in the motor cabling, interrupt the screen near these components and connect it to the mounting plate (PES) using a large contact surface connection. The free, unscreened connecting cables should not be longer than about 100 mm.

Example: Maintenance switch

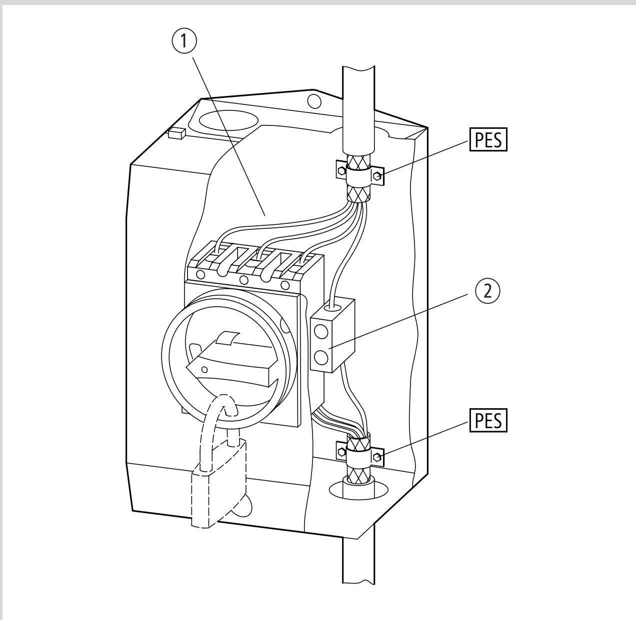


Figure 18: Maintenance switch, e.g. **T… in an enclosure**

① Metal plate

② Insulated PE terminal

In an EMC-compliant control cabinet (metal-enclosed, damped to about 10 dB), the motor cables do not need to be screened provided that the frequency inverter and motor cables are spatially separated from each other and arranged in a separate partition from the other control system components. The motor cable screening must then be connected at the control cabinet (PES) with a large surface area connection.

The control cable and signal (analog setpoint and measured value) cable screens must be connected only at one cable end. The screen connection must have a large contact surface and a low impedance. Digital signal cable screens must be connected at both cable ends, also with large-surface, low-resistance connections.

Electrical connection

This section describes how to connect the motor and the supply voltage to the power terminals, and the signal cables to the control terminals and the signalling relay.

Warning!
Carry out the wiring work only after the frequency inverter has been correctly mounted and secured. Otherwise, there is a danger of electrical shock or injury.

Warning!
Carry out wiring work only under zero voltage conditions.

Warning!
Use only cables, residual-current circuit breakers and contactors with a suitable rating. Otherwise there is a danger of fire.

The following illustration provides an overview of the connections.

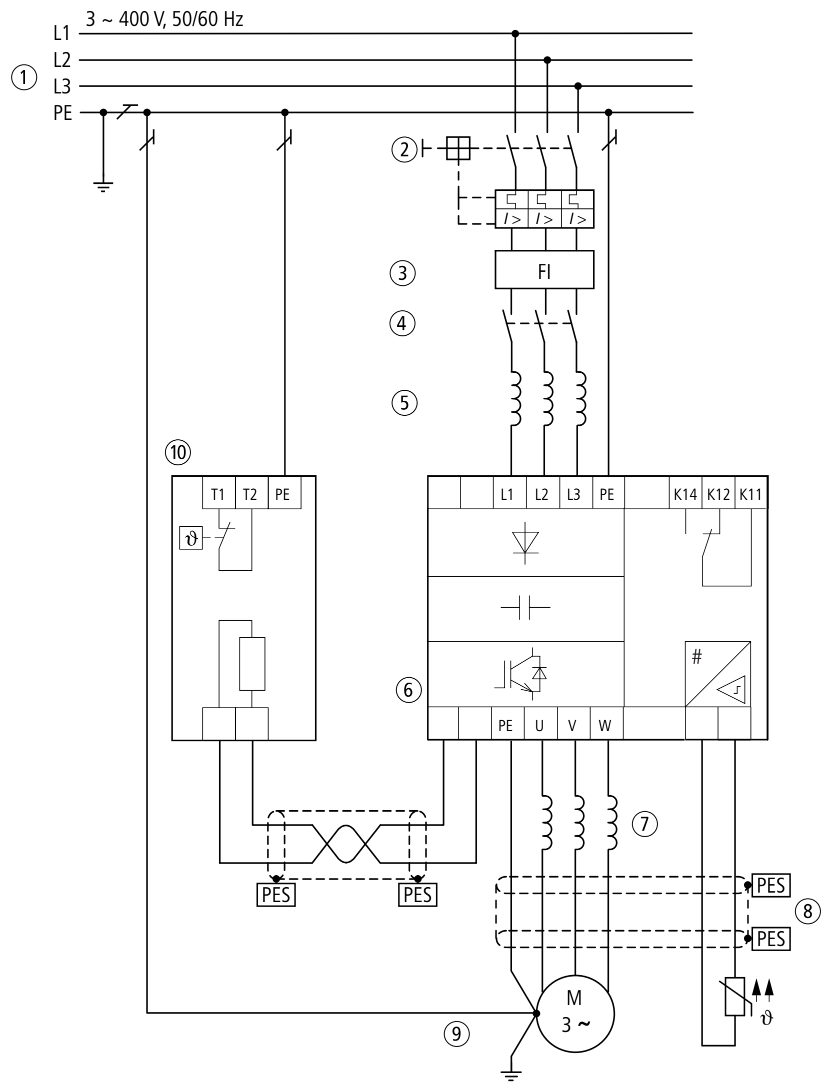


Figure 19: Power supply connection: Example for 400 V

① Network configuration, mains voltage, mains frequency
Interaction with p.f. correction systems

② Fuses and cable cross-sections

③ Protection of persons and domestic animals with residual-current protective devices

④ Mains contactor

⑤ Mains choke, radio interference filter, line filter

⑥ Mounting, installation
Power connection
EMC measures
Example of circuits

⑦ Motor filter
d*u*/d*t* filter
Sinusoidal filter

⑧ Motor cables, cable length

⑨ Motor connection
Parallel operation of multiple motors on a single frequency inverter

⑩ Braking units: Terminals DC+ and DC–
DC bus voltage coupling: Terminals DC+ and DC–
DC infeed: Terminals DC+ and DC–

Thermistor connection: Terminals 5 and L

Connecting the power section

To connect the cables to the supply voltage and signal relay terminals, open the front cover.

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

Opening the front cover and the front of the enclosure

▶ First, open the front cover.

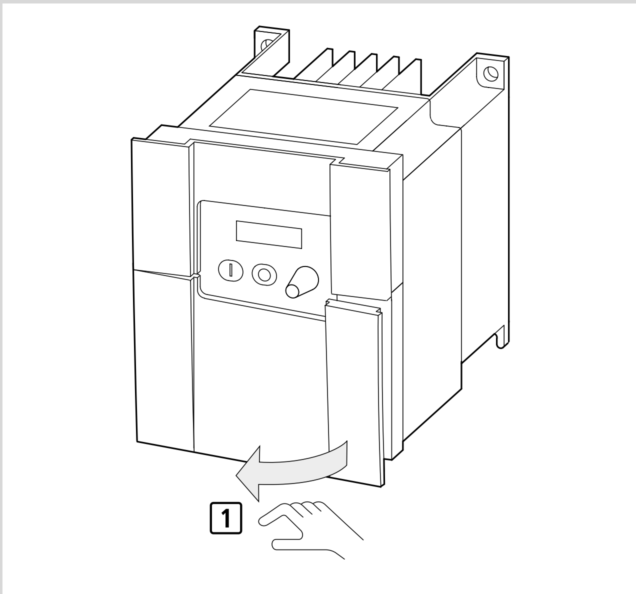


Figure 20: Opening the front cover

▶ Loosen the screw

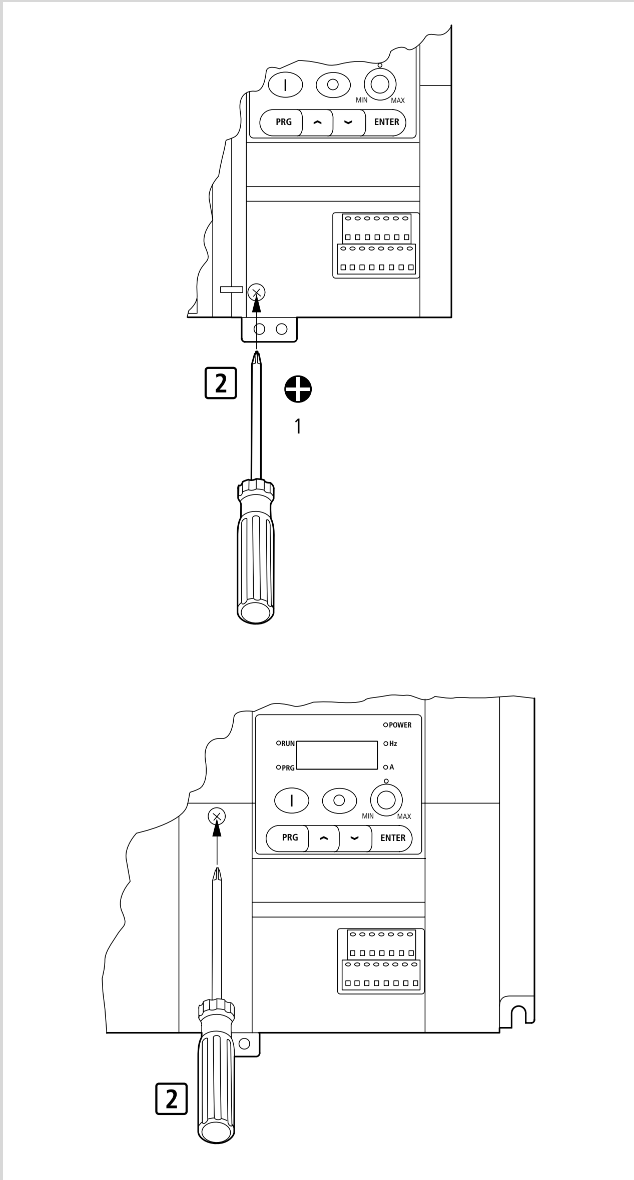


Figure 21: Loosening the screw

▶ Open the front cover and remove the terminal shroud.

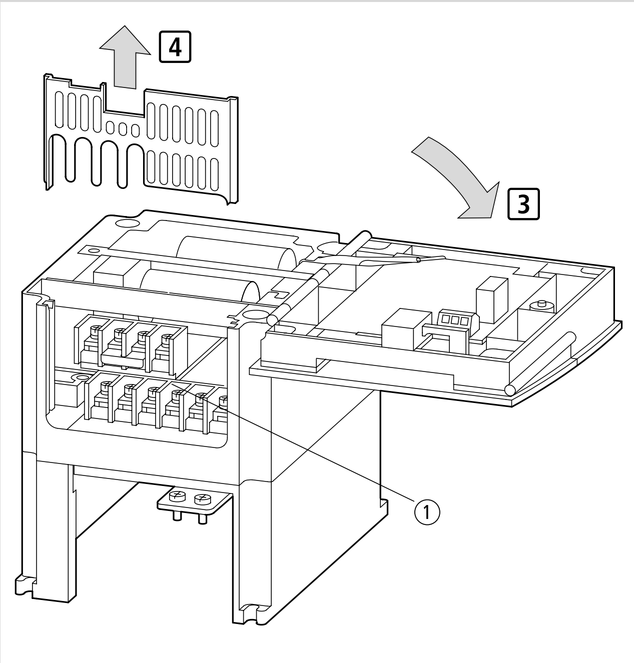


Figure 22: Opening the front cover and removing the terminal shroud

① Power terminals

Arrangement of the power terminals

The arrangement of the power terminals is shown in the figure below.

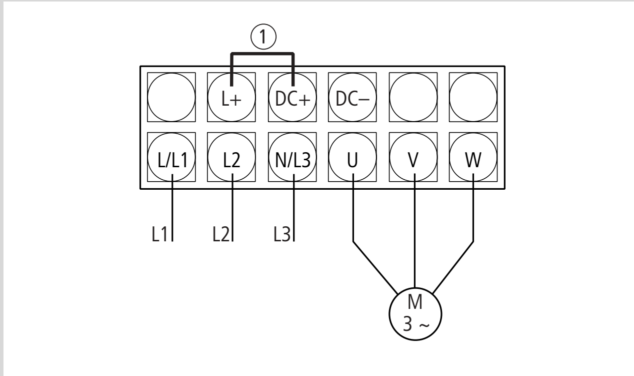
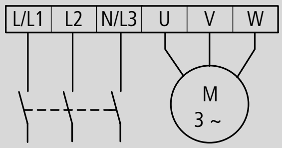


Figure 23: Arrangement of the power terminals

① Internal connection. Remove if a DC link choke is used.

Table 2: Description of the power terminals

Terminal designation	Function	Description	
L, L1, L2, L3, N	Supply voltage (mains voltage)	• Single-phase mains voltage: Connection to L and N • Three-phase mains voltage: Connection to L1, L2, L3	
U, V, W	Frequency inverter output	Connection of a three-phase motor	
L+, DC+	External DC choke	Normally, terminals L+ and DC+ are fitted with a jumper. If a DC link choke is used, remove this jumper.	
DC+, DC–	Internal DC link	These terminals are used for connecting an optional braking resistor and for DC linking and supplying DC multiple frequency inverters with DC power.	
⏚, PE	Earthing	Enclosure earthing (prevents dangerous voltages on the enclosure in the event of a malfunction)	

Connecting the power terminals

Warning!
Select a frequency inverter that is suitable for the available supply voltage (→ section "Appendix", page 113):

- DF5-320: Three-phase 230 V (180 to 264 V ± 0 %)
- DF5-322: Single- or three-phase 230 V (180 to 264 V ± 0 %)
- DF5-340: Three-phase 400 V (342 to 506 V ± 0 %)

Warning!
Never connect mains voltage to output terminals U, V and W. Danger of electrical shock or fire.

Warning!
Each phase of the supply voltage for the frequency inverter must be protected with a fuse (danger of fire).

Warning!
Make sure that all power cables are correctly tightened in the power section.

Warning!
The frequency inverter must be earthed. Danger of electrical shock or fire.

Laying the cables

Lay the cables for the power section separately from the signal and control cables.

The connected motor cables must be screened. The maximum cable length must not exceed 50 m. With larger cable lengths, a motor choke is required for d*u*/d*t* limitation

If the cable leading from the frequency inverter to the motor is longer than about 10 m, the fitted thermal overload relays (bimetallic relays) may malfunction due to high frequency harmonics. Install a motor filter on the output of the frequency inverter in this case.

Warning!
Do not connect cables to the unmarked terminals in the power section. Some of these terminals do not have a function (dangerous voltages) or are reserved for internal use.

Tightening torques and conductor cross-sections

Warning!
Tighten the screws on the terminals correctly (→ Table 3) so that they do not come loose unintentionally.

▶ Tighten the cable connections according to Table 3.

Table 3: Tightening torques and conductor cross-sections for the power terminals

L, L1, L2, L3, N L+, DC+, DC– U, V, W, PE							⊕
DF5-	mm2	AWG	mm	mm		Nm	
320-4K0[1)]	4	12	8 to 10	9	M4	1.2 to 1.3	1
320-5K5[1)]	6	10	12 to 14	13	M5	2 to 2.2	
320-7K5[1)]	10	8	12 to 14	13	M5	2 to 2.2	
322-018 322-037	1.5	16	6 to 8	7.1	M3.5 M4 (PE)	0.8 to 0.9	1
322-055 340-037 340-075 340-1K5 340-2K2	1.5	16	8 to 10	9	M4	1.2 to 1.3	1
322-075 322-1K1 340-3K0 340-4K0	2.5	14	8 to 10	9	M4	1.2 to 1.3	1
322-1K5 322-2K2 340-5K5 340-7K5	4	12	12 to 14	13	M5	2 to 2.2	2

1) Special versions for 3 AC 230 V

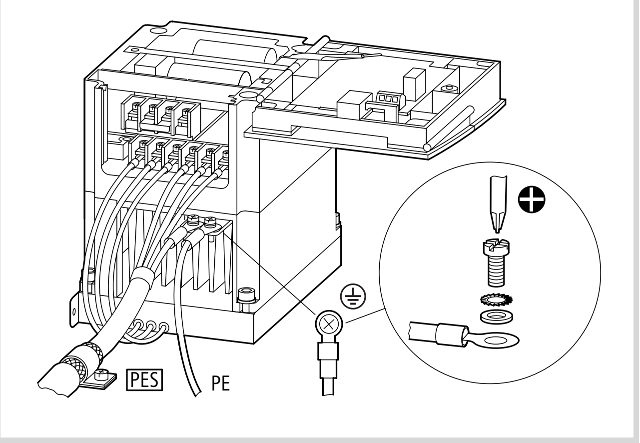


Figure 24: Cable connection to the power terminals

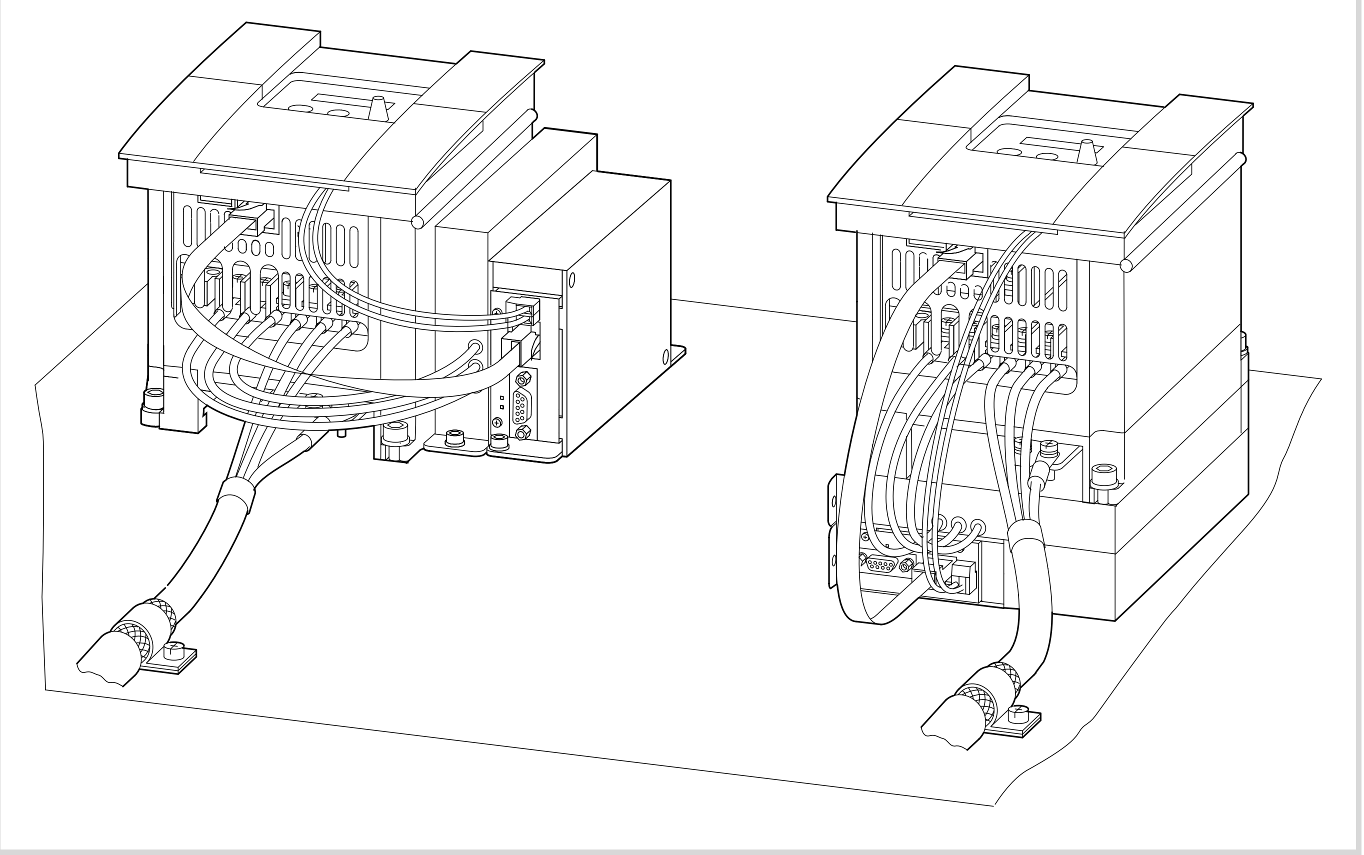


Figure 25: DF5 with filter and fieldbus module

Connecting the supply voltage

▶ Connect the supply voltage to the power terminals:
- Single-phase supply voltage: L, N and PE
- Three-phase supply voltage: L1, L2, L3 and PE

Connecting the motor supply cable

▶ Connect the motor cable to the U, V, W and PE terminals:

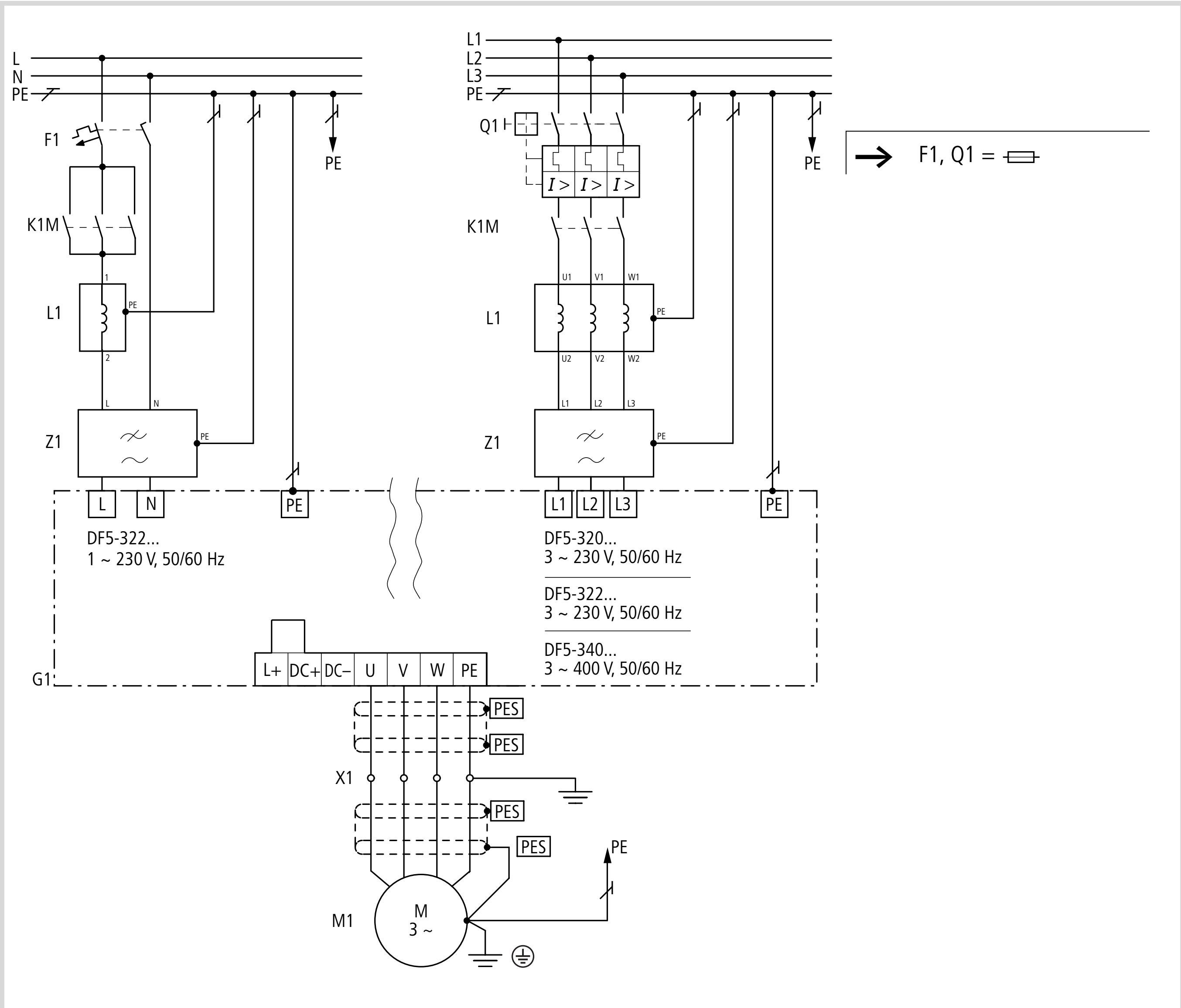


Figure 26: Power terminal connection example

F1, Q1: Line protection
K1M: Mains contactor
L1: Mains choke
Z1: RFI filter

→ Observe the electrical connection data (rating data) on the motor's rating label (nameplate).

The motor's stator winding can be connected in a star or delta configuration in accordance with the rating data on the nameplate.

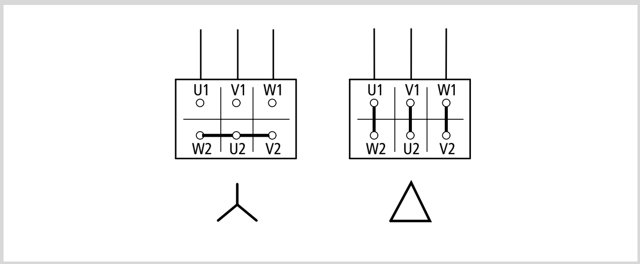


Figure 27: Connection types

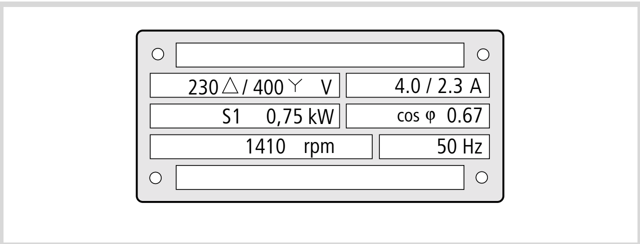


Figure 28: Example of a motor nameplate

Frequency inverter	DF5-320-5K5	DF5-322-075	DF5-340-075
Mains voltage	3-phase 230 V	Single-phase 230 V	3-phase 400 V
Mains current	30 A	9 A	3.3 A
Motor circuit	Delta	Delta	Star
Motor current	19.6 A	4 A	2.3 A
Motor voltage	3 AC 0 to 230 V	3 AC 0 to 230 V	3 AC 0 to 400 V

Warning!
If motors are used whose insulation is not suitable for operation with frequency inverters, the motor may be destroyed.

If you use a motor filter or a sinusoidal filter here, the rate of voltage rise can be limited to values of about 500 V/µs (DIN VDE 0530, IEC 2566).

By default, the DF5 frequency inverters have a clockwise rotation field. Clockwise rotation of the motor shaft is achieved by connecting the motor and frequency inverter terminals as follows:

Motor	DF5
U1 V1 W1	U V W

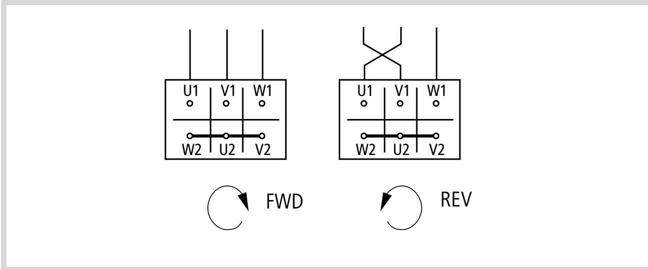


Figure 29: Direction of rotation, change of direction

In frequency inverter operation, you can reverse the direction of rotation of the motor shaft by:

- exchanging two of the phases connected to the motor.
- actuating terminal 1 (FWD = clockwise) or 2 (default: REV = anticlockwise)
- applying a control command through the interface or fieldbus interface connection

The speed of a three-phase motor is determined by the number of pole pairs and the frequency. The output frequency of the DF5 frequency inverter is indefinitely variable from 0.5 to 360 Hz.

Pole-changing three-phase motors (Dahlander pole-changing motors), rotor-fed three-phase commutator shunt motors (slipring rotor) or reluctance motors, synchronous motors and servo motors can be connected, provided they are approved for use with frequency inverters by the motor manufacturer.

Warning!
The operation of a motor at speeds above its rated speed (indicated on the nameplate) can cause mechanical damage to the motor (bearings, unbalance) and the machinery to which it is connected, and can lead to dangerous operating conditions.

Caution!
Uninterrupted operation in the lower frequency range (less than about 25 Hz) can lead to thermal damage (overheating) of self-ventilated motors. Possible countermeasures include over-dimensioning or external cooling independent of motor speed.

Observe the manufacturers recommendations for operating the motor.

Parallel connection of motors to a frequency inverter

DF5 frequency inverters can control several parallel-connected motors. If the motors are required to run at different speeds, this must be implemented with the number of pole pairs and/or the gear transmission ratio.

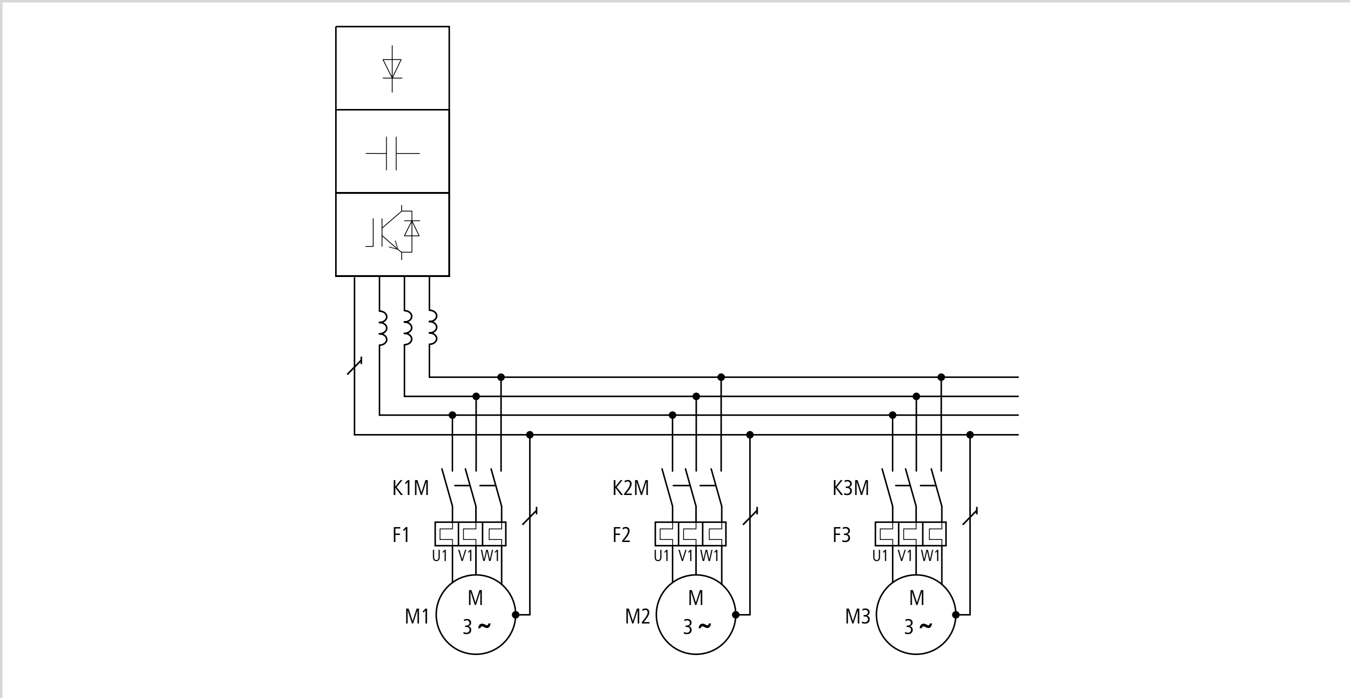


Figure 30: Parallel connection of multiple motors

Caution!
If a frequency inverter controls a number of motors in parallel, the contactors for the individual motors must be designed for AC-3 operation. Do not use the mains contactors listed in the table in the appendix (section "Mains contactors", page 119). These mains contactors are designed only for the frequency inverter's mains (primary) currents. If they are used in multiple-motor circuits, their contacts may weld.

Connecting motors in parallel reduces the load resistance at the frequency inverter output and the total stator inductivity, and increases the leakage capacitance. As a result, the current distortion is larger than it is in a single-motor circuit. To reduce the current distortion, chokes or sinusoidal filters can be connected at the frequency inverter output.

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

→ Electronic motor protection can not be used when operating the frequency inverter with several connected motors. You must however, protect each motor with thermistors and/or overload relays.

If motors with widely differing ratings (for example 0.37 kW and 2.2 kW) are connected in parallel to the output of a frequency inverter, problems may arise during starting and at low speeds. Motors with a low motor rating may be unable to develop the required torque due to the relatively high ohmic resistance of their stators. They require a higher voltage during the starting phase and at low speeds.

Motor cable

To ensure electromagnetic compatibility, use only screened motor cables. The length of the motor cable and the associated use of further components has an influence on the motor control mode and the performance characteristics. In parallel operation (multiple motors connected to the frequency inverter output), the resulting cable lengths l_{res} must be calculated:

$$l_{res} = \Sigma l_M \times \sqrt{n}M$$

Σl_M: Sum of all motor cable lengths

n_M: Number of motor circuits

→ With long motor cables, the leakage currents caused by parasitic cable capacities can cause the "earth fault" message. In this case, motor filters must be used.

Keeping the motor cables as short as possible will positively influence the drive's characteristics.

Motor chokes, du/dt filters, sinusoidal filters
Motor chokes compensate for capacitive currents with long motor cables and with grouped drives (multiple connection of parallel drives to a single inverter).

The use of motor chokes is recommended (observe the manufacturers instructions):

- for grouped drives
- for the operation of three-phase current asynchronous motors with maximum frequencies greater than 200 Hz,
- for the operation of reluctance motors or permanently excited synchronous motors with maximum frequencies above 120 Hz.

d*u*/d*t* filters are used for limiting the rate of voltage rise at the motor terminals to values below 500 V/ms. They should be applied for motors with unknown or insufficient withstand voltage for the insulation.

Caution!
During the engineering phase, keep in mind that the voltage drop across motor filters and d*u*/d*t* filters can be up to 4 % of the frequency inverter's output voltage.

When sinusoidal filters are used, the motor supply voltage and current are almost sinusoidal.

Caution!
During the engineering phase, keep in mind that the sinusoidal filter must be matched to the output voltage and to the frequency inverter's pulse frequency.

The voltage drop at the sinusoidal filter can be up to 15 % of the frequency inverter's output voltage.

Bypass operation
If you want to have the option of operating the motor with the frequency inverter or directly from the mains supply, the incoming supplies must be mechanically interlocked:

Caution!
A changeover between the frequency inverter and the mains supply must take place in a voltage-free state.

Warning!
The frequency inverter outputs (U, V, W) must not be connected to the mains voltage (destruction of the device, risk of fire).

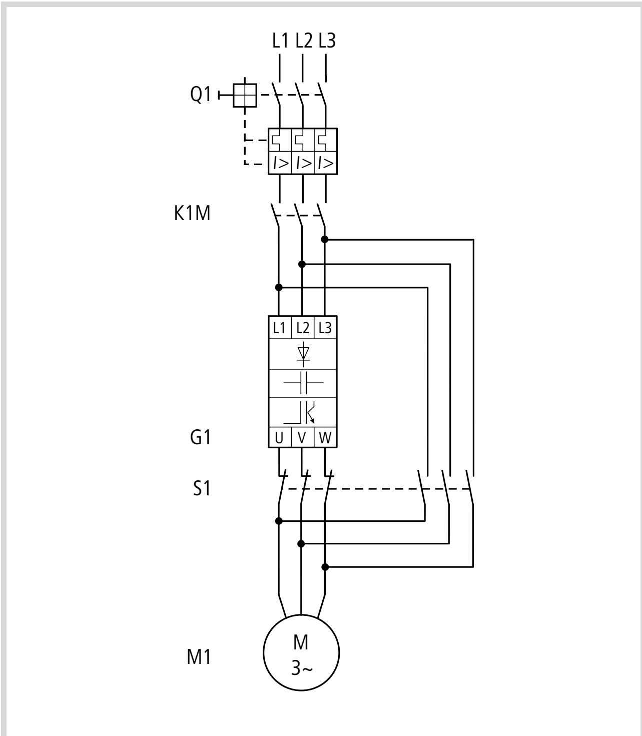


Figure 31: Bypass motor control

Connecting a signalling relay

The following figure indicates the position of the signalling relay.

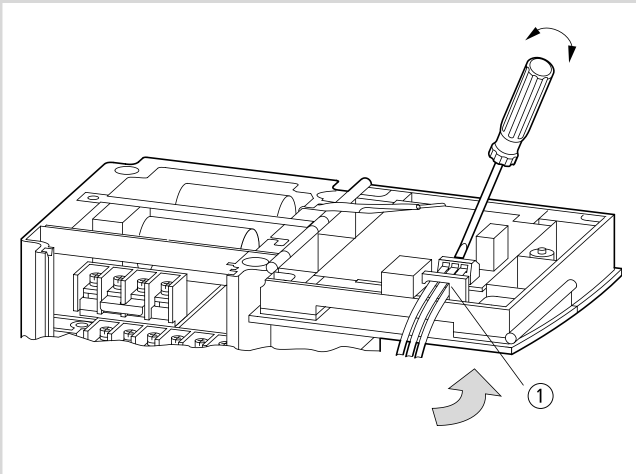


Figure 32: Connecting the signalling relay

① Signalling relay terminals

→ When connecting the signalling relay, support the open enclosure front.

▶ Refit the terminal shroud to the enclosure and close the enclosure front.

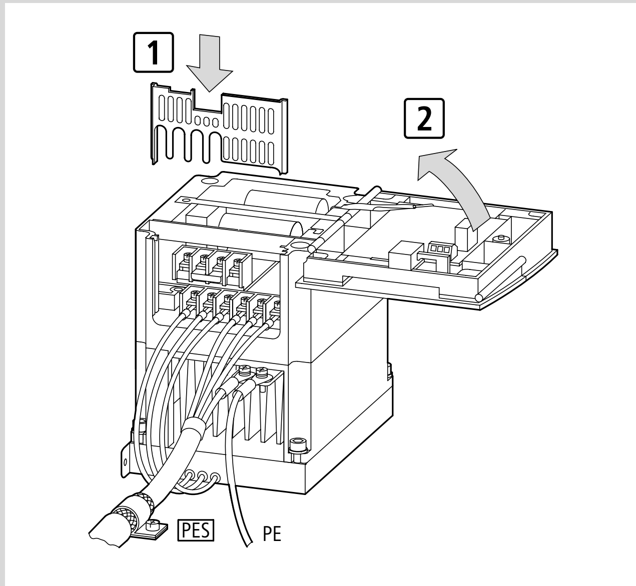


Figure 33: Closing the power section

Table 4: Description of the signalling relay terminals

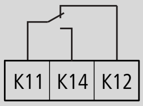
Terminal designation	Description
K11 K12 K14	Default settings: • Operating signal: K11–K14 closed. • Fault message or power supply off: K11–K12 closed Characteristics of the relay contacts: • Maximum 250 V AC/2.5 A (resistive) or 0.2 A (inductive, power factor = 0.4); minimum 100 V AC/10 mA • Maximum 30 V DC/3.0 A (resistive) or 0.7 A (inductive, power factor = 0.4); minimum 5 V DC/100 mA 

Table 5: Signalling relay conductor cross-sections and tightening torques

n	mm2	mm	AWG	mm	M3 Nm
1 ×	0.14 to 1.5	6	6 to 16	0.4 × 2.5	0.5 to 0.6
2 ×	0.14 to 0.75	6	–	0.4 × 2.5	0.5 to 0.6

Connecting the control signal terminals

The illustration below shows the arrangement of the individual control signal terminals.

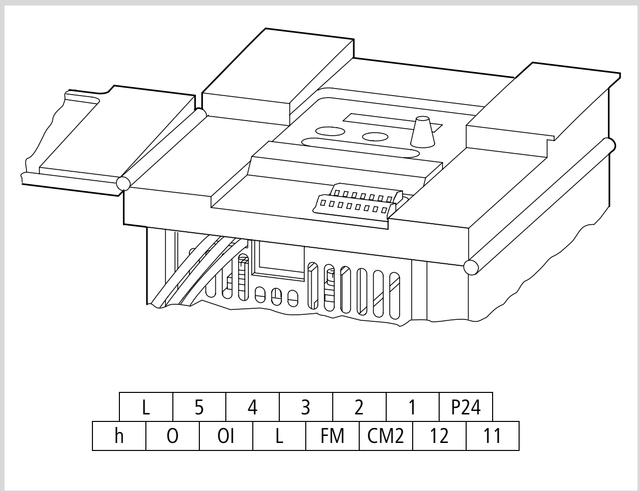


Figure 34: Location of the control signal terminals

ESD measures
Discharge yourself on an earthed surface before touching the frequency inverter and its accessories.
This prevents damage to the devices through electrostatic discharge.

Function of the control signal terminals

Table 6: Functions of the control signal terminals

No.	Function	Level	Default	Technical data, description
L	Common reference potential	0 V	–	Reference potential for the internal voltage sources P24 and H
5	Digital input	HIGH = +12 to +27 V LOW = 0 to +3 V	Reset	PNP logic, configurable, R_i = 33 kΩ Reference potential: Terminal L
4	Digital input		FF2 (FF3) = fixed frequency 2 (3)	PNP logic, configurable, R_i = 5 kΩ Reference potential: Terminal L
3	Digital input		FF1 (FF3) = fixed frequency 1 (3)	
2	Digital input		REV = anticlockwise operation	
1	Digital input		FWD = clockwise operation	
P24	Control voltage output	+24 V	–	Supply voltage for actuation of digital inputs 1 to 5. Load carrying capacity: 30 mA Reference potential: Terminal L
h	Setpoint voltage output	+10 V	–	Supply voltage for external setpoint potentiometer. Load carrying capacity: 10 mA Reference potential: Terminal L
O	Analog input	0 to +10 V	Frequency setpoint value (0 to 50 Hz)	R_i = 10 kO Reference potential: Terminal L
OI	Analog input	4 to 20 mA	Frequency setpoint value (0 to 50 Hz)	R_B = 250 Ω Output: Terminal L

No.	Function	Level	Default	Technical data, description
L	Common reference potential	0 V	–	Reference potential for the internal voltage sources P24 and H
FM	Analog output	0 to +10 V	Frequency actual value (0 to 50 Hz)	Configurable, monitored DC voltage; 10 V corresponds to set final frequency (50 Hz). Accuracy: ±5 % from final value Load carrying capacity: 1 mA Reference potential: Terminal L
CM2	External control voltage input	Up to 27 V	–	Connection: Reference potential (0 V) of the external voltage source for the transistor outputs, terminals 11 and 12. Load carrying capacity: Up to 100 mA (sum of terminals 11 + 12)
12	Transistor output	Up to 27 V = CM2	RUN (operation)	Configurable, open collector Load carrying capacity: Up to 50 mA
11	Transistor output		Frequency setpoint reached	

Control signal terminal wiring

Wire the control signal terminals as appropriate for their application. For instructions for changing the function of the control signal terminals, see section "Programming the control signal terminals" from page 53.

Caution!
Never connect terminal P24 with terminals L, H, OI or FM.

Caution!
Never connect terminal H with terminal L.

Use twisted or screened cables for connecting to the control signal terminals. Earth the screen on one side with a large contact area connection near the frequency inverter. The cable length should not exceed 20 m. For longer cables, use a suitable signal amplifier.

The following figure shows a sample protective circuit for the control signal terminals

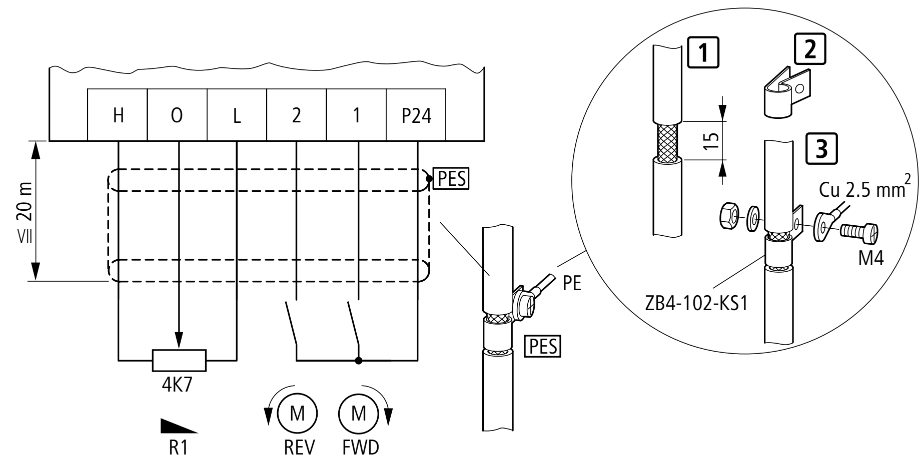


Figure 35: Control terminal connection (factory setting)

If a relay is connected to one of the digital outputs 11 or 12, connect a freewheeling diode in parallel to the relay to prevent destruction of the digital outputs through the self-induced e.m.f. which results when the relay is switched off.

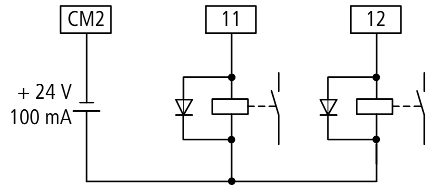


Figure 36: Relay with freewheeling diode (e.g. ETS-VS3)

→ Use relays that switch reliably at 24 V ⎓ and a current of about 3 mA.

→ Lay the control and signal cables separately from the mains and motor cables.

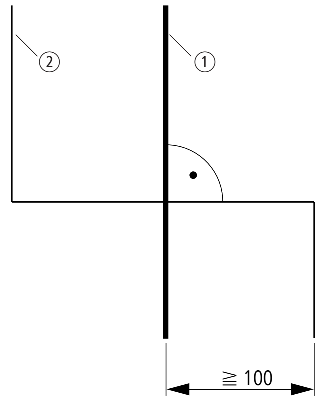


Figure 37: Crossover of signal and power cables

① Power cable: L1, L2, L3 or L and N, U, V, W, L+, DC+, DC–

② Signal cables: H, O, OI, L, FM, 1 to 5 11 and 12, CM2, P24, K11, K12, K14

Example for the protective circuit of the digital inputs using the internal P24 supply voltage or a separate external 24 V power supply:

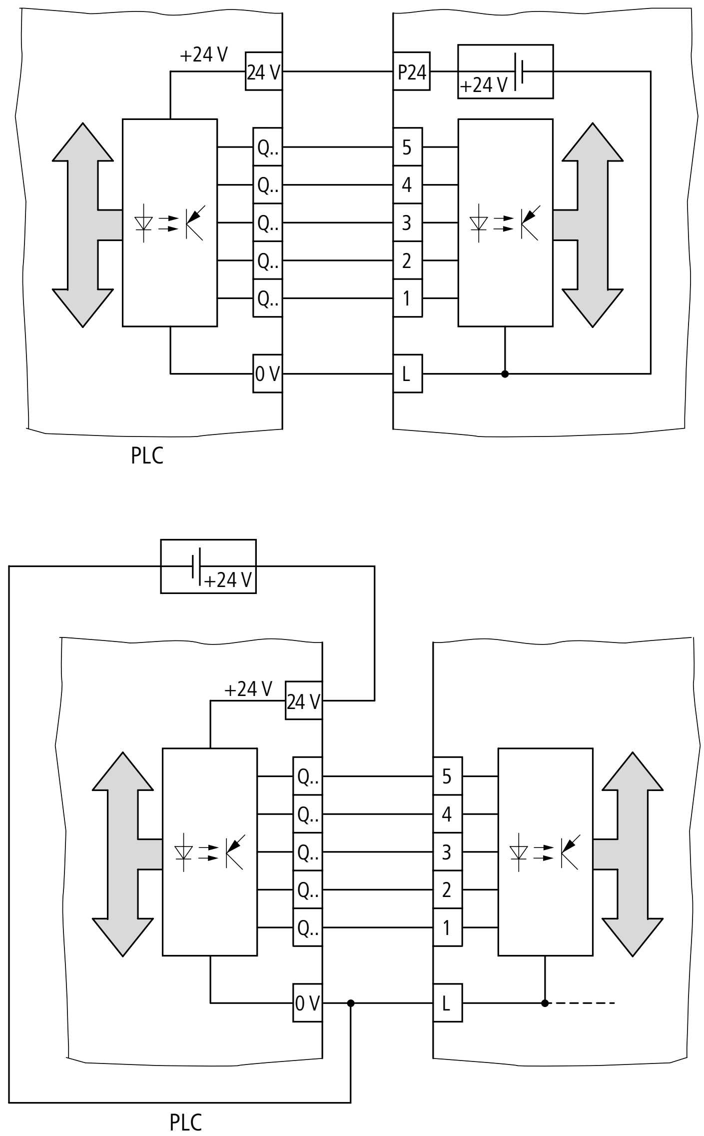


Figure 38: Actuating the digital inputs

Caution!
Before commissioning, remove the covering on the upper ventilation slots and openings, as the frequency inverter will otherwise overheat (→ Fig. 39).

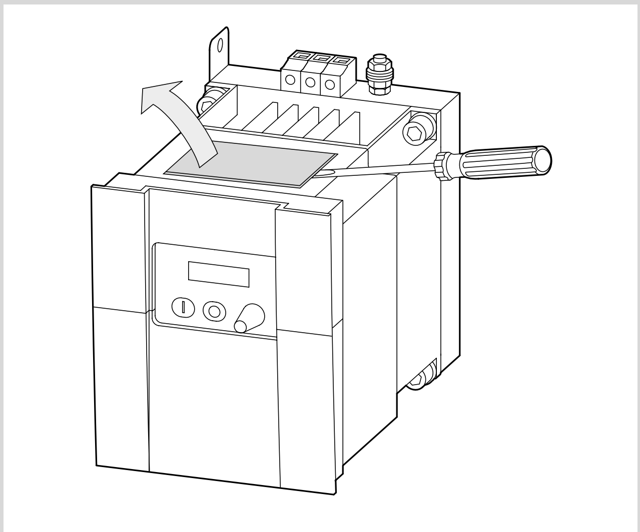


Figure 39: Removing the upper cover

4 Operating the DF5

This section describes how to take the DF5 frequency inverter into operation and what you should observe during its operation.

Initial starting

Observe the following points before you take the frequency inverter into operation:

- Make sure that the power lines L1 and N or L1, L2 and L3 and the frequency inverter outputs U, V and W are connected correctly.
- The control lines must be connected correctly.
- The earth terminal must be connected correctly.
- Only the terminals marked as earthing terminals must be earthed.
- The frequency inverter must be installed vertically on a non-flammable surface (e.g. a metal surface).
- Remove any residue from wiring operations – such as pieces of wire – and all tools from the vicinity of the frequency inverter.
- Make sure that the cables connected to the output terminals are not short-circuited or connected to earth.
- Ensure that all terminal screws have been sufficiently tightened.
- Make sure that the frequency inverter and the motor are correct for the mains voltage.
- The configured maximum frequency must match the maximum operating frequency of the connected motor.
- Never operate the frequency inverter with opened power section covers. The front enclosure must be closed and secured with the screw provided.

Caution!
Do not carry out h.v. tests. Built-in overvoltage filters are fitted between the mains voltage terminals and earth, which could be destroyed.

→ Sparkover voltage and insulation resistance tests (megger tests) have been carried out by the manufacturer.

The control signal terminals are wired as follows.

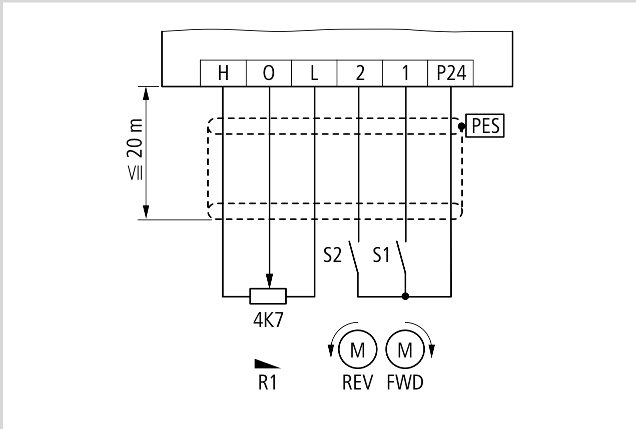


Figure 40: Connecting the control signal terminals (default settings)

▶ Switch on the supply voltage.

The POWER and Hz LEDs light up (keypad). The display should indicate 0.0.

▶ Close switch S1 (FWD = clockwise operation).
▶ With potentiometer R1, you can set the frequency and therefore the motor speed.

The motor turns clockwise and the display indicates the set frequency.

▶ Open switch S1.

The motor speed is reduced to zero (display: 0.0)

▶ Close switch S2 (REV = anticlockwise operation).
▶ With potentiometer R1, you can set the frequency and therefore the motor speed.

The motor turns anticlockwise and the display indicates the set frequency.

▶ Open switch S2.

The motor speed is reduced to zero (display: 0.0)

If both switches S1 and S2 are closed, the motor will not start. If you close both switches during operation, the motor speed is reduced to zero.

Caution!
During or after initial operation, check the following points to prevent damage to the motor:

- Was the direction of rotation correct?
- Has a fault occurred during acceleration or deceleration?
- Was the frequency displayed correctly?
- Did any unusual motor noise or vibration occur?

If a fault has occurred due to overcurrent or overvoltage, increase the acceleration or deceleration time (→ section "Acceleration time 1", page 80 and section"Deceleration time 1", page 81).

As supplied, the frequency inverter's START key and the potentiometer on the keypad have no function. For details about activating these controls, see section"Setting the frequency and start signal parameters", page 81.

Keypad

The following illustration shows the LCD keypad of the DF5.

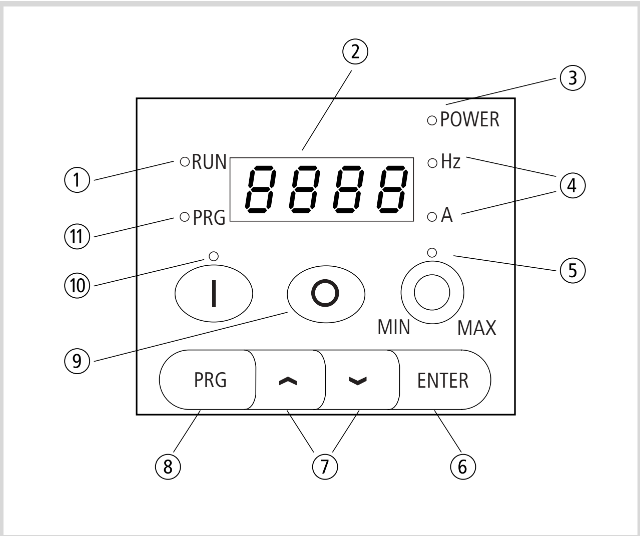


Figure 41: Keypad view

For an explanation of each of the elements, see Table 7.

Table 7: Explanation of the operating and indication elements

Number	Name	Explanation
①	RUN LED	LED lit in **RUN mode** when the frequency inverter is ready for operation or is in operation.
②	7-segment display	Display for frequency, motor current, fault messages, etc.
③	POWER LED	LED is lit when the frequency inverter has power.
④	Hz or A LED	Indication in ②: Output frequency (Hz) or output current (A)
⑤	Potentiometer and LED	Frequency setpoint setting LED is lit when the potentiometer is activated.
⑥	ENTER key ENTER	The key is used for saving entered or changed parameters.
⑦	Arrow keys ⌃ ⌄	Selecting functions, changing numeric values ⌃ Increase ⌄ Reduce
⑧	PRG key PRG	For selecting and exiting the programming mode.
⑨	STOP key O	Stops the running motor and acknowledges a fault message. Active by default, also when actuation is through terminals.
⑩	START key and LED I	Starts the motor in the specified direction (not active by default).
⑪	PRG LED	LED is lit during parameterization.

Operation with LCD keypad

The functions of the DF5 are organized in parameter groups. The following sections describe how to set the parameter values and how the setting menu is structured.

For a detailed description of the parameters, see section "Setting Parameters", page 79.

Using the keypad

Example for changing over control mode from control signal terminals (default) to keypad.

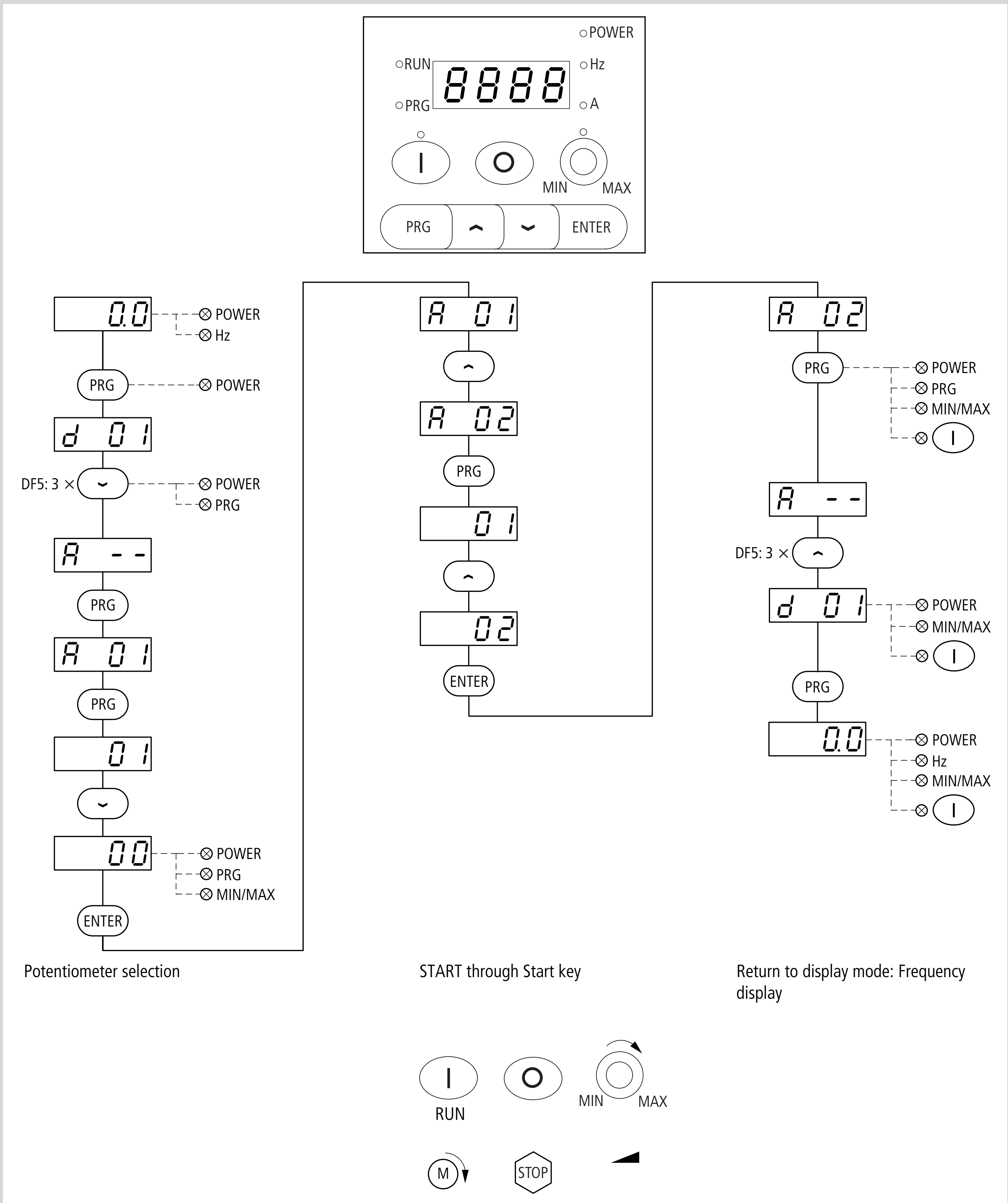


Figure 42: Specify setpoint definition through keypad

Menu overview

The following figure shows the sequence in which the parameters appear on the display. Table 8 provides a brief description of the parameters.

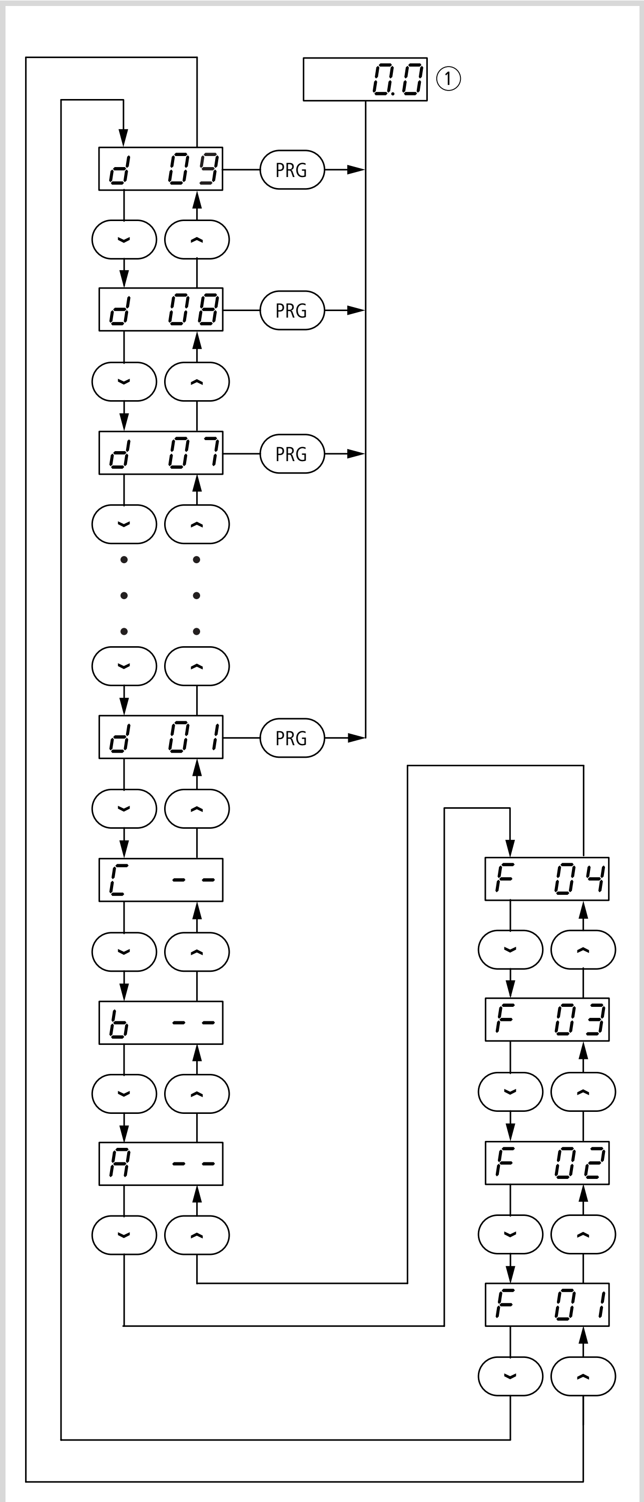


Figure 43: DF5 keypad menu structure

① The contents of this display depends on which display parameter (PNU d01 to d09) you have selected.

Table 8: Explanation of the parameters

Display	Explanation
Indication parameter	
d 01	Output frequency display
d 02	Output current display
d 03	Direction of rotation display
d 04	PID feedback display
d 05	Digital inputs 1 to 5 status
d 06	Status of digital outputs 11 and 12
d 07	Scaled output frequency
d 08	Display of last alarm
d 09	Display of second and third to last alarm
Basic parameters	
F 01	Frequency setpoint adjustment
F 02	Set acceleration time 1
F 03	Set deceleration time 1
F 04	Direction of rotation adjustment
Extended parameter groups	
A --	Extended functions group A
b --	Extended functions, group B
C --	Extended functions, group C

For a detailed description of the parameters, see section "Setting Parameters", page 79.

Changing display and basic parameters

Press the PRG key to switch from display or RUN mode to programming mode. The PRG lamp lights up in this mode.

You can access the individual parameters or parameter groups with the UP and DOWN arrow keys .

To access the programming mode, press the PRG key. You can modify the parameter values with the arrow keys.
Exceptions are the display parameters PNU d01 to d09. These parameters have no values. Once you have selected a display parameter with the arrow keys, you can return to the display mode with the PRG key. The display then shows the selected display parameter (→ section "Setting the display parameters"page 79.

You can accept parameter values with the ENTER key or reject them with the PRG key.

To return to the display mode, press the PRG key in the display parameter range PNU d01 to d09.

Example for changing acceleration time 1: PNU F02
The frequency inverter is in display mode and the RUN lamp is lit.

▶ Press the PRG key.

The frequency inverter changes to programming mode, the PRG lamp lights up and d 01 or the most recently modified parameter appears on the display.

▶ Press the DOWN key six times until F 02 appears on the display.
▶ Press the PRG key.

The set acceleration time 1 in seconds appears on the display (default value: 10.0).

▶ To change the set value, use the UP and DOWN arrow keys.

There are now two possibilities:

▶ Accept the displayed value by pressing the ENTER key.
▶ Reject the displayed value by pressing the PRG key.

The display should indicate F 02.

▶ Press the UP key six times until d 01 appears.
▶ Press the PRG key.

The frequency inverter changes to the display mode and displays the set frequency.

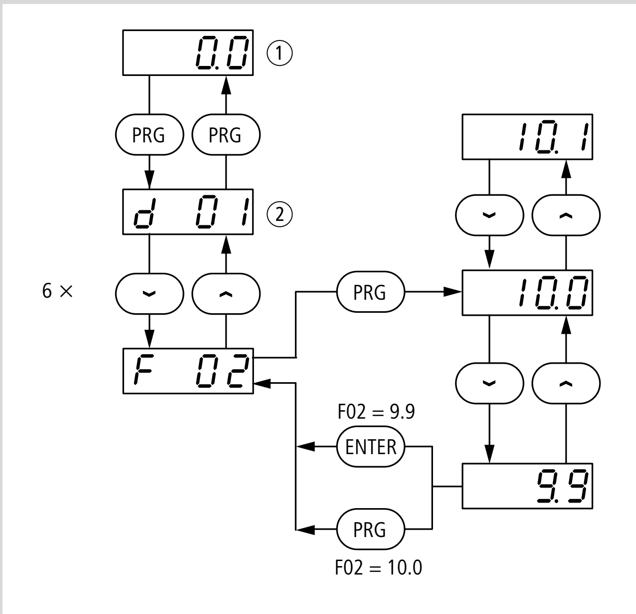


Figure 44: Change acceleration time 1

① Display dependent on the selected display parameter PNU d01 to d09
② Display of the most recently changed parameter

Changing parameters of the extended parameter groups

The following example illustrates how to change PNU A03 of the extended parameter group A. You can also change the parameter values of groups B and C as described in the example. For a detailed description of the extended parameter groups, see from section“Setting the frequency and start signal parameters”, page 81.

Example for changing the base frequency PNU A03
▶ Press the PRG key to change to programming mode.

The most recently modified parameter appears on the display and the PRG lamp lights up.

▶ Press the UP or DOWN key until the extended parameter group A -- appears on the display.
▶ Press the PRG key.

A 01 appears on the display.

▶ Press the UP key twice until A 03 appears on the display.
▶ Press the PRG key.

The value set under PNU A03 appears on the display (default value: 50.0).

▶ To change the value, use the UP and DOWN arrow keys.

There are now two possibilities:

▶ Accept the displayed value by pressing the ENTER key.
▶ Reject the displayed value by pressing the PRG key.

The display shows A 03.

▶ Press the PRG key.

The display shows A --.

▶ Press the UP key three times until d 01 appears.
▶ Press the PRG key.

The frequency inverter changes to the display mode and displays the current frequency.

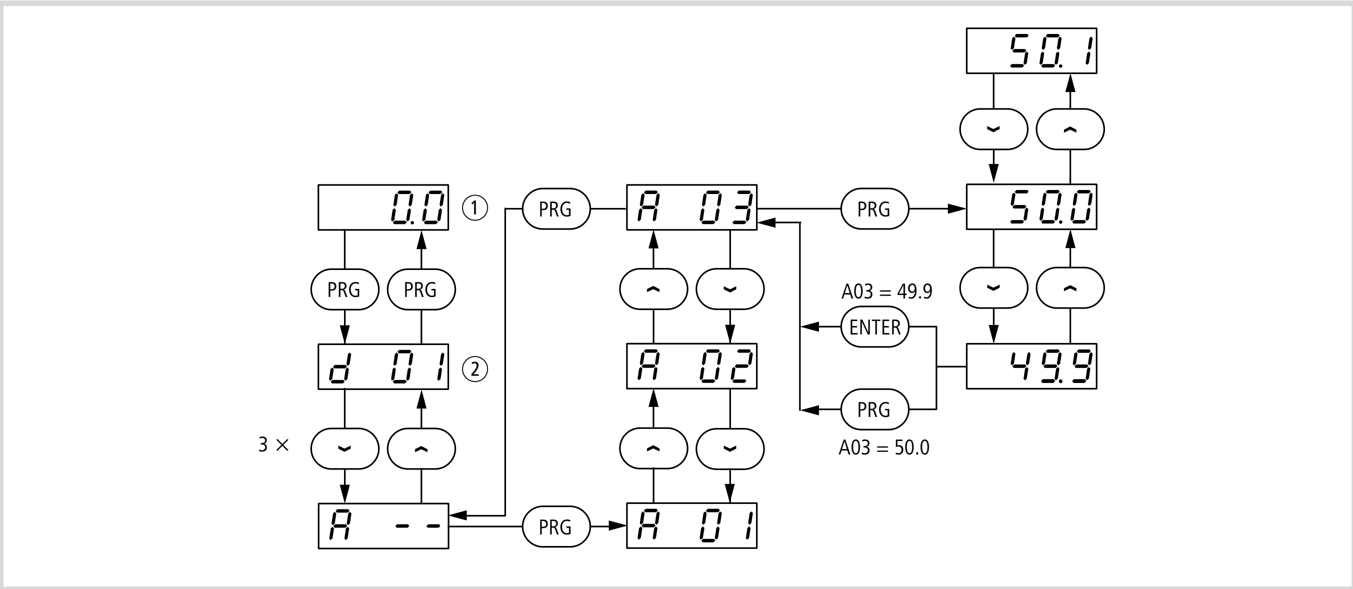


Figure 45: Change the base frequency (example with default setting)

① Display dependent on the selected display parameter PNU d01 to d09

② Display of the most recently changed parameter

Display after the supply voltage is applied

After the supply voltage is switched on, the last screen which was visible before switch off will reappear (but not within the extended parameter groups).

Connection examples

Operation using an external potentiometer

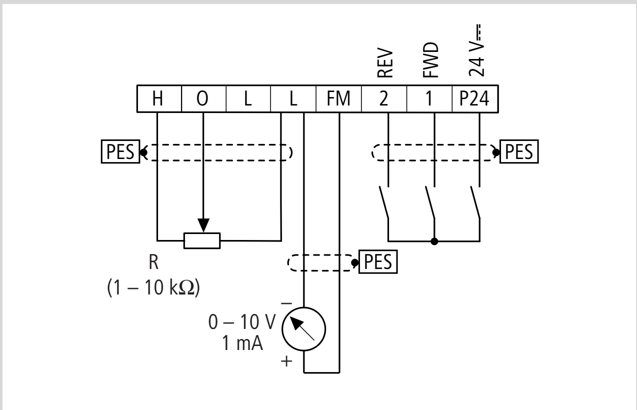


Figure 46: Connecting an external potentiometer

Parameter settings

PNU	Value	Function
A01	01	Setpoint definition through control signal terminal strip
A02	01	Start signal through FWD/REV terminals
F02	10	Acceleration time in s
F03	10	Deceleration time in s
C01	00	FWD: Start clockwise operation on digital input 1
C02	01	REV: Start anticlockwise operation on digital input 2
C23	00	Indication of the output frequency (analog) through the measurement device connected to terminals L and FM
b81	80	Adjustment of the analog frequency display connected to terminals L and FM

Method of operation

You can start the frequency inverter in a clockwise direction with terminal 1 and in an anticlockwise direction with terminal 2. If both terminals are closed simultaneously, a stop signal is issued.

With the externally connected potentiometer, the required frequency setpoint (voltage setpoint) can be defined.

You can use the measuring instrument for showing the frequency (PNU C23 = 00) or the motor current (PNU C23 = 01). With PNU b81, you can match analog output FM to the measuring instrument's measuring range (indication: frequency or current).

Operation through an analog setpoint value

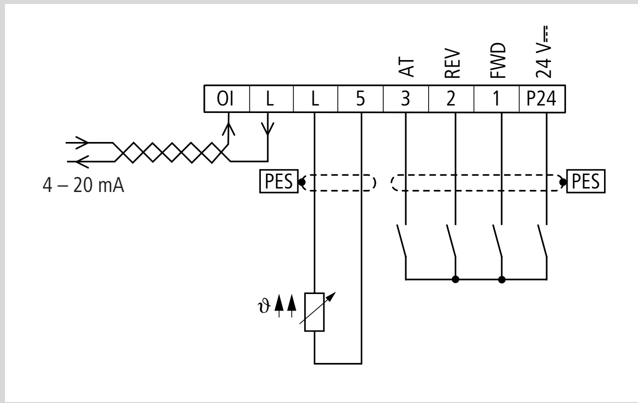


Figure 47: Analog setpoint definition

Parameter settings

PNU	Value	Function
A01	01	Setpoint definition through control signal terminal strip
A02	01	Start signal through FWD/REV terminals
F02	10	Acceleration time in s
F03	10	Deceleration time in s
C01	00	FWD: Start clockwise operation on digital input 1
C02	01	REV: Start anticlockwise operation on digital input 2
C03	16	AT: Changeover to current setpoint value (4 to 20 mA)
C05	19	PTC: PTC thermistor on digital input 5

Method of operation

Inputs 1 and 2 function exactly as described in the previous example.

With digital input 3 (configured as AT), you can change over from a voltage setpoint value (0 to 10 V) to a current setpoint value (4 to 20 mA).

Instead of permanent or switch-connected wiring at terminal 3, you can set PNU C13 = 01. Digital input 3 is then configured as a break contact (NC).

The circuit example also includes a motor PTC thermistor. It is important to use a screened control cable and to lay the motor PTC thermistor cable separately from the other motor cables. However, the screen should be earthed at the inverter side only.

Operation at fixed frequencies

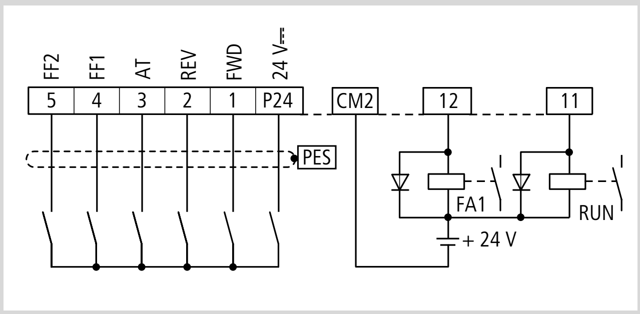


Figure 48: Fixed frequency definition

Parameter settings

PNU	Value	Function
A01	01	Setpoint definition through control signal terminal strip
A02	01	Start signal through FWD/REV terminals
F02	10	Acceleration time in s
F03	10	Deceleration time in s
C01	00	FWD: Start clockwise operation on digital input 1
C02	01	REV: Start anticlockwise operation on digital input 2
C03	16	AT: Changeover to current setpoint value (4 to 20 mA)
C04	02	FF1: Fixed frequency input 1
C05	03	FF2: Fixed frequency input 2
C21	00	RUN output signal at terminal 11
C22	01	FA1 output signal at terminal 12
A21	*f*	The fixed frequency to be applied when FF1 is active and FF2 is inactive is entered here.
A22	*f*	The fixed frequency applied when FF1 is inactive and FF2 is active is entered here.
A23	*f*	The fixed frequency is applied when FF1 and FF2 are both active is entered here.

Method of operation

Inputs 1 and 2 function exactly as described in the first example.

With the activation of one or both fixed frequency inputs FF1 and FF2, the current frequency setpoint applied to the motor is replaced by the fixed frequency determined by FF1 and FF2, and the motor brakes or accelerates according to the fixed frequency applied. If neither of the fixed frequency inputs FF1 and FF2 is activated, the frequency setpoint is determined through analog inputs O (voltage setpoint value) or OI (current setpoint value). The wiring for these terminals is not shown in this circuit example. For the combination of the individual fixed frequency values, see section"Fixed frequency selection (FF1 to FF4)", page 60.

The circuit example also contains the parameterization for an output signal at each of the terminals 11 and 12. Digital output 11 is configured with PNU C21, and digital output 12 with PNU C22.

Operational warnings

Warning!
If the supply voltage recovers after an intermittent failure, the motor may restart automatically if a start signal is still present. If personnel is endangered as a result, an external circuit must be provided which prevents a restart after voltage recovery.

Warning!
If the frequency inverter has been configured so that the stop signal is not issued through the OFF key on the LCD keypad, pressing the OFF key will not switch off the motor. A separate Emergency-Stop switch must be provided in this case.

Warning!
Before carrying out maintenance and inspection work on the frequency inverter, wait at least five minutes after the supply voltage has been switched off. Failure to observe this point can result in electric shock due to high equipment voltages.

Warning!
Never pull on the cable to unplug connectors (e.g. for fan or circuit boards).

Warning!
If a reset is carried out after a fault, the motor will start again at once automatically if a start signal is applied simultaneously. To avoid the risk of serious or fatal injury to personnel, you must ensure that the start signal is not present before acknowledging a fault message with a reset.

Warning!
When the supply voltage for the frequency inverter is applied while the start signal is active, the motor will start immediately. Make sure that the start signal is not active before the supply voltage is switched on.

Warning!
Do not connect cables or connectors during operation when the supply voltage is switched on.

Caution!
To prevent a risk of serious or fatal injury to personnel, never interrupt the operation of the motor by opening the contactors installed on the primary or secondary side.

→ The START key is functional only if the corresponding parameters of the frequency inverter have been configured accordingly (→ section "Setting the frequency and start signal parameters" page 81 .

→ If motors are to be operated at frequencies above the standard 50 or 60 Hz, consult the motor manufacturer to make sure that the motors are suitable for operation at higher frequencies. The motors could otherwise incur damage.

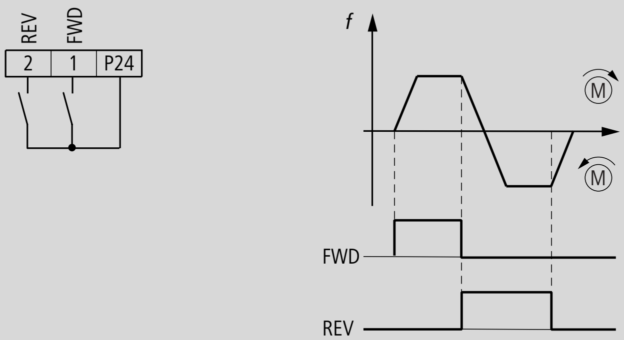
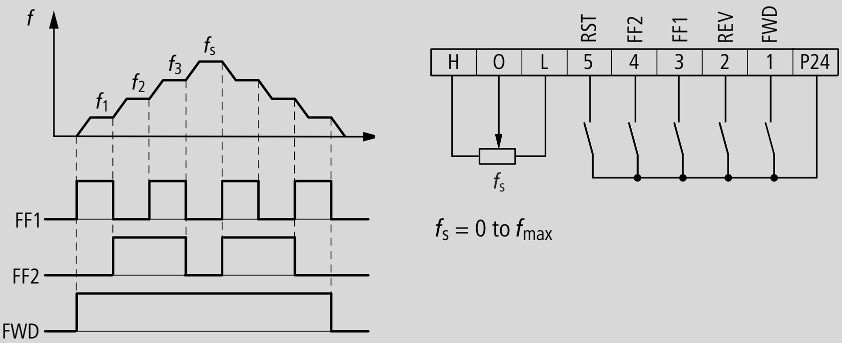
5 Programming the control signal terminals

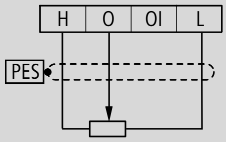
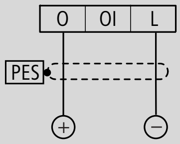
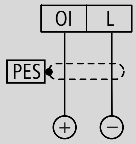
This section describes how to assign various functions to the control signal terminals.

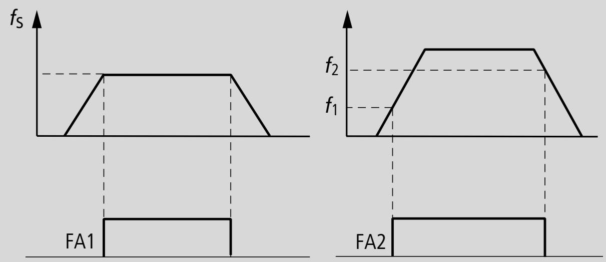
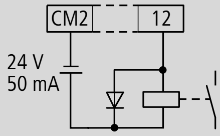
Overview

Table 9 provides an overview of the control signal terminals and a brief description of the functions which you can assign to the programmable digital inputs and outputs. For a detailed description of each function, see from page 56.

Table 9: Description of the functions

Name	Value1)	Function	Description
Digital inputs 1 to 5			Parameter definition under PNU C01 to C05
FWD	00	Clockwise (start/stop)	
REV	01	Anticlockwise (start/stop)	FWD input closed: motor starts up in a clockwise direction. FWD input open: controlled motor deceleration to stop (clockwise). REV input: as for FWD, but in an anticlockwise direction FWD and REV inputs closed simultaneously: controlled motor deceleration to stop.
FF1	02	Programmable fixed frequencies 1 to 4	Example: Four fixed frequencies 
FF2	03		
FF3	04		
FF4	05		For four fixed frequency stages (three programmable fixed frequencies and a setpoint value), two fixed frequency inputs (3 = FF1 and 4 = FF2) are required ($2^2 = 4$).
JOG	06	Jog mode	The jog mode, which is activated by switching on the JOG input, is used, for example, for setting up a machine in manual mode. When a start signal is received, the frequency programmed under PNU A38 is applied to the motor. Under PNU A39, you can select one of three different operating modes for stopping the motor.
2CH	09	Second time ramp	Activates the second acceleration and deceleration with PNU A92 and PNU A93 respectively
FRS	11	Controller inhibit (free run stop)	When FRS is switched on, the motor is immediately switched off and coasts to a stop.

Name	Value[1)]	Function	Description
EXT	12	External fault	When the EXT input is switched on, the fault signal activates PNU E12 and the motor switches off. The fault signal can be acknowledged, for example, with the RST input.
USP	13	Unattended start protection	When the USP input is switched on, unattended start protection is active. This prevents a motor restart when the voltage recovers after a mains failure while a start signal is present.
SFT	15	Parameter protection	The parameter protection, which is activated by switching on the SFT input, prevents loss of the entered parameters by inhibiting write operations to these parameters.
AT	16	Setpoint input OI (4 to 20 mA) active	When the AT input is active, only the setpoint value input OI (4 to 20 mA) is processed.
RST	18	Reset	To acknowledge an error message, switch on the RST input. If a reset is initiated during operation, the motor coasts to a stop. The RST input is a make (NO) contact; it cannot be programmed as a break (NC) contact.
PTC	19	Connection for a PTC thermistor	Only digital input 5 can be programmed as a PTC thermistor input with PNU C05. Use terminal L as the reference potential.
P24	–	+24 V ⎓ for digital inputs	24 V ⎓ potential for digital inputs 1 to 5
Frequency setpoint input			
h	–	+10 V setpoint voltage for external potentiometer	The setpoint value can be set with the potentiometer:  *R*: 1 to 10 kO Setpoint value through voltage input:  0 to 10 V ⎓ Input impedance: 10 kO Setpoint value through current input:  4 to 20 mA ⎓ Load resistor: 250 Ω
O	–	Analog input for frequency setpoint (0 to +10 V)	
OI	–	Analog input for frequency setpoint (4 to 20 mA)	
L	–	0 V reference potential for setpoint inputs	The OI input for a setpoint value from 4 to 20 mA is used only when the digital input configured as the AT input is closed.
Analog output			
FM	–	Frequency monitor	Through this output, the frequency can be issued through a connected analog or digital measurement device. Alternatively, the motor current can be output.
L	–	0 V	0 V reference potential for the FM output

Name	Value[1)]	Function	Description
Digital outputs 11 and 12			Parameterizing PNU C21 and C22
FA1	01	Signal when frequency is reached or exceeded	 f_S = setpoint frequency Connection of a signal relay to digital output 11 or 12:  Transistor output (open collector) (maximum 27 V ⎓, 50 mA)
FA2	02		If a digital output is configured as FA1, a signal is issued as long as the setpoint value is reached. If a digital signal is configured as FA2, a signal is output as long as the frequencies defined under PNU C42 and PNU C43 are exceeded.
RUN	00	RUN signal	The RUN signal is output during operation of the motor.
OL	03	Signal on overload	The OL signal is output when the overload alarm threshold (adjustable under PNU C41) is exceeded.
OD	04	Signal on PID control deviation	The OD signal is output when the PID control deviation set under PNU C44 is exceeded.
AL	05	Signal (alarm) on fault	The AL signal is issued when a fault occurs.
CM2	–	0 V	0 V reference potential for programmable digital outputs 11 and 12. These transistor outputs (open collector) are controlled through optocouplers, whose reference potential is CM2. CM2 is isolated from reference potential L.
Signalling relay			
K11	–	Signalling relay contacts	During normal fault-free operation, terminals K11-K14 are closed. If a malfunction occurs or the supply voltage is switched off, terminals K11-K12 are closed. Maximum permissible values: • 250 V ~; maximum load 2.5 A (purely resistive) or 0.2 A (with a power factor of 0.4) • 30 V ⎓; maximum load 3.0 A (purely resistive) or 0.7 A (with a power factor of 0.4) • Minimum required values: 100 V ~ at a load of 10 mA or 5 V ⎓ at a load of 100 mA
K12			
K14			

1) To activate the function, enter this value in the corresponding parameter.

Frequency indication through FM

The FM terminal provides the output frequency or the motor current as a frequency signal.

The selection between the frequency and motor current indication is made with PNU C23.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
C23	Indication through FM output	–	00	Indication of the output frequency (analog 0 to 10 V ⎓ signal)	00
			01	Indication of motor current (analog 0 to 10 V ⎓ signal; 100 % motor full load current corresponds to 5 V ⎓)	
			02	Indication of the output frequency (digital impulse signal)	

Analog frequency indication

The output (PNU C23 = 00 or 01) is a square wave signal with a constant period of oscillation. Its pulse width is proportional to the current frequency value (0 to 10 V correspond to 0 Hz to the end frequency).

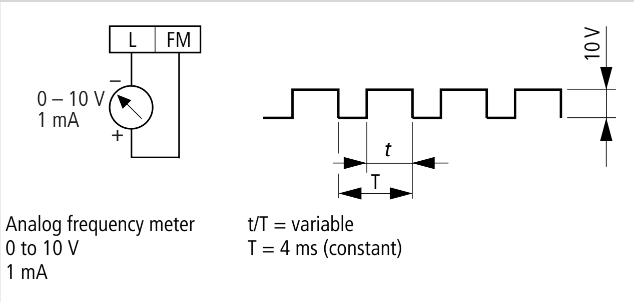


Figure 49: Connection of an analog frequency meter

Signal compensation takes place in PNU b81. The signal accuracy after compensation is ±5 %.

If for example, a higher level of smoothing of the FM signal is required for a motor current display, an external low-pass filter circuit is required. The accuracy is about ±20 %.

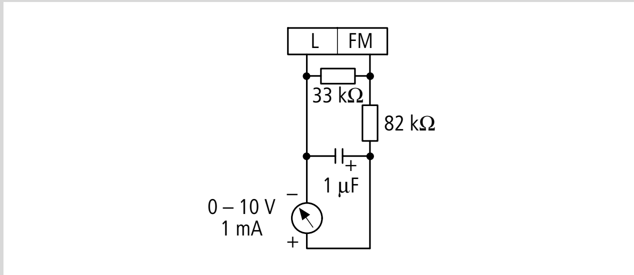


Figure 50: Example of a low-pass circuit

PNU	Name	Adjustable in RUN mode	Value	Function	DS
b81	Adjustment value for analog signal at FM terminal	✓	0 to 255	The analog signal issued at the FM terminal (frequency actual value or output current) can be adjusted here. The pulse signal (digital frequency actual value) cannot be compensated.	80

Digital frequency indication

The frequency of this signal (PNU C23 = 02) changes proportionally to the output frequency. The pulse duty factor remains constant at about 50 %.

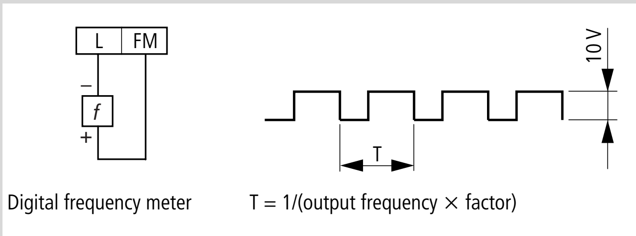


Figure 51: Digital frequency meter connection

The signal frequency results from the product of the current output frequency and a factor adjustable with PNU b86.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
b86	Frequency factor	✓	0.1 to 99.9	The product of the value displayed under PNU d01 and this factor is displayed at PNU d07. This value is also available at the FM terminal.	1.0

Programmable digital inputs 1 to 5

Various functions can be assigned to terminals 1 to 5. Depending on your requirements, you can configure these terminals as follows:

- clockwise start signal (FWD),
- anticlockwise start signal (REV),
- selection inputs for various fixed frequencies (FF1 to FF4),
- reset input (RST),
- etc.

The terminal functions for programmable digital inputs 1 to 5 are configured with PNU C01 to C05. I.e. you use PNU C01 to specify the function of digital input 1, PNU C02 to specify the function of digital input 2, etc. You cannot, however, assign the same function to two inputs.

Programmable digital inputs 1 to 5 are configured by default as make contacts. If, therefore, the function of an input terminal is to be activated, the corresponding input must be closed (i.e. the input terminal is connected to terminal P24). Conversely, to deactivate the input terminal, the input must be opened.

Caution!
If an EEPROM error occurs, (fault message E08), all parameters must be checked to ensure that they are correct (especially the RST input).

Table 10: Digital inputs 1 to 5

PNU	Terminal	Adjustable in RUN mode	Value	DS
C01	1	–	→ Table 11	00
C02	2			01
C03	3			02[1)]
C04	4			03[2)]
C05	5			18[3)]

1) 16 for DF5-320-…
2) 13 for DF5-320-…
3) 09 for DF5-320-…

For a detailed description of the input functions, see the pages listed in Table 11.

Table 11: Function of the digital inputs

Value	Function	Description	→ Page
00	FWD	Start/stop clockwise	59
01	REV	Start/stop anticlockwise	59
02	FF1	First fixed frequency input	60
03	FF2	Second fixed frequency input	
04	FF3	Third fixed frequency input	
05	FF4	Fourth fixed frequency input	
06	JOG	Jog mode	68
09	2CH	Second acceleration and deceleration time	63
11	FRS	Motor shutdown and free run stop	64
12	EXT	External fault	65
13	USP	Unattended start protection	66
15	SFT	Parameter protection	70
16	AT	Setpoint definition through current signal	62
18	RST	Reset	67
19	PTC	PTC thermistor input (digital input 5 only)	69

If required, the digital inputs can be configured as break (NC) contacts. To do this, enter 01 under PNU C11 to C15 (corresponding to digital inputs 1 to 5). An exception applies only to inputs configured as RST (reset) or PTC (PTC thermistor input). These inputs can be operated only as make (NO) contacts.

Caution!
If you reconfigure digital inputs set up as FWD or REV as break contacts (the default setting is as a make contact), the motor starts immediately. They should not be reconfigured as break contacts unless this is unavoidable.

Table 12: Configuring digital inputs as break contacts

PNU	Terminal	Value	Adjustable in RUN mode	Function	DS
C11	1	00 or 01	–	00: Make contact 01: Break contact	00
C12	2				
C13	3				
C14	4				
C15	5				

Start/stop

FWD: clockwise operation

If you activate a digital input which has been configured as a FWD input, the motor starts to run in a clockwise direction. When the input is deactivated, the motor is decelerated to a stop under frequency inverter control.

If you activate the FWD and the REV input at the same time, the motor is decelerated under frequency inverter control.

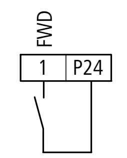


Figure 52: Digital input 1 configured as FWD (start/stop clockwise rotation)

REV: anticlockwise operation

When a digital input configured as REV is activated, the motor starts to run in an anticlockwise direction. When this input is deactivated, the motor is decelerated to a stop under frequency inverter control.

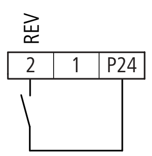


Figure 53: Digital input 2 configured as REV (start/stop anticlockwise rotation)

Issue start signal

By default, the start command is issued through the inputs configured as FWD or REV. If the start command is to be issued with the START key on the keypad, set PNU A02 to 01 (start command via FWD/REV input) (→ section "Start signal"page 82

- ▶ Program one of the digital inputs 1 to 5 as FWD by setting the corresponding PNU (C01 to C05) to 00.
- ▶ Program one of the digital inputs 1 to 5 as REV by setting the corresponding PNU (C01 to C05) to 01.

By default, REV is assigned to digital input 2.

Warning!
If the supply voltage for the frequency inverter is applied when the start signal is activated, the motor will start immediately. Make sure that the start signal is not active before the supply voltage is switched on.

Warning!
Note that, when the FWD input is opened (inactive condition if FWD/REV has been configured as a make contact) and is then reconfigured as break contact, the motor will start immediately after the reconfiguration.

Fixed frequency selection (FF1 to FF4)

With the digital inputs configured as FF1 to FF4, you can select up to 16 user-definable fixed frequencies (including frequency setpoints), depending on which of the inputs is active or inactive (→ Table 13). It is not necessary to use all the fixed frequency selection inputs at the same time. Using only three inputs, for example, allows you to choose between eight fixed frequencies; with two fixed frequency selection inputs, four fixed frequencies are available for selection.

The fixed frequencies have a higher priority than all other setpoint values and can be accessed at any time through inputs FF1 to FF4 without needing to be enabled separately. Jog mode, to which the highest priority is assigned, is the only operation with a higher priority than the fixed frequencies.

Table 13: Fixed frequencies

Fixed frequency stage	PNU	Input			
		FF4	FF3	FF2	FF1
0 = fs	Setpoint frequency	0	0	0	0
f	A21	0	0	0	1
f	A22	0	0	1	0
f	A23	0	0	1	1
f	A24	0	1	0	0
f	A25	0	1	0	1
f	A26	0	1	1	0
f	A27	0	1	1	1
f	A28	1	0	0	0
f	A29	1	0	0	1
f	A30	1	0	1	0
f	A31	1	0	1	1
f	A32	1	1	0	0
f	A33	1	1	0	1
f	A34	1	1	1	0
f	A35	1	1	1	1

0 = input deactivated
1 = input activated

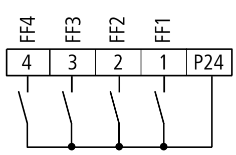


Figure 54: Digital inputs 1 to 4 configured as FF1 to FF4 (fixed frequency)

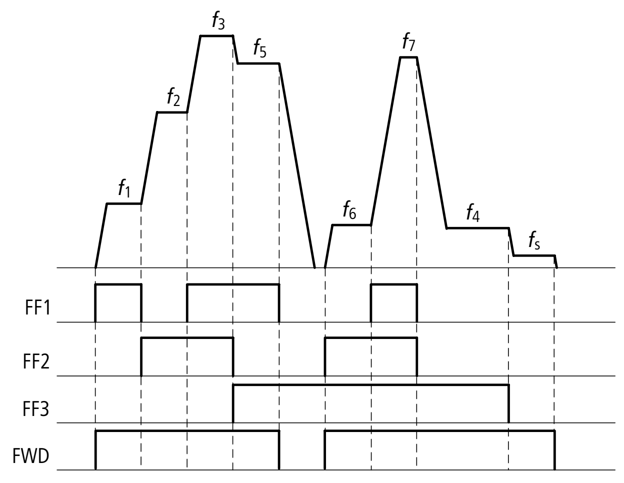


Figure 55: Function chart for FF1 to FF3 (fixed frequency control)

▶ Program one or more of the digital inputs 1 to 5 as FF1 to FF4, by entering the value 02 (FF1) to 05 (FF4) under the corresponding PNU (C01 to C05).

By default, FF1 is preassigned to digital input 3 and FF2 to digital input 4.

The fixed frequencies can be programmed in two ways:

- by entering the fixed frequencies under PNU A21 to A35,
- by entering the fixed frequencies under PNU F01.

With PNU F01, you can change parameters even if parameter protection PNU b31 has been set (→ page70).

Entering the fixed frequencies under PNU A21 to A35

▶ Go to PNU A21 and press the PRG key.
▶ Use the arrow keys to enter the fixed frequency and confirm with the ENTER key.
▶ Enter the remaining fixed frequencies by repeating these steps for PNU A22 to A35.

Entering the fixed frequencies under PNU F01.

Before you can enter the frequencies under PNU F01, you must enter the value 02 in PNU A01.

▶ To select a fixed frequency stage, activate the digital inputs as listed in Table 13.
▶ Go to PNU F01.

The current frequency appears on the display.

▶ Use the arrow keys to enter the fixed frequency and confirm with the ENTER key.

The entered value is saved under the parameter which you have selected with the digital inputs (→ Table 13).

▶ Repeat these steps for your additional fixed frequencies.

Specifying frequency setpoints

The frequency setpoint value can be assigned in one of three ways, depending on PNU A01:

- via the installed potentiometer on the keypad, PNU A01 = 00;
- via analog input O (0 to 10 V) or OI (4 to 20 mA), PNU A01 = 01 (default setting);
- via PNU F01 or PNU A20, PNU A01 = 02.

Selecting fixed frequencies

▶ The set fixed frequency values are selected by activating the corresponding digital inputs (→ Table 13).

Table 14: Fixed frequency parameters

PNU	Name	Adjustable in RUN mode	Value	Function	DS
A01	Frequency setpoint definition	–	00	Definition with the potentiometer on the keypad	01
			01	Definition through analog input O (0 to 10 V) or OI (4 to 20 mA)	
			02	Definition under PNU F01 and/or PNU A20	
A20	Setpoint frequency	✓	0.5 to 360 Hz	You can enter a frequency setpoint value. You must input 02 under PNU A01 for this purpose.	0.0
A21	Fixed frequency			You can assign a frequency to each of the 15 fixed frequency parameters from PNU A21 to A35.	
A22					
A23					
…					
A35					
F01	Indication/ input of frequency value			Indication of the current frequency setpoint value or the current fixed frequency. Modified values are saved with the ENTER key according to the selection of the digital inputs configured as FF1 to FF4. Resolution ±0.1 Hz	

→ If one or more of the fixed frequencies exceeds 50 Hz you must first increase the end frequency with PNU A04 (→ section “Maximum end frequency”, page 82).

→ Fixed frequency stage 0 (none of the inputs FF1 to FF4 are activated) corresponds to the frequency setpoint value. Depending on the value entered in PNU A01, this can be defined with the installed potentiometer, the setpoint value inputs O and/or OI or through PNU F01 and PNU A20.

Current setpoint value AT (4 to 20 mA)

When the digital input which has been configured as AT is active, the setpoint value is defined by the current flow (4 to 20 mA) at terminal OI. If however the AT input is inactive, the setpoint value is defined by the voltage present (0 to 10 V) at terminal O.

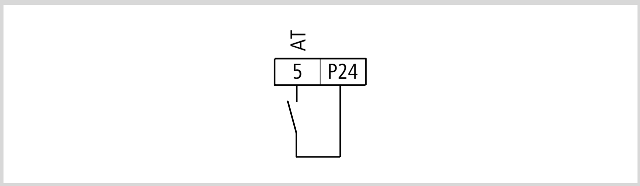


Figure 56: Digital input 5 configured as AT (setpoint definition through current signal)

Under PNU A01, enter the setpoint frequency input method. At the default setting of 01, the voltage (0 to 10 V) at terminal O or the incoming current of 4 to 20 mA at terminal OI is interpreted as the setpoint value. If none of the digital inputs are configured as AT, both voltage input O and current input OI are active. The setpoint frequency is then determined by adding the two input signals.

▶ Program one of the digital inputs 1 to 5 as AT by entering the value 16 under the corresponding PNU (C01 to C05).

Digital input AT		**Signal at terminal**		**Control**	**Output frequency**
Configured	**Active**	**O**	**OI**		
No	–	30 %	40 %	O + OI	70 %
No	–	60 %	70 %	O + OI	100 % (60 % + 70 % > 100 % => 100 %)
Yes	No	30 %	40 %	O	30 %
Yes	No	0 %	40 %	O	0 %
Yes	Yes	30 %	40 %	OI	40 %
Yes	Yes	30 %	0 %	OI	0 %

2CH: Second time ramp

If the digital input configured as 2CH is active, the motor is accelerated or braked with the second acceleration or deceleration time. If the 2CH input is again deactivated, a changeover to the first acceleration/deceleration time takes place.

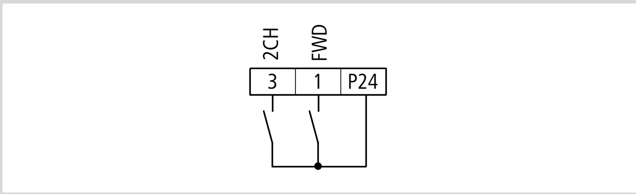


Figure 57: Digital input 3 configured as 2CH (second time ramp)

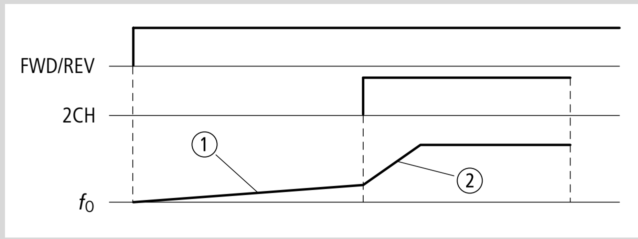


Figure 58: Function chart for 2CH (second acceleration time)

f_0: Output frequency

① First acceleration time

② Second acceleration time

- ▶ Under PNU A92 and PNU A93, set the required value for the second acceleration and deceleration time.
- ▶ Then, set PNU A94 to 00 so that the changeover to the second acceleration and deceleration time through the 2CH input is enabled (this is the default setting).
- ▶ Program one of the digital inputs 1 to 5 as 2CH, by setting the corresponding PNU (C01 to C05) to 09.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
A92	Second acceleration time	✓	0.1 to 3000 s	Setting times for the second acceleration and deceleration time 0.1 to 999.9 s; resolution: 0.1 s 1000 to 3000 s; resolution: 1 s	15
A93	Second deceleration time				
A94	Changeover from the first to the second time ramp	–	00	Changeover to the second time ramp if an active signal is present at digital input 2CH.	00
			01	Changeover to the second time ramp when the frequencies entered in PNU A95 and/or A96 are reached.	

→ If you set PNU A94 to 01, the changeover to the second acceleration or deceleration time can take place automatically at the frequency set under PNU A95 or A96 (→ section "Time ramps" page 99)

→ The value for the first acceleration and deceleration time is defined in PNU F01 and F02 (→ section "Acceleration time 1" page 80)

Controller inhibit and coasting (free run stop – FRS)

If you activate the digital input configured as FRS, the motor is switched off and coasts to a stop (for example if an Emergency-Stop is made). If you deactivate the FRS input, then, depending on the inverter's configuration, the frequency output is either synchronized to the current speed of the coasting motor or restarts at 0 Hz.

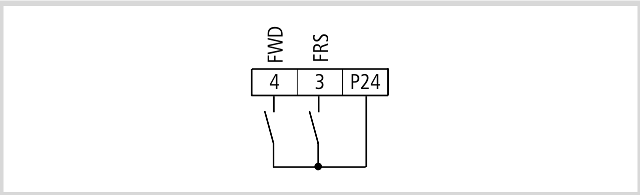


Figure 59: Configuration of digital input 3 as "controller inhibit" FRS (free run stop) and 4 as FWD (start/stop clockwise rotation)

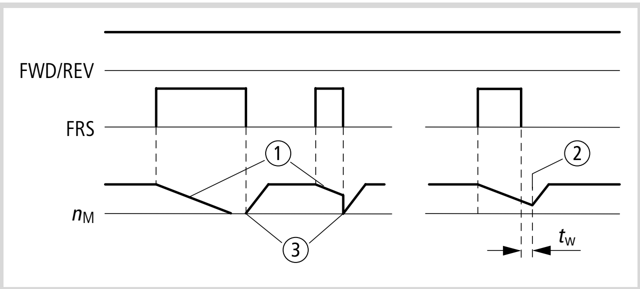


Figure 60: Function chart for FRS (control inhibit and free run stop)

n_M: Motor speed

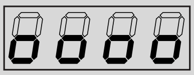
t_W: Waiting time (setting under PNU b03)

① Motor coasts to a stop

② Synchronization to the current motor speed

③ Restart from 0 Hz

- ▶ Use PNU b88 to specify whether the motor is to restart at 0 Hz after the FRS input has been deactivated, or if synchronization to the current motor speed should take place after a waiting time specified under PNU b03.
- ▶ Program one of the digital inputs 1 to 5 as FRS by setting the corresponding PNU (C01 to C05) to 11.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
b03	Waiting time before restart	–	0.3 to 100 s	Here, set a time which is to expire before an automatic restart is initiated after a fault signal. This time can also be used in conjunction with the FRS function. During the delay, the following message appears on the LED display: 	1.0
b88	Motor restart after removal of the FRS signal	–	00	0 Hz restart after deactivation of the FRS input	00
			01	Synchronization of the motor to the current motor speed after the waiting time entered under PNU b03.	

EXT: External fault message

When the digital input configured as EXT is activated, fault message E12 is issued (for example to be used as input for thermistor contacts). The fault message remains active even if the EXT input is deactivated again and must be acknowledged with a reset.

A reset can be carried out with:

- the RST input or
- the STOP key.
- Alternatively, the supply voltage can be switched off and on again.

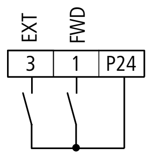


Figure 61: Digital input 1 configured as FWD (start/stop clockwise operation) and digital input 3 as EXT (external fault)

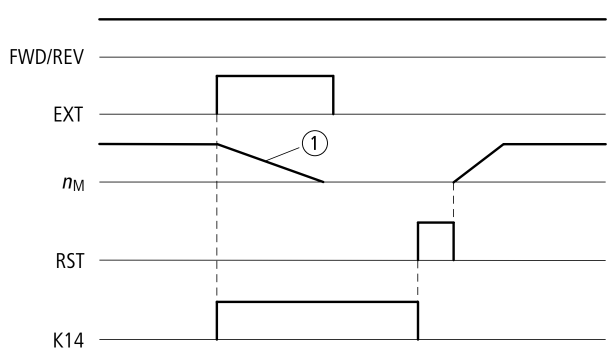


Figure 62: Function chart for EXT (external fault message)

n_M: Motor speed

K14: Signalling relay contact K14

① Motor coasts to a stop

▶ Program one of the digital inputs 1 to 5 as EXT by setting the corresponding PNU (C01 to C05) to 12.

Warning!
After a reset, the motor restarts immediately if a start signal (FWD or REV) is active.

USP: Unattended start protection

If the digital input configured as USP is activated, unattended start protection is also activated. This prevents a restart of the motor when the voltage recovers after a mains fault while a start signal (active signal on FWD or REV) is present. Fault message E13 is issued. E13 is cancelled by pressing the STOP key or with an active signal on the RST input. Alternatively, the start signal can be revoked.

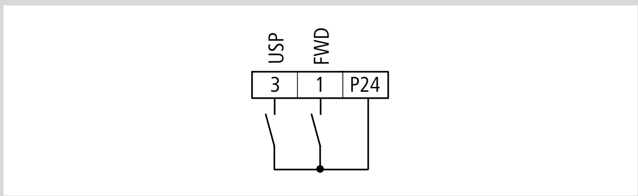


Figure 63: Digital input 1 configured as FWD (start/stop clockwise operation) and digital input 3 as USP (unattended start protection).

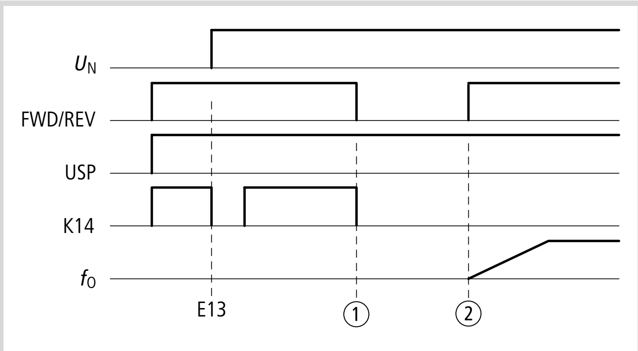


Figure 64: Function chart for USP (unattended start protection)

ΔU_N:Supply voltage

K14: Signalling relay contact K14

f_0: Output frequency

① Revoke start signal (alarm no longer present)

② Start signal

▶ Program one of the digital inputs 1 to 5 as USP by setting the corresponding PNU (C01 to C05) to 13.

Warning!
If unattended start protection is triggered (fault message E13) and the fault message is acknowledged with a reset command while a start signal is still active (input FWD or REV active), the motor will restart immediately.

→ If you issue a start signal within three seconds of reestablishing the power supply and unattended start protection is active, the unattended start protection is also triggered and issues fault message E13. When unattended start protection is used, you should therefore wait for at least three seconds before issuing a start signal to the frequency inverter.

→ Unattended start protection can still be activated when you issue a reset command through the RST input after an undervoltage fault message (E09) has occurred.

RST: Reset

A fault message can be acknowledged by activating and subsequently deactivating (i.e. resetting) the digital input configured as RST.

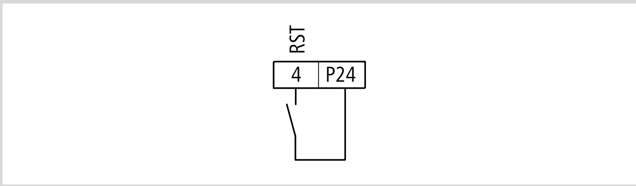


Figure 65: Digital input 4 configured as RST (reset)

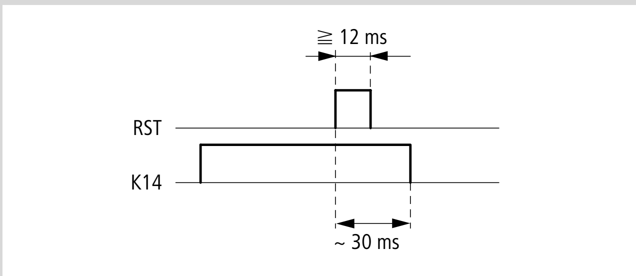


Figure 66: Function chart for RST (reset)

K14: Signalling relay contact K14

▶ Program one of the digital inputs 1 to 5 as RST by setting the corresponding PNU (C01 to C05) to 18.

By default, RS is assigned to digital input 5.

Warning!
If a reset is carried out after a fault, the motor will start immediately if a start signal is applied simultaneously. To avoid the risk of serious or fatal injury to personnel, you must ensure that the start signal is not present before acknowledging an error message with a reset .

→ When a fault has occurred, the STOP key on the keypad acts as a RESET key. and can be used instead of the RST input to reset the fault.

→ If the RST input is active for more than four seconds, it can cause a false trip.

→ The RST input is always a make (NO) contact and cannot be programmed as a break (NC) contact.

→ Alternatively, you can acknowledge a fault message by briefly switching the supply voltage off and on again.

→ If a reset is initiated during operation, the motor coasts to a stop.

JOG: Jog mode

When the digital input configured as JOG is activated, the motor can be operated in jog mode. This mode is used, for example, for manual setting up of a machine by issuing a start signal on the FWD or REV input with a relatively low frequency without applying an acceleration ramp to the motor.

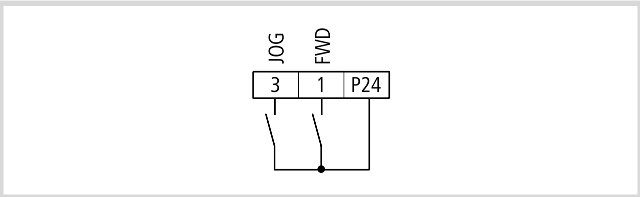


Figure 67: Digital input 1 configured as FWD (start/stop clockwise operation) and 3 as JOG (jog mode).

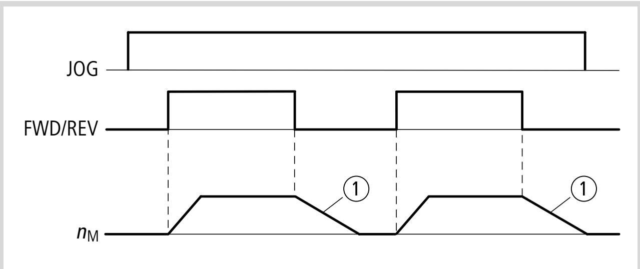


Figure 68: Function chart for JOG (jog mode)

n_M: Motor speed

① Depending on the value of PNU A39
00: Coasting
01: Deceleration ramp
02: DC braking

▶ First, under PNU A38, enter the frequency which is to be applied to the motor when jog mode is active.

Make sure that the frequency is not too high, as it is applied directly to the motor without an acceleration ramp. This could cause a fault message. Set a frequency below about 5 Hz.

▶ Because the start signal is issued through the FW or REV input in jog mode, PNU A02 must be set to 01.
▶ Under PNU A39, specify how the motor is to be braked.
▶ Program one of the digital inputs 1 to 5 as JOG by entering the value 06 under the corresponding PNU (C01 to C05).

Caution!
Make sure that the motor has stopped before using jog mode.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
A02	Start signal	–	01	The signal for starting the motor is issued through the digital inputs configured as FWD or REV.	01
			02	The signal for starting the motor is issued with the START key on the keypad.	
A38	Frequency in jog mode	✓	0.5 to 9.99 Hz	The frequency to be applied to the motor in jog mode.	1.0
A39	Type of motor stop in jog mode	–	00	Stop signal active: the motor coasts to halt	00
			01	Stop signal active: The motor is decelerated to standstill using a deceleration ramp.	
			02	Stop signal active: The motor is decelerated to standstill using DC braking.	

→ Operation in jog mode is not possible when the jogging frequency set under PNU A38 is less than the start frequency set under PNU b82 (→ section "RUN signal" page 74).

→ Jog mode can only be activated when the frequency inverter is in the Stop state.

PTC thermistor input

If programmable digital input 5 is configured as PTC, the motor temperature can be monitored with a thermistor with a positive temperature coefficient (PTC) connected to terminals 5 and L. If the resistance of the thermistor rises above 3000 Ω (±10 %), the motor is stopped and fault message E35 is displayed.

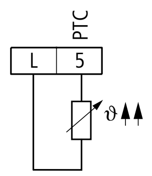


Figure 69: Digital input 5 configured as PTC (thermistor input)

▶ Program digital input 5 as PTC by setting PNU C05 to 19.

→ The PTC thermistor can be connected only to digital input 5; digital inputs 1 to 4 can not be used.

→ If digital input 5 is configured as PTC, but no thermistor is connected, fault message E35 is displayed.

→ The PTC input is always a make contact; it cannot be configured as a break contact.

If the DF5 has issued fault signal E35 and you want to reprogram digital input 5, which is configured as PTC, do the following:

▶ Connect a link between digital input 5 and terminal L.
▶ Press the STOP key to acknowledge the fault message.
▶ You can now assign a new function to digital input 5 under PNU C05.

SFT: Software protection

When you activate the digital input configured as SFT, the configured parameters cannot be overwritten unintentionally.

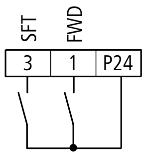


Figure 70: Digital input 3 configured as SFT (software protection)

- ▶ With PNU b31, specify whether software protection will also apply to the frequency setting under PNU F01.
- ▶ Then, program one of the digital inputs 1 to 5 as SFT by setting the corresponding PNU (C01 to C05) to 15.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
b31	Software-dependent parameter protection	–	00	Software protection through SFT input; all functions inhibited	01
			01	Software protection through SFT input; input through PNU F01 possible	
			02	Software protection without SFT input; all functions inhibited	
			03	Software protection without SFT input; input through PNU F01 possible	

→ There is, however, an alternative method of software protection available which does not require an SFT input. For this, enter the value 02 or 03 under PNU b31 depending on whether software protection should also apply to the frequency setting under PNU F01 or not.

Programmable digital outputs 11 and 12

Programmable digital outputs 11 and 12 are open collector transistor outputs (→ Fig. 71), to which you can connect, for example, relays (such as ETS4-VS3, Order No. 083094). These outputs can both be used for various functions, for example to signal when a determined frequency setpoint is reached or when a fault occurs.

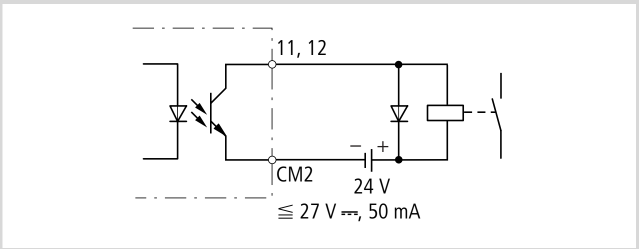


Figure 71: Digital output, relay (e.g. ETS4-VS3)

Transistor output: maximum 27 V ⎓, 50 mA

The terminal functions for programmable digital outputs 11 and 12 are configured under PNU C21 and C22 respectively, i.e. PNU C21 defines the function of digital output 11, and PNU C22 the function of digital output 12.

Table 15: Digital outputs 11 and 12

PNU	Terminal	Adjustable in RUN mode	Value	DS
C21	11	–	→ Table 16	01
C22	12			00

For a detailed description of the output functions, see the pages listed in Table 16.

Table 16: Functions of the digital outputs

Value	Function	Description	a page
00	RUN	Signal during motor operation	74
01	FA1	Frequency setpoint reached	73
02	FA2	Frequency exceeded	
03	OL	Overload signal	75
04	OD	PID control deviation exceeded	76
05	AL	Fault	77

Programmable digital outputs 11 and 12 are by default configured as make (NO) contacts. If, therefore, you activate the function of an output terminal, the corresponding input closes; If you deactivate it, the output opens.

Optionally, you can configure the digital outputs as break (NC) contacts. To do this, enter 01 under PNU C31 and C32 (corresponding to digital output 11 and 12).

Table 17: Configuration of digital outputs as break contacts

PNU	Terminal	Value	Adjustable in RUN mode	Function	DS
C31	11	00 or 01	–	00: Make contact 01: Break contact	00
C32	12				

Directly connecting digital outputs 11 and 12 with digital PLC inputs

You can connect the frequency inverter's digital outputs 11 and 12 (negative logic) directly to the digital inputs of a PLC (positive logic) as follows:

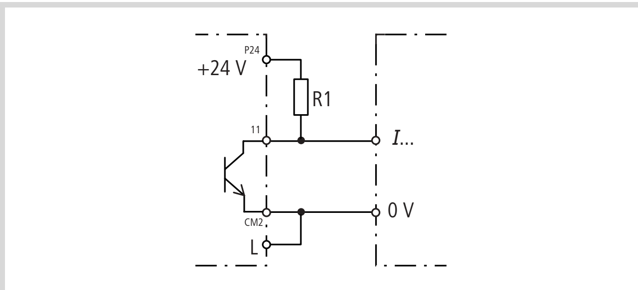


Figure 72: Digital output 11 with pull-up resistor R1

▶ Connect digital output 11 or 12 through R1 with terminal P24.

This connects the digital output with +24 V.

By default, digital outputs 11 and 12 are configured as make contacts. If a digital output is not active, the PLC's digital input receives a HIGH signal. If the digital output is active, the PLC receives a LOW signal.

For an open-circuit protected circuit, configure the digital outputs as break contacts (PNU C31 = 0, PNU C32 = 0).

The value of R1 depends on the PLC or control relay used:

easy	2.2 kΩ	0.5 W
PS4/PS416	1.5 kΩ	1.0 W

If you are using only one digital output, you can connect it without any accessories.

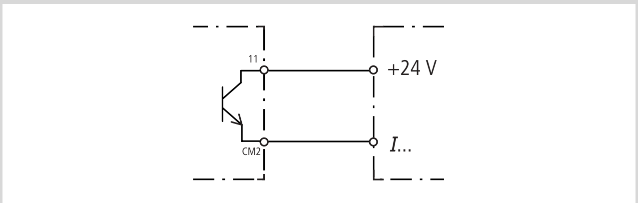


Figure 73: Connecting digital output 11 to PLC

Frequency value signal FA1/FA2

The digital output configured as FA1 is activated as soon as the setpoint frequency is reached (→ Fig. 74).

The digital output configured as FA2 becomes active when the frequency falls below the frequency set under PNU C42. FA2 is deactivated as soon as the actual frequency falls below the value set in PNU C43. The frequency specified with PNU C42 must be higher than the frequency in PNU C43. If PNU F01 or PNU A20 is used for the reference input, the frequency set with PNU C42 can be smaller than the value in PNU C43. (→ Fig. 76).

To ensure system hysteresis, signals FA1 and FA2 are activated each time the actual frequency is 0.5 Hz short of the setpoint or the frequency set under PNU C42 and deactivated 1.5 Hz past the setpoint or the frequency set under PNU C43.

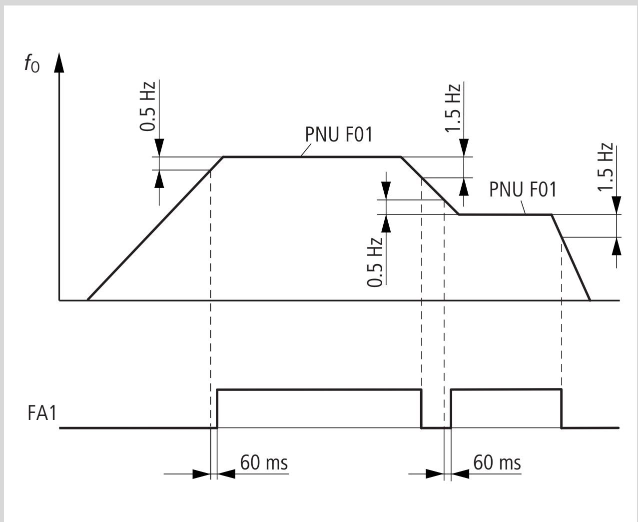


Figure 74: Function chart for FA1 (frequency reached)

f_0: Output frequency

F01: Setpoint value

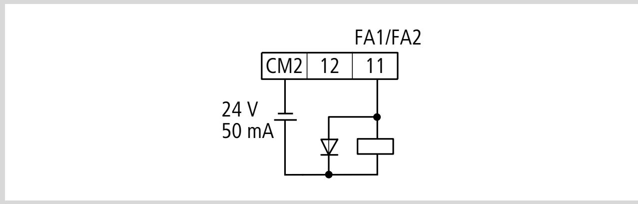


Figure 75: Digital output 11 configured as FA1/FA2 (frequency reached/exceeded)

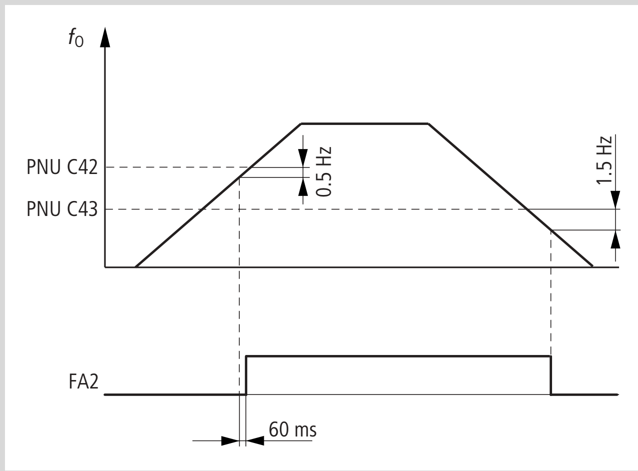
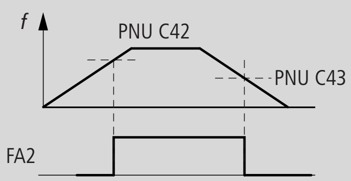


Figure 76: Function chart for FA2 (frequency exceeded)

f_0: Output frequency

- ▶ If you configure a programmable digital output as FA2, you must also, under PNU C42, enter the frequency from which the FA2 signal is active during acceleration.
- ▶ With PNU C43, set the respective frequency which is to remain active until the FA2 signal is deactivated during deceleration.
- ▶ Then, program one of the digital outputs 11 or 12 as the FA1 or FA2 output by setting PNU C21 or PNU C22 to 01 for FA1 or 02 for FA2.

→ The transition of an FA1 or FA2 signal from the inactive to the active state takes place with a delay of about 60 ms.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
C42	Frequency from which FA2 becomes active during acceleration	–	0 to 360 Hz	 The digital output (11 or 12) configured as FA2 becomes active when the frequency entered here is exceeded during acceleration.	0.0
C43	Frequency at which FA2 becomes inactive during deceleration			The digital output (11 or 12) configured as FA2 remains active as long as the actual frequency remains higher than the frequency entered during deceleration (→ also the illustration for PNU C42).	

RUN signal

The digital output configured as RUN remains activated as long as a frequency not equal to 0 Hz is present, i.e. as long as the motor is driven in a clockwise or anticlockwise direction.

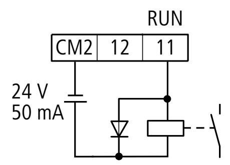


Figure 77: Digital output 11 configured as RUN (Run signal)

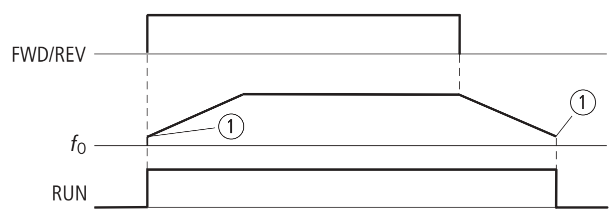


Figure 78: Function chart for RUN "operational"

f_0: Output frequency

① Starting frequency defined with PNU b82

▶ Program one of the digital outputs 11 or 12 as a RUN output by setting PNU C21 or PNU C22 to 00.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
b82	Increased starting frequency	–	0.5 to 9.9 Hz	A higher starting frequency results in shorter acceleration and deceleration times (for example to overcome high frictional resistance). If the frequencies are too high, fault message E02 may be issued. Up to the set starting frequency, the motor accelerates without a ramp function.	0.5

Overload signal (OL)

The digital output configured as OL is activated when a user-definable motor current is exceeded. The OL output is active as long as the motor current is higher than this threshold.

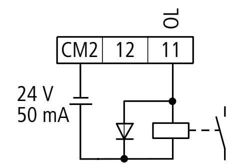


Figure 79: Digital output 11 configured as an OL (overload signal)

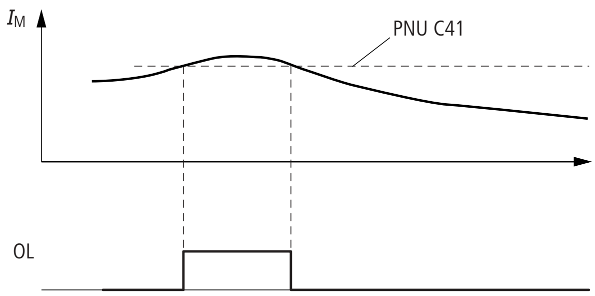


Figure 80: Function chart for OL (overload signal)

I_M: Motor current

- To configure a programmable digital output as OL, define the current under PNU C41 at which, when exceeded, the OL signal is activated.
- Then, define one of the digital outputs 11 or 12 as OL output by setting PNU C21 or PNU C22 to 03.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
C41	Overload alarm threshold	–	0 to 2 × I_e 1)	The current value entered here determines when the OL signal should be activated.	I_e 1)

1) Frequency inverter rated current

PID control deviation signal (OD)

The digital output configured as OD is activated when a user definable PID deviation (of the actual value from the setpoint value) is exceeded. The OD output remains active as long as this differential is exceeded.

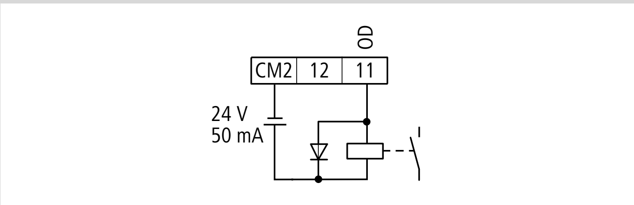


Figure 81: Digital output 11 configured as OD "PID deviation"

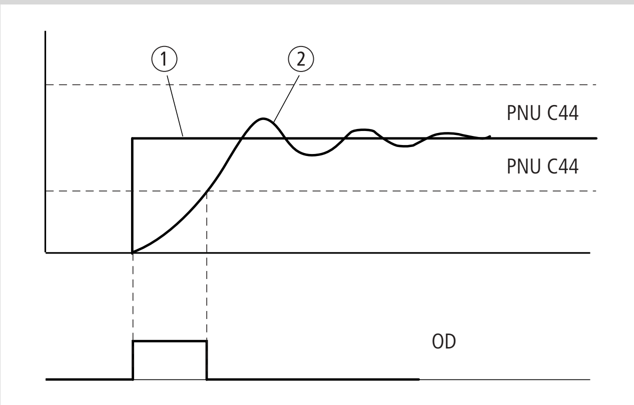


Figure 82: Function chart for OD (PID control deviation)

① Setpoint

② Actual value

- ▶ If you configure a programmable digital output as OD, you must also, under PNU C44, enter the threshold at which the OD signal is activated when the value is exceeded.
- ▶ Program one of the digital outputs 11 or 12 as OD by setting PNU C21 or PNU C22 to 04.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
C44	PID regulator deviation	–	0 to 100%	If the deviation between the setpoint and actual value exceeds the value entered here when PID control is active, the OD signal is activated.	3.0

Fault signal (AL)

The digital output configured as AL activates when a fault has occurred.

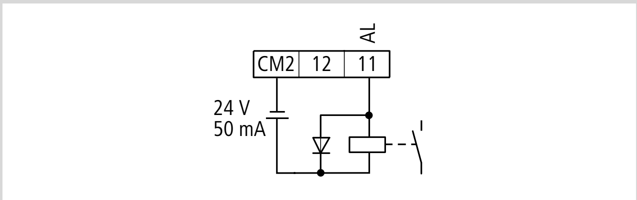


Figure 83: Digital output 11 configured as AL (fault occurrence)

▶ Program one of the digital outputs 11 or 12 as an AL by setting PNU C21 or PNU C22 to 05.

When the AL output is configured as a break contact, remember that there is a delay from the time the supply voltage is switched on until the AL output is closed, and a fault message relating to the AL output therefore appears for a short time after the supply is switched on.

Please note that the programmable digital outputs (including the one configured as AL) are open collector types and therefore have different electrical characteristics than the signalling relay outputs (terminals K11, K12 and K14). In particular, the maximum voltage and current carrying capacity ratings are significantly lower than those of the relay outputs.

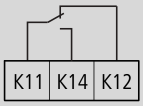
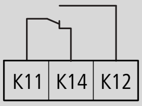
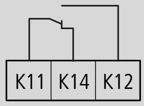
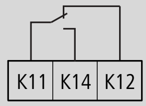
After the frequency inverter supply voltage has been switched off, the AL output remains active until the DC bus voltage has dropped below a certain level. This time depends, among other factors, on the load applied to the inverter.

The delay from the time a fault occurs until the AL output is activated is about 300 ms.

Signalling relay terminals K11, K12, K14

If a fault occurs, the signalling relay (changeover) is triggered. The switching conditions can be programmed as required.

Table 18: Default setting of the signalling relay

Default setting of the signalling relay				Reconfigured signalling relay terminals (PNU C33 = 00)			
Fault or DF5 switched off 		Run signal 		Fault message 		Run signal or DF5 switched off 	
Voltage	**Operating state**	**K11-K12**	**K11-K14**	**Voltage**	**Operating state**	**K11-K12**	**K11-K14**
On	Normal	Open	Closed	On	Normal	Closed	Open
On	Fault	Closed	Open	On	Fault	Open	Closed
Off	–	Closed	Open	Off	–	Closed	Open

▶ Use the above table to configure contacts K11–K12 or K11K14 as make or break contacts under PNU C33.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
C33	Signalling relay output	–	00	K11-K14 close with a fault message	01
			01	K11-K14 close when the supply voltage is applied	

After a fault has occurred, the associated fault message is retained even after the voltage supply is switched off. The fault message can be viewed again after the voltage has been switched back on. However, the inverter is reset when the device is switched off, i.e. the fault message will not be signalled on the terminals of the signalling relay after the inverter is switched back on.

→ If however, the fault signal is to be retained even after the inverter is switched back on, a latching (self maintaining) relay should be used.

Note that, when the signalling relay output is configured as a break contact, there is a delay from the time the supply voltage is switched on until the AL output is closed, and that a fault message for the AL output therefore appears for a short time after the supply is switched on.

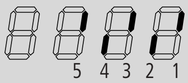
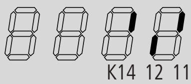
6 Setting Parameters

The parameters listed in this section can be set using the keypad.

The adjustment and setting possibilities listed below are thematically arranged according to their function. This provides a clear overview of all parameters assigned to a particular functional area (e.g. section “DC braking (DCB)”, PNU A51 to A55).

Setting the display parameters

This section describes the parameters with which you can set the display of the LCD keypad.

PNU	Name	Function
d01	Output frequency in Hz	Output frequency display from 0.5 to 360 Hz. The “Hz” lamp on the keypad lights up.
d02	Motor current in A	Display of the output current from 0.01 to 999.9 A. The “A” lamp on the keypad lights up.
d03	Direction of rotation	Display: • F for clockwise operation (forward), • r for anticlockwise operation (reverse), • 0 for stop
d04	Actual value × factor	Only with active PID control. The factor is set under PNU A75 and can have a value from 0.01 to 99.99; the default is 1.0.
d05	Status of digital inputs 1 to 5	 Example: Digital inputs 1, 3 and 5 are activated. Digital inputs 2 and 4 are deactivated.
d06	Digital outputs 11 and 12 and fault message output	 Example: Digital output 11 and signal output K14 are activated. Digital output 12 is deactivated.
d07	Output frequency × factor	Indication of the product of the factor (PNU b86) and the output frequency in the range 0.01 to 99990. Examples: • Display indication 11.11 corresponds to 11.11, • 111.1 corresponds to 111.1, • 1111. corresponds to 1111, • 1111 corresponds to 11110.
d08	Last alarm indication	Display of the most recent fault message and (after the PRG key is pressed) the output frequency, motor current and DC bus voltage at the time the fault occurred. If there is no current fault message, the display shows ---
d09	Older fault messages (fault history register)	Display of the second from last and (after the PRG key is pressed) third from last fault message. If neither the second from last or third from last fault message has been saved, the display shows ---

Basic functions

Input/indication of frequency value

PNU F01 displays the current frequency setpoint value or the current fixed frequency. You can change the frequencies with the arrow keys and save the settings in accordance with the setting of PNU A01 and the fixed frequency stages FF1 to FF4 (digital inputs) (→ section "Fixed frequency selection (FF1 to FF4)", page 60).

With PNU F01, you can change parameters even when the parameter protection PNU b31 has been set (→ page70).

Input/indication of frequency setpoint value
If you have not activated any fixed frequencies, PNU F01 displays the frequency setpoint value.

The frequency setpoint value can be assigned in one of three ways, depending on PNU A01:

- via the installed potentiometer on the keypad, PNU A01 = 00;
- via analog input O (0 to 10 V) or OI (4 to 20 mA), PNU A01 = 01 (default setting);
- via PNU F01 or PNU A20, PNU A01 = 02.

If you specify the setpoint frequency with PNU A20, (→ page81), you can enter a new value under PNU F01, This is automatically saved under PNU A20:

▶ Change the current value with the arrow keys.
▶ Save the modified value with the ENTER key.

The saved value is automatically written to PNU A20.

Input/indication of frequency value
If you have activated the fixed frequencies via the functions FF1 to FF4 of the digital inputs, PNU F01 displays the selected fixed frequencies.

For details about changing the fixed frequencies, see section "Entering the fixed frequencies under PNU F01.", page 60.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
F01	Input/indication of frequency setpoint value	✓	0.5 to 360 Hz	Resolution ±0.1 Hz The setpoint can be defined using various methods: • With PNU F01 or A20: Enter the value 02 under PNU A01. • With the potentiometer on the keypad: Enter the value 00 under PNU A01. • With a 0 to 10 V voltage signal or a 4 to 20 mA current signal at input terminals O or OI: Enter the value 01 under PNU A01. • With the digital inputs configured as FF1 to FF4. After selection of the required fixed frequency stage using FF1 to FF4, the frequency for the respective stage can be entered. The display of the setpoint value is independent of which method was used to set the setpoint value.	0.0

Acceleration time 1

Acceleration time 1 defines the time in which the frequency inverter reaches its end frequency after a start signal is issued.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
F02	Acceleration time 1	✓	0.1 to 3000 s	Resolution of 0.1 s at an input of 0.1 to 999.9 Resolution of 1 s at an input of 1000 to 3000	10.0

Deceleration time 1

Deceleration time 1 defines the time in which the frequency inverter reduces the output frequency from the end frequency to 0 Hz after a stop signal.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
F03	Deceleration time 1	✓	0.1 to 3000 s	Resolution of 0.1 s at an input of 0.1 to 999.9 Resolution of 1 s at an input of 1000 to 3000	10.0

Direction of rotation

The direction of rotation defines the direction in which the motor turns after a start signal is issued.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
F04	Direction of rotation	–	00	The motor runs in a clockwise direction.	00
			01	The motor runs in an anticlockwise direction.	

Setting the frequency and start signal parameters

This section describes the methods for adjusting and setting the start signal and basic frequency parameters.

Frequency setpoint definition

With PNU A01, you set how the frequency setpoint value is to be defined:

- using the potentiometer on the keypad
- via analog input O (0 to 10 V) or OI (4 to 20 mA)
- through PNU F01 or PNU A20

PNU	Name	Adjustable in RUN mode	Value	Function	DS
A01	Frequency setpoint definition	–	00	Definition with the potentiometer on the keypad	01
			01	Definition through analog input O (0 to 10 V) or OI (4 to 20 mA)	
			02	Definition under PNU F01 and/or PNU A20	
A20	Setpoint frequency	✓	0.5 to 360 Hz	You can enter a frequency setpoint value. You must assign 02 under PNU A01 for this purpose.	0.0
F01	Indication/ input of frequency value	✓		Indication of the current frequency setpoint value or the current fixed frequency. Modified values are saved with the ENTER key according to the selection of the digital inputs configured as FF1 to FF4 (→ section "Fixed frequency selection (FF1 to FF4)"page 60 Resolution ±0.1 Hz	

Start signal

With PNU A02, you define whether the start signal is issued using the ON key of the keypad or through the digital inputs configured as FWD and REV.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
A02	Start signal	–	01	The signal for starting the motor is issued through the digital inputs configured as FWD or REV.	01
			02	The signal for starting the motor is issued with the START key on the keypad.	

Base frequency

The base frequency is the frequency at which the output voltage has its maximum value.

PNU	Name	Adjustable in RUN mode	Value	DS
A03	Base frequency	–	50 to 360 Hz	50[1)]

1) 60 for DF5-320-…

Maximum end frequency

If you want to set another frequency range with a constant voltage that lies beyond the base frequency set under PNU A03, this frequency is set with PNU A04. The maximum end frequency must not be smaller than the base frequency.

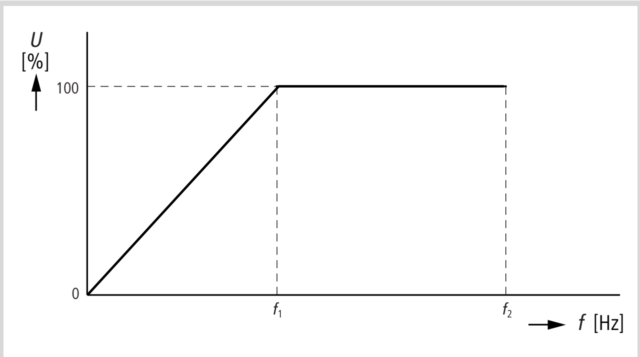


Figure 84: Maximum end frequency

f_1: Base frequency

f_2: Maximum end frequency

PNU	Name	Adjustable in RUN mode	Value	DS
A04	Maximum end frequency	–	50 to 360 Hz	50[1)]

1) 60 for DF5-320-…

Analog setpoint value matching

The external setpoint signal can be specifically matched with parameters PNU A11 to A16, which are described below. A configurable voltage or current setpoint range can be assigned to a configurable frequency range.

Furthermore, analog setpoint signal filtering can be adjusted using PNU A16.

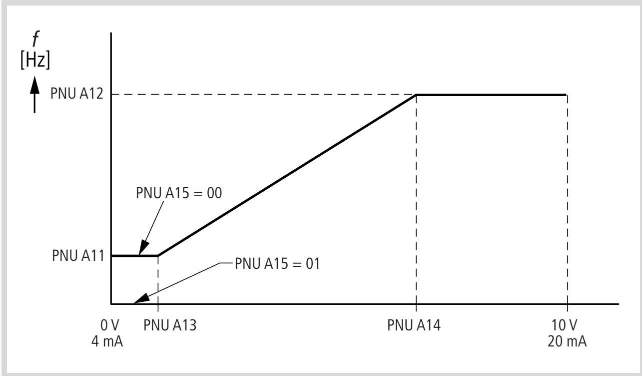


Figure 85: Setpoint value matching

x: Voltage or current setpoint signal at analog input O or OI

PNU	Name	Adjustable in RUN mode	Value	Function	DS
A11	Frequency with minimum setpoint value	–	0 to 360 Hz	Here, the frequency that corresponds to the minimum voltage setpoint value under PNU A13 is set.	0.0
A12	Frequency with maximum setpoint value		0 to 360 Hz	Here, the frequency that corresponds to the maximum voltage setpoint value under PNU A14 is set.	0.0
A13	Minimum setpoint value		0 to 100 %	The minimum setpoint value entered here is a percentage of the highest possible voltage or current setpoint (10 V or 20 mA).	0
A14	Maximum setpoint value		0 to 100 %	The maximum setpoint value entered here is a percentage of the highest possible voltage or current setpoint (10 V or 20 mA).	100
A15	Conditions for starting frequency		Determines the behaviour at setpoint values below the minimum setpoint value.		01
			00	The frequency defined under PNU A11 is applied to the motor.	
			01	A frequency of 0 Hz is applied to the motor.	
A16	Analog input filter time constant		To reduce the inverter’s response time to setpoint changes at analog input O or OI, and thereby determine the degree to which analog signal harmonics are filtered, you can enter a value between 1 and 8 here.		8
			1	Minimal filtering effect/fast response to setpoint value changes	
			….		
			8	Maximum filtering effect/slow response to setpoint value changes	

Voltage/frequency characteristic and voltage boost

Boost

The boost function increases the voltage of the *U*/*f* characteristic (thereby boosting the torque) in the lower frequency range. Manual voltage boost raises the voltage in the frequency range from the starting frequency (default setting: 0.5 Hz) to half the base frequency (25 Hz at the default setting of 50 Hz) in every operating state (acceleration, static operation, deceleration), irrespective of the motor load. With automatic boost, by contrast, the voltage is boosted according to the motor load. A voltage boost may cause a fault message and trip due to the higher currents involved.

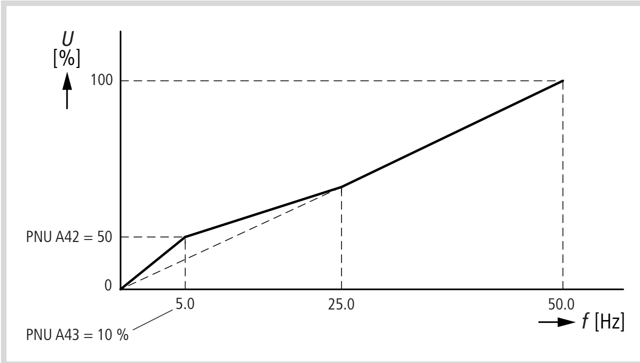
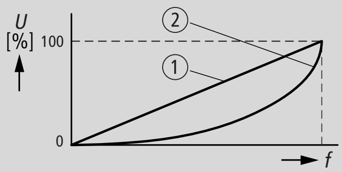
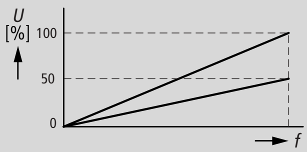


Figure 86: Voltage boost characteristics

Parameter settings, using manual boost as an example:
A41 = 00
A42 = 50
A43 = 10.0
A44 = 00
A45 = 100

Voltage/frequency characteristics

Under PNU A44 and A45, adjust the behaviour of the DF5 to match its load.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
A41	Voltage boost characteristics	–	00	Manual voltage boost	00
			01	Automatic voltage boost	
A42	Manual boost percentage	✓	0 to 99 %	Setting the voltage increase with manual boost.	11
A43	Maximum boost at x % of the base frequency	✓	0 to 50 %	Setting the frequency with the highest voltage boost as a percentage of the base frequency (PNU A03).	10.0
A44	Voltage/frequency characteristic	–	 ① Linear ② Quadratic	You can select a square-law or a U/*f* characteristic for accelerating or decelerating the motor. If SLV control is active, you should set the pulse frequency to at least 2.1 kHz with PNU b83 (→ section "Carrier frequency", page 105).	00 100
			00	Linear U/*f* characteristic (constant torque).	
			01	Quadratic *U f* characteristic (reduced torque)	
A45	Output voltage	✓	50 to 100 % of the input voltage	 The output voltage can be set from 50 to 100 % of the input voltage.	

DC braking (DCB)

DC braking for decelerating the motor is activated automatically when the frequency falls below the value set with PNU A52.

By applying a pulsed DC voltage to the motor stator, a braking torque is induced in the rotor and acts against the rotation of the motor. With DC braking, a high level of stopping and positioning accuracy can be achieved.

Under PNU A51, specify whether DC braking is used.

Under PNU A52, enter the frequency at which DC braking is activated.

Under PNU A53, enter the waiting time which is to expire after the set starting frequency is reached before DC braking is activated.

In PNU A54, enter the braking torque between 0 and 100 %.

In PNU A55, enter the DC braking duration.

Caution!
DC braking results in additional heating of the motor. You should therefore configure the braking torque (PNU A54) as low and the braking duration (PNU A55) as short as possible.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
A51	DC braking active/ inactive	–	00	Automatic DC braking disabled	00
			01	Automatic DC braking activated	
A52	DC braking starting frequency		0.5 to 10 Hz	When PNU A51 is set to 01, DC braking is activated when the actual frequency falls below the frequency entered here.	0.5
A53	DC braking waiting time		0.0 to 5 s	When the frequency set with PNU A52 is reached, the motor coasts for the time duration entered here before DC braking is activated.	0.0
A54	DC braking torque		0 to 100 %	Adjustment range for the level of braking torque.	0
A55	DC braking duration		0.0 to 60 s	The time during which DC braking is active.	0.0

Operating frequency range

The frequency range which is determined by the values configured under PNU b82 (start frequency) and PNU A04 (end frequency) can be limited by PNU A61 and A62 (→ Fig. 87). As soon as the frequency inverter receives a start signal, it outputs the frequency set with PNU A62; at maximum setpoint frequency, the frequency set with PNU A61.

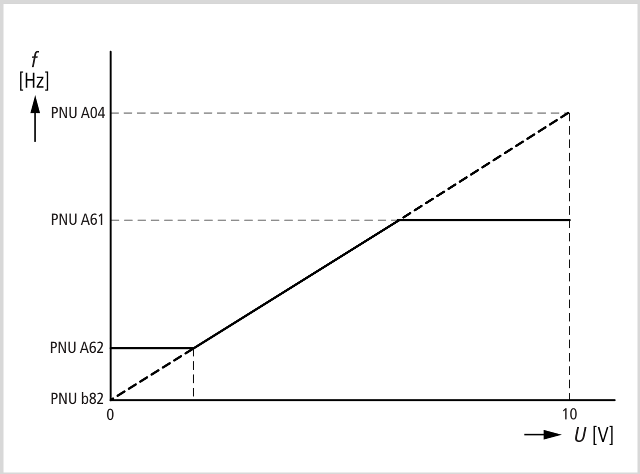


Figure 87: Upper frequency limit (PNU A61) and lower frequency limit (PNU A62)

To avoid resonance within the drive system, it is possible to program three frequency jumps under PNU A63 to A68. In the example (→ Fig. 88), the first frequency jump (PNU A63) is defined as 15 Hz, the second (PNU A65) as 25 Hz and the third (PNU A67) as 35 Hz. In the example, the frequency jump widths (adjustable under PNU A64, A66 and A68) are set to 1 Hz.

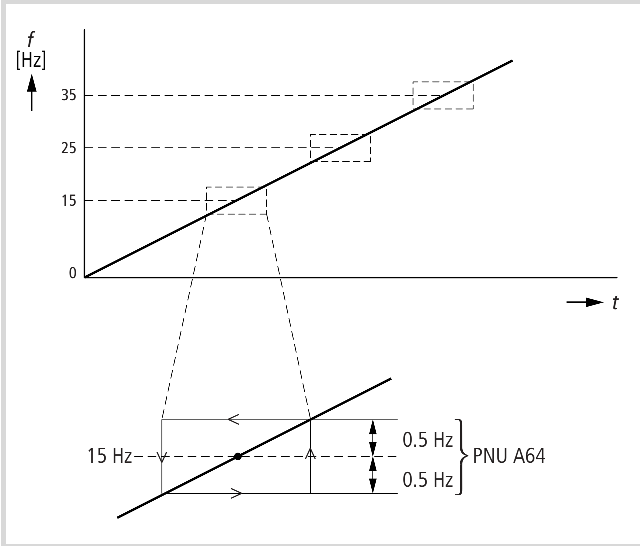


Figure 88: Frequency jumps

PNU	Name	Adjustable in RUN mode	Value	Function	DS
A61	Maximum operating frequency	–	0.5 to 360 Hz	This function can be deactivated by entering 0.0	0.0
A62	Minimum operating frequency		0.5 to 360 Hz		0.0
A63	First frequency jump		0.1 to 360 Hz		0.0
A64	First jump width		0.1 to 10 Hz		0.5
A65	Second frequency jump		0.1 to 360 Hz		0.0
A66	Second jump width		0.1 to 10 Hz		0.5
A67	Third frequency jump		0.1 to 360 Hz		0.0
A68	Third jump width		0.1 to 10 Hz		0.5

For further information, see section “Output boost in 87 Hz operation”, page 123.

PID control

The DF5 frequency inverters have PID control as standard. This can be used, for example, for flow and throughput controllers with fans and pumps. PID control has the following features:

- The setpoint value can be issued through the frequency inverter keypad or through an external digital signal (fixed frequencies). Sixteen different setpoint values are possible. In addition, the setpoint can be defined with an analog input signal (0 to 10 V or 4 to 20 mA).
- With the DF5, the actual value signal can be fed back using an analog input voltage (up to 10 V) or an analog input current (up to 20 mA).
- The permissible range for the actual value signal feedback can be specifically matched (e.g. 0 to 5 V, 4 to 20 mA, or other ranges).
- With the aid of a scale adjustment, you can match the setpoint signal and/or the actual value signal to the actual physical quantities (such as air or water flow, temperature, etc.) and view them on the display.

PID control

"P" stands for **p**roportional, "I" for **i**ntegral and "D" for **d**ifferential. In control engineering, the combination of these three components is termed PID closed-loop control, PID regulation or PID control. PID control is used in numerous types of application, e.g. for controlling air and water flow or for controlling pressure and temperature. The output frequency of the inverter is controlled by a PID control algorithm to keep the deviation between the setpoint and actual value as small as possible. The figure below illustrates PID control in the form of a block diagram:

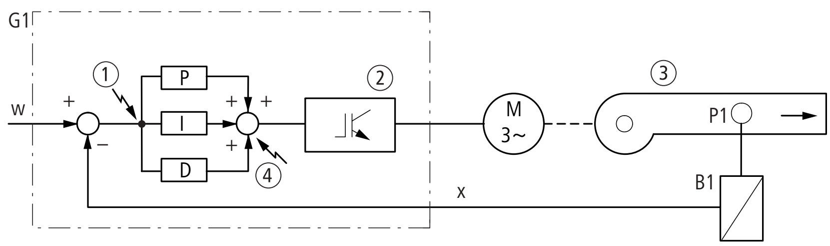


Figure 89: PID control block diagram

G1: DF5 frequency inverter
w: Setpoint value
x: Actual value
P1: Controlled variable
B1: Measured value converter

① System deviation
② Inverter
③ Fans, pumps or similar devices
④ Setpoint frequency

→ PID control is only possible after the type of setpoint value and actual value used have been defined.

The example in the following figure shows a fan control system:

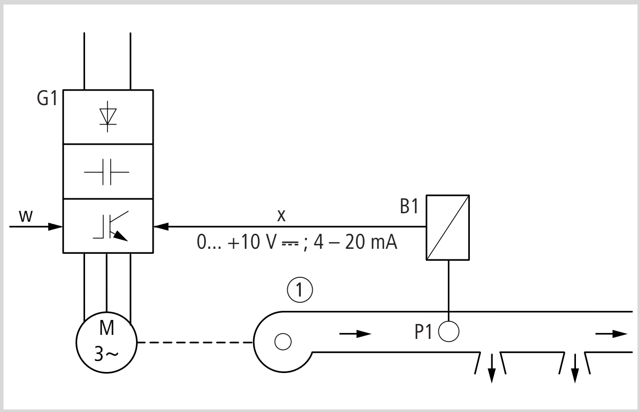


Figure 90: Example of a fan control system

G1: DF5 frequency inverter
w: Setpoint value
x: Actual value
P1: Controlled variable
B1: Measured value converter
① Fan

P: Proportional component
This component ensures that the output frequency and the system deviation are proportional to each other. Using PNU A72, the so-called proportional gain (K_p), expressed in %, can be defined.

The following figure illustrates the relationship between system deviation and output frequency. A large value of K_p results in a quick response to a change of the system deviation. If, however, K_p is too large, the system becomes unstable.

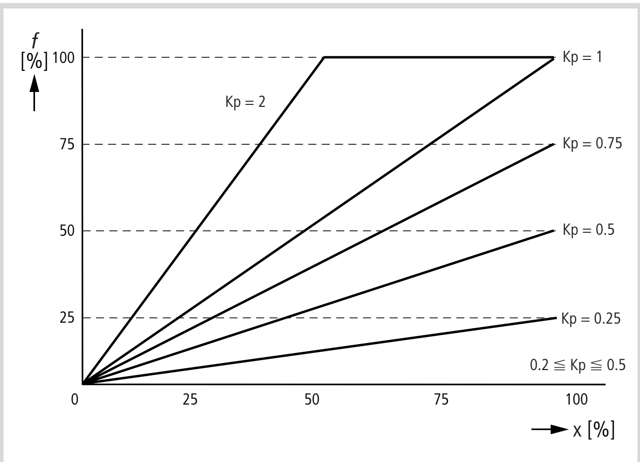


Figure 91: Proportional gain Kp

x: System deviation

The maximum output frequency in Figure 91 is defined as 100 %. K_p can be set between 0.2 and 5.0 under PNU A72.

I: Integral component
This component results in a correction of the output frequency by integration of the system deviation. In the case of purely proportional control, a large system deviation causes a large change in the output frequency. It follows, then, that if the system deviation is very small, the change in the output frequency is also very small. The problem is that the system deviation cannot be completely eliminated. Hence the need for an integral component.

The integral component causes a continuous adding up of the system deviation so that the deviation can be reduced to zero. The reciprocal value of the integration gain is the integration time $T_i=1/K_i$.

For the DF5 frequency inverters, set the integration time (T_i). The value may be between 0.5 s and 150 s. To disable the integral component, enter 0.0.

D: Differential component
This component causes a differentiation of the system deviation. Because pure proportional control uses the current value of the system deviation and pure integral control the values from previous actions, a certain delay in the control process always occurs. The D component compensates for this behaviour.

Differential control corrects the output frequency using the rate of change of the system deviation. The output frequency can therefore be compensated very quickly.

K_d can be set between 0 and 100 s.

PID control
PID control combines the P, I and D components described in the previous sections. In order to achieve the optimum control characteristics, each of the three PID parameters must be set. Uniform control behaviour without large steps in the output frequency is guaranteed by the proportional component; the integral component minimizes the existing system deviation the steady-state and the differential component ensures a quick response to a rapidly changing actual value signal.

As differential control is based on the differentiation of the system deviation, it is very sensitive and also responds to unwanted signals – such as interference – which can result in system instability. Differential control is normally not required for flow, pressure and temperature control.

Setting the PID parameters

Values for the PID parameters must be chosen depending on the application and the system's control characteristics. The following points are important to achieve effective PID control:

- A stable steady-state behaviour
- Fast reaction
- Small system deviation in the steady state.

Parameters K_p, T_i and K_d must be set within the stable operating range. As a general rule, increasing one of the parameters K_p, K_i (= reduction of T_i) and K_d results in a faster system response. A very large increase however, causes system instability, as the returned actual value will begin to oscillate, in the worst case, resulting in divergent behaviour (→ Fig. 92 to Fig. 95):

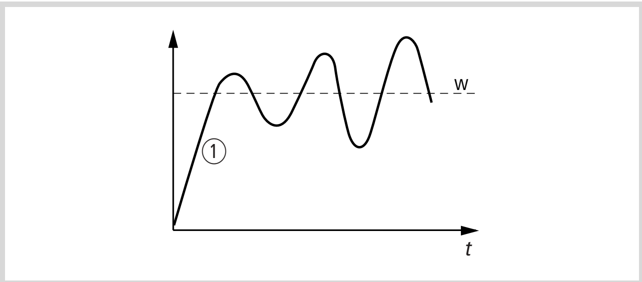


Figure 92: Divergent behaviour

w: Setpoint value

① Output signal

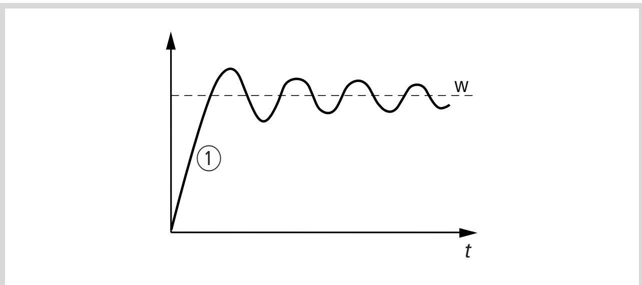


Figure 93: Oscillation, dampened

w: Setpoint value

① Output signal

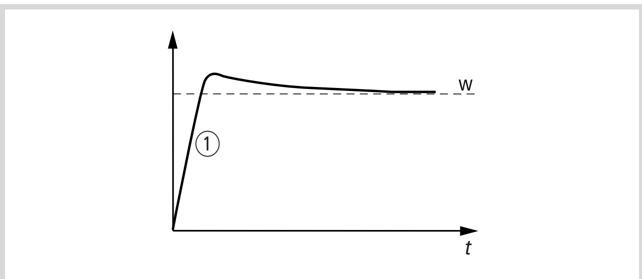


Figure 94: Good control characteristics

w: Setpoint value

① Output signal

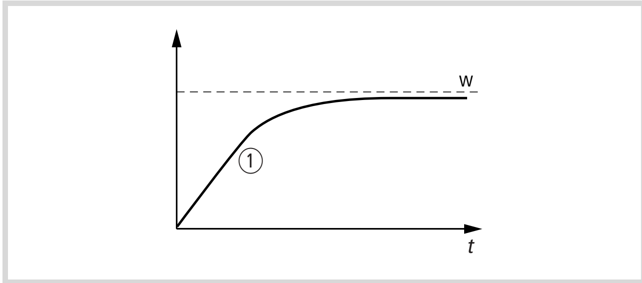


Figure 95: Slow control, large static system deviation

w: Setpoint value

① Output signal

The following table provides guidelines for setting each parameter.

Table 19: Setting the controller regulation times

A setpoint change	causes a slow response:	Increase proportional component (K_p)
	causes a fast but unstable reaction	Set a lower P component
Setpoint and actual value	differ greatly:	Reduce integral component (T_i)
	approach each other after oscillation:	Set a higher I component
After increasing K_p	the response is still slow:	Increase D component (K_d)
	the response is still unstable:	Set a lower D component

Structure and parameters of the PID controller

PID control active/inactive

DF5 frequency inverters can work in one of the following two control modes:

- Frequency control active (i.e. PID closed loop control inactive)
- PID control active

You can switch between the two modes with PNU A71 (PID control active/inactive).

PNU	Name	Adjustable in RUN mode	Value	Function	DS
A71	PID control active/ inactive	–	00	PID control is not used (inactive)	00
			01	PID control is used (active)	

Frequency control is the standard control method used by many frequency inverters. A setpoint value is defined by a control unit (keypad) as an analog voltage or current signal, or through a four bit wide digital command applied to the control signal terminals.

With PID control, the inverter's output frequency is controlled by a control algorithm to ensure that the deviation between the setpoint and actual value is kept at zero.

Parameter

The following figure illustrates which parameters are effective in different areas of the PID block diagram. The stated parameters (e.g. PNU A72) correspond to those on the integrated frequency inverter keypad:

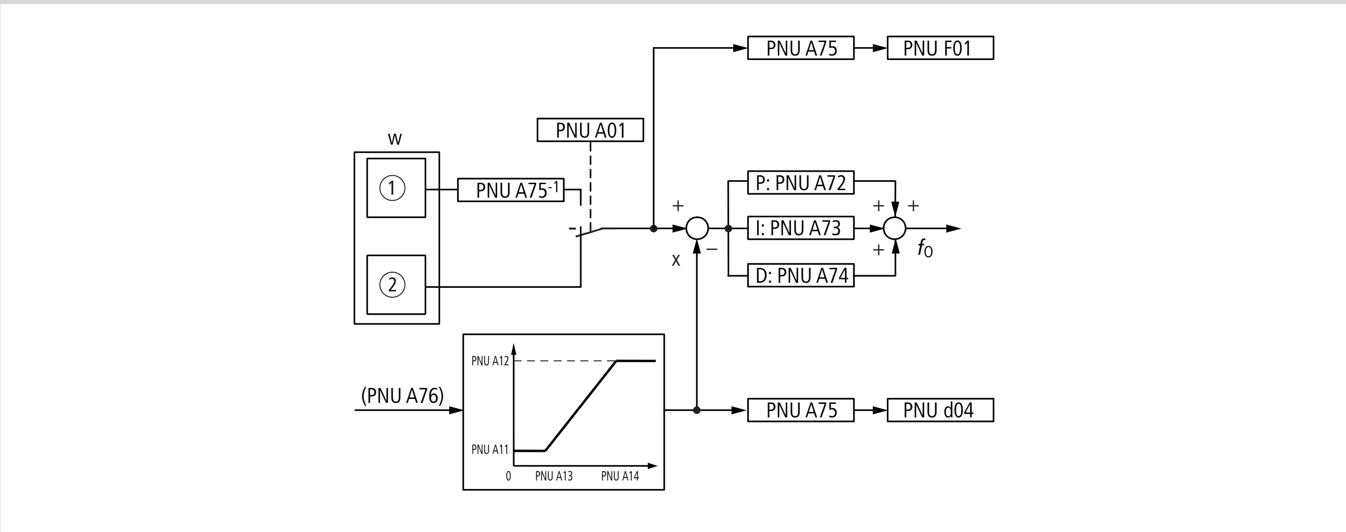


Figure 96: PID control parameters

w: Setpoint value

x: Actual value

f_0: Output frequency

① Frequency definition with keypad, fixed frequency

② Analog definition with potentiometer, analog inputs, current or voltage

PNU	Function	Adjustable in RUN mode	Value	Function	DS
A01	Frequency setpoint definition	–	00	Definition with the potentiometer on the keypad	01
			01	Definition through analog input O (0 to 10 V) or OI (4 to 20 mA)	
			02	Definition under PNU F01 and/or PNU A20	
A11	Frequency with minimum setpoint value	–	0 to 360 Hz	Here, the frequency that corresponds to the minimum voltage setpoint value under PNU A13 is set.	0.0
A12	Frequency with maximum setpoint value	–	0 to 360 Hz	Here, the frequency that corresponds to the maximum voltage setpoint value under PNU A14 is set.	0.0
A13	Minimum setpoint value	–	0 to 100 %	The minimum setpoint value entered here is a percentage of the highest possible voltage or current setpoint (10 V or 20 mA).	0
A14	Maximum setpoint value	–	0 to 100 %	The maximum setpoint value entered here is a percentage of the highest possible voltage or current setpoint (10 V or 20 mA).	100
d04	Actual value × factor	✓	–	Only with active PID control. The factor is entered under PNU A75 in the range 0.01 to 99.99; default value: 1.0.	–
F01	Input/indication of frequency value	✓	0.5 to 360 Hz	Resolution ±0.1 Hz The setpoint can be defined using various methods: • With PNU F01 or A20: Enter the value 02 under PNU A01. • With the potentiometer on the keypad: Enter the value 00 under PNU A01. • With a 0 to 10 V voltage signal or a 4 to 20 mA current signal at input terminals O or OI: Enter the value 01 under PNU A01. • With the digital inputs configured as FF1 to FF4. After selection of the required fixed frequency stage using FF1 to FF4, the frequency for the respective stage can be entered. The display of the setpoint value is independent of which method was used to set the setpoint value.	0.0
A72	P component of the PID control	✓	0.2 to 5.0	Adjustment range of the proportional component of the PID control	1.0
A73	I component of the PID control	✓	0.0 to 150 s	Adjustment time T_i of the integral component of the PID control	1.0
A74	D component of the PID control	✓	0.0 to 100 s	Adjustment time T_d of the differential component of the PID control	0.0
A75	Setpoint factor of the PID control	–	0.01 to 99.99	The display of the frequency setpoint or actual value can be multiplied by a factor, so that process related quantities (e.g. flow or similar) can be displayed instead of the frequency.	1.00
A76	Input actual value signal for PID control	–	00	Actual value signal present on analog input OI (4 to 20 mA)	00
			01	Actual value signal present on analog input O (0 to 10 V)	

Internal regulator-based calculations

All calculations within the PID algorithm are carried out in percentages, so that different physical units can be used, such as

- Pressure (N/m^2),
- Flow rate (m^3/min),
- Temperature (°C), etc.

The setpoint and returned actual values can, for example, also be compared as percentages.

A useful scaling function (PNU A75) is also available. When these parameters are used, you can define the setpoint directly as the required physical quantity and/or display setpoint and actual values as physical quantities suitable for the process.

Additionally, analog signal matching (PNU A11 to A14) is available, with which a range based on the actual value feedback can be defined. The following graphs illustrate the mode of operation of this function.

Setpoint definition

There are three ways of defining the setpoints:

- Keypad
- Digital control signal terminal input (4 bit)
- Analog input (terminals O–L or OI–L)

If the digital setpoints are defined through the control signal terminals, define the required setpoint value in PNU A21 to A35. The setting procedure is similar to the one which is used in frequency regulation mode (i.e. with deactivated PID control) for setting the respective fixed frequencies (→ section "Fixed frequency selection (FF1 to FF4)"page 60

Actual value feedback and actual value signal matching

You can specify the actual value signal as follows:

- With an analog voltage on control signal terminal O (maximum 10 V)
- With an analog current on control signal terminal OI (maximum 20 mA)

One of the two methods mentioned is selected via PNU A76.

To adapt the PID control to the respective application, the actual value feedback signal can also be matched as shown in Figure 97:

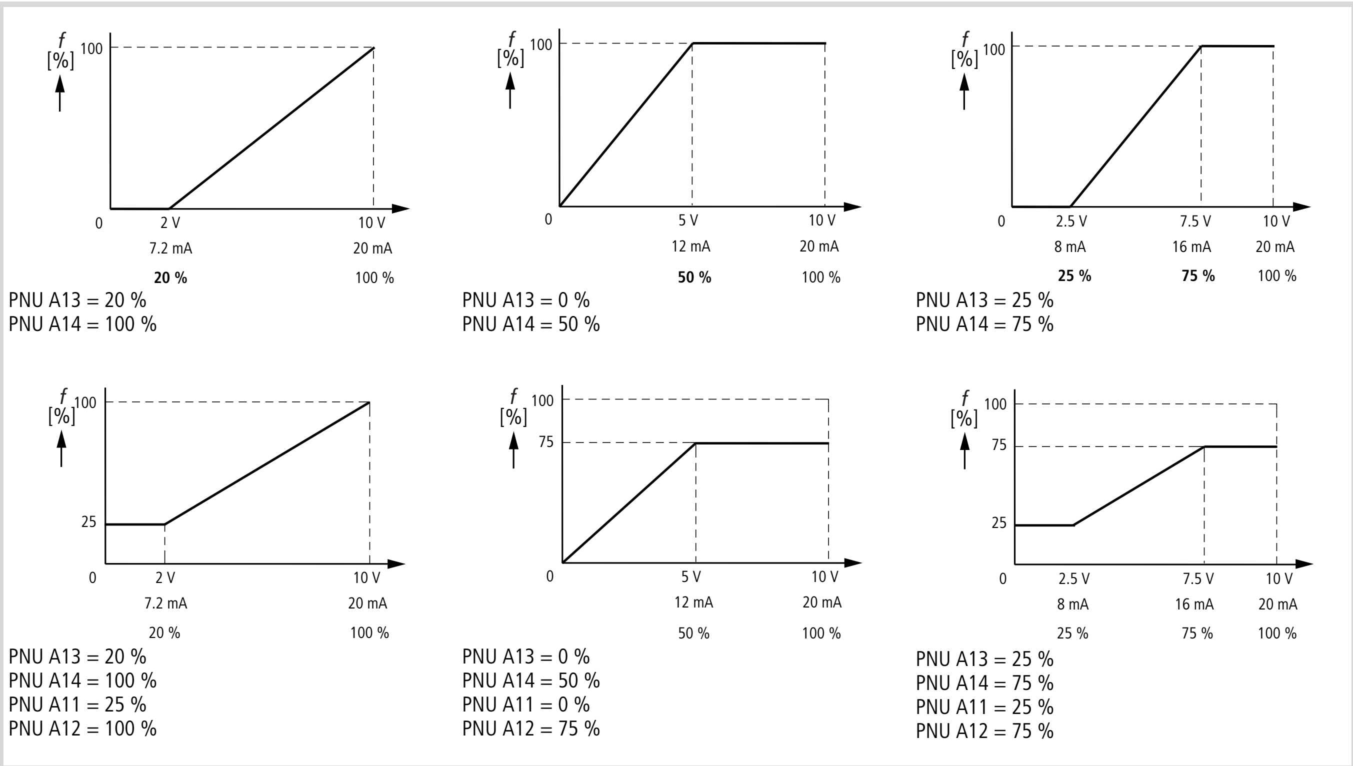


Figure 97: Analog actual value signal matching

As evident from the graphs, the setpoint value must be within the valid range on the vertical axis if you have set functions PNU A11 and A12 to a value not equal to 0. Because there is no feedback signal, stable control cannot otherwise be guaranteed. This means that the frequency inverter will either

- output the maximum frequency,
- go to stop mode, or
- output a lower limit frequency.

Scaling adjustment

Scaling adjustment and scaling allow the setpoint and actual value to be displayed and the setpoint value to be entered directly in the correct physical unit. For this purpose, 100 % of the returned actual value is taken as a basis. By default, inputs and displays are based on 0 to 100 %.

Example: In the first diagram in Figure 97, 20 mA of the feedback signal correspond to 100 % of the PID internal factor. If for example the current flow is 60 m³/min with a feedback signal of 20 mA, the parameter is set to 0.6 with PNU A75 (= 60/100). With PNU d04, the process corrected value can be displayed and the setpoint value can be entered directly as a process corrected quantity.

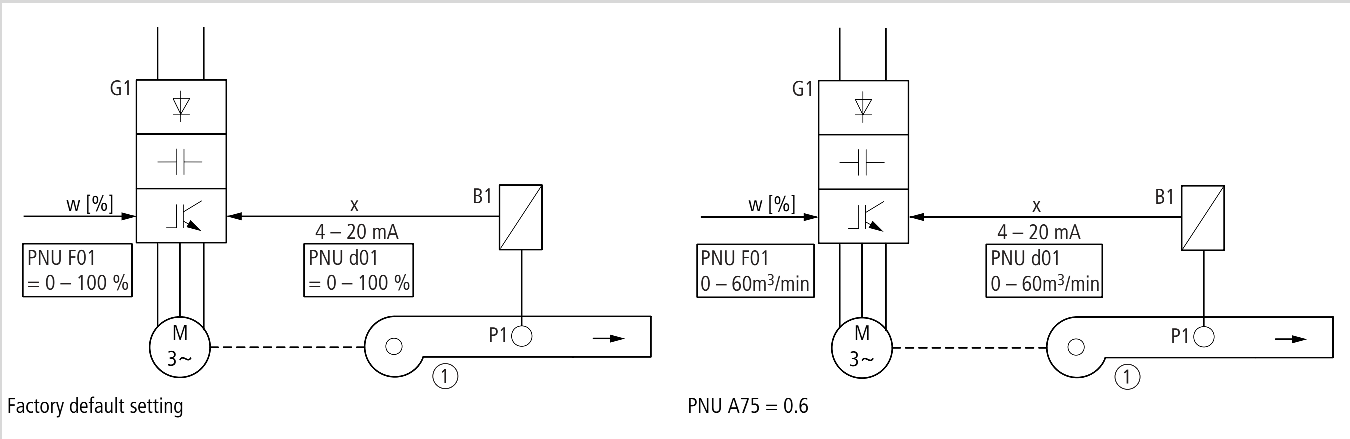


Figure 98: Example for scaling adjustment

w: Setpoint value

x: Returned actual value

① Fan

Summary of the relevant parameters

The DF5 frequency inverters use the same parameters for both frequency control and PID modes. The designations of the respective parameter relate only to frequency control mode, as this mode is used in most cases. When PID mode is used, some of the parameters have other designations.

The table below contains an explanation of these parameters for both frequency control mode and PID mode:

PNU	Meaning of the parameters when used in Frequency control mode	PID mode
d04	–	Indication of the returned actual value
F01	Indication of the output frequency	Indication of the setpoint value
A01	Frequency setpoint definition	Setpoint definition
A11	Frequency at minimum setpoint value (units: Hz)	Feedback percentage actual value for lower acceptance threshold (units: %)
A12	Frequency at maximum setpoint value (units: Hz)	Feedback percentage actual value for upper acceptance threshold (units: %)
A13	Minimum setpoint value (units: Hz)	Lower acceptance threshold for voltage or current on the actual value input (units: %)
A14	Maximum setpoint value (units: Hz)	Upper acceptance threshold for voltage or current at the actual value input (unit: %)
A21 to A35	Fixed frequencies 1 to 15	Digital adjustable setpoint values 1 to 15

PNU	Meaning of the parameters when used in	
	Frequency control mode	PID mode
A71	–	PID control active/inactive
A72		P component of the PID control
A73		I component of the PID control
A74		D component of the PID control
A75		Setpoint factor of the PID control
A76		Input actual value signal for PID control

Settings in frequency control mode
Before you use PID mode, you must configure the parameters in frequency control mode. Observe the following two points:

Acceleration and deceleration ramp
The output frequency calculated with the PID algorithm is not immediately available at the frequency inverter output, as the output frequency is affected by the set acceleration and deceleration times. Even if, for example, a large D component is defined, the output frequency is significantly influenced by the acceleration and deceleration time, and this causes unstable control behaviour.

To achieve stable behaviour in every PID control range, the acceleration and deceleration times should be set as low as possible.

After every acceleration and deceleration ramp parameter change, parameters PNU A72, A73 and A74 must be rematched.

Frequency jumps/frequency range
Frequency jumps must be defined to meet the following requirement: A change to the feedback actual value signal must not occur during execution of a frequency jump. If a stable operating point exists within a frequency jump range, an oscillation between the end values of this range occurs.

Configuration of setpoint value and actual value
In PID mode, you must first specify how the setpoint is to be defined and where the actual value is to be supplied. The table below lists the required settings:

Actual value input	Setpoint definition				
	Built-in keypad	Digitally through control terminals (fixed frequencies)	Integrated potentiometer	Analog voltage at O-L	Analog current at OI-L
Analog voltage (O-L: 0 to 10 V)	PNU A01 = 02 PNU A76 = 01	PNU A01 = 02 PNU A76 = 01	PNU A01 = 00 PNU A76 = 01	–	PNU A01 = 01 PNU A76 = 01
Analog current (OI–L: 4 to 20 mA)	PNU A01 = 02 PNU A76 = 00	PNU A01 = 02 PNU A76 = 00	PNU A01 = 00 PNU A76 = 00	PNU A01 = 01 PNU A76 = 00	–

The setpoint value and the actual value cannot be supplied through the same analog input terminal.

Note that the frequency inverter brakes and stops according to the set deceleration ramp as soon as a stop signal is issued in PID operation.

Scaling
Set the scaling to the process-corrected physical unit as required by your application, for example to flow, pressure or temperature. For a detailed description, see section “Scaling adjustment”, page 93.

Setpoint adjustment through digital inputs
The following points must be observed when defining the setpoint through the digital inputs (4 bit):

Assigning the digital inputs
The DF5 frequency inverters have five programmable digital inputs. Assign the functions FF1 to FF4 to four of the inputs. using PNU C01 to C05 to correspond to inputs 1 to 5 of the inverter.

Adjustment of the setpoint values
First, select the required number of different setpoints (up to 16) from the table below. In PNU A21 (corresponds to the first setpoint) to A35 (corresponds to 15th setpoint), enter the required setpoint. PNU A20 and F01 correspond to setpoint 0.

→ If the setpoints are to be scaled, note that they must be entered as process-corrected quantity values in accordance with this scaling.

No.	FF4	FF3	FF2	FF1	Setpoint number (PNU)
1	0	0	0	0	Setpoint value 0 (PNU A20 or F01)
2	0	0	0	1	Setpoint value 1 (PNU A21)
3	0	0	1	0	Setpoint value 2 (PNU A22)
4	0	0	1	1	Setpoint value 3 (PNU A23)

No.	FF4	FF3	FF2	FF1	Setpoint number (PNU)
5	0	1	0	0	Setpoint value 4 (PNU A24)
6	0	1	0	1	Setpoint value 5 (PNU A25)
7	0	1	1	0	Setpoint value 6 (PNU A26)
8	0	1	1	1	Setpoint value 7 (PNU A27)
9	1	0	0	0	Setpoint value 8 (PNU A28)
10	1	0	0	1	Setpoint value 9 (PNU A29)
11	1	0	1	0	Setpoint value 10 (PNU A30)
12	1	0	1	1	Setpoint value 11 (PNU A31)
13	1	1	0	0	Setpoint value 12 (PNU A32)
14	1	1	0	1	Setpoint value 13 (PNU A33)
15	1	1	1	0	Setpoint value 14 (PNU A34)
16	1	1	1	1	Setpoint value 15 (PNU A35)

1: On
0: Off

If, for example, you only require up to four different setpoint values, only FF1 and FF2 need to be used; for five to eight different setpoint values, only FF1 to FF3 are required.

Activating PID mode

▶ Set PNU A71 to 01.

You can make this entry at the very start, before defining all other settings.

Example for setting K_p and T_i

As for the parameter changes, check the output frequency or the feedback actual value signal with an oscilloscope (→ Fig. 92 to Fig. 95, page 89).

Use two different setpoint values and switch between them using the digital control signal terminals.

The output should then always exhibit a stable behaviour.

Adjustment of the P component

Begin by setting only the P component, but not the I component and the D component.

▶ First of all, set a small P component via PNU A72 and check the result.
▶ If necessary, slowly increase this value until an acceptable output behaviour has been achieved.

Alternatively, set a very large P component and observe the behaviour of the output signal. If the behaviour is unstable, set a lower value and observe the result. Repeat this process.

If the behaviour is unstable, reduce the P component.

The P component is correct when the system deviation reaches a static state within acceptable limits.

Setting the integral component and matching K_p

▶ First of all, define a very small integral component in PNU A73.
▶ Set the P component a little lower.

If the system deviation does not decrease, reduce the integral component a little. If the performance becomes unstable as a result, reduce the P component.

▶ Repeat this process until you have found the correct parameter settings.

Note about the AVR function

If you have set the AVR function (PNU A81) to 02, whereby the automatic voltage regulation function with an active PID closed loop control is deactivated only during deceleration of the motor, the motor may, depending on the application, start to “knock”. In other words, instead of running smoothly, the motor accelerates and decelerates alternately. In this case, set the AVR function to 01 (OFF).

Application examples

This section contains some setting examples of practical applications.

Flow control

In the example shown in the figure below, the setpoint values are 150 m3/min and 300 m3/min:

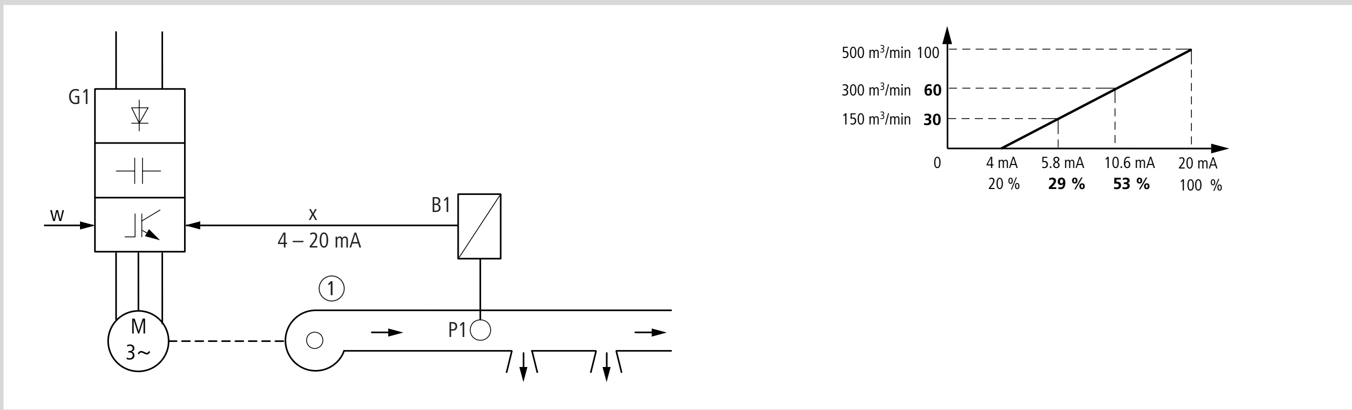


Figure 99: Examples for flow control

w: Setpoint value, 4-bit digital

x: Feedback actual value (500 m3/min at 20 mA)

B1: Measured value converter

P1: Flow sensor

① Pump

PNU	Meaning in PID control mode	Value	Notes
F01	Setpoint	150	Direct input of "150 m3/min", since the scaling factor has been set
A01	Frequency setpoint input	02	Keypad
A11	Feedback percentage actual value for lower acceptance threshold (units: %)	0	0 %
A12	Feedback percentage actual value for upper acceptance threshold (units: %)	100	100 %
A13	Lower acceptance threshold for voltage or current on the actual value input (in %)	20	20 %
A14	Upper acceptance threshold for voltage or current on the actual value input (in %)	100	100 %
A21	Digitally adjustable setpoint value 1	300	300 m3/min
A71	PID control active/inactive	01	PID mode active
A72	P component of the PID control	–	Application-dependent
A73	I component of the PID control	–	
A74	D component of the PID control	–	
A75	Setpoint factor of the PID control	5.0	100 % at 500 m3/min
A76	Input actual value signal for PID control	00	Feedback from OI-L terminal

Temperature control

With the flow control in the previous example, the frequency inverter's output frequency increases if the feedback signal is less than the setpoint and falls if the feedback signal is greater than the setpoint. With temperature control, the opposite behaviour must be implemented: if the temperature is above the setpoint, the inverter must increase its output frequency to increase the speed of the connected fan.

The following figure contains an example for temperature control with the two setpoints 20 and 30 °C:

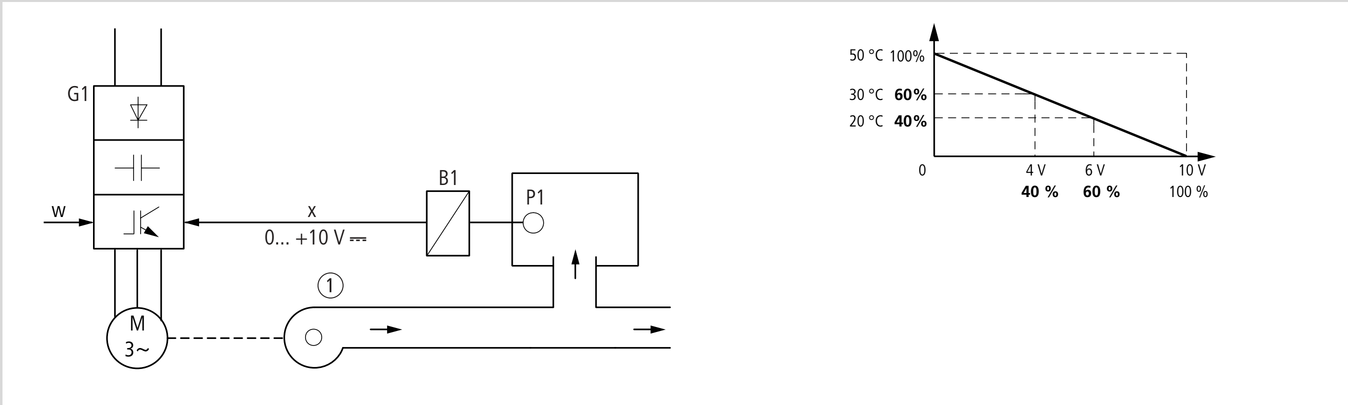


Figure 100:Example of temperature control

w: Setpoint value, 4-bit digital

x: Feedback actual value (50 °C at 10 V)

B1: Measured value converter

P1: Temperature sensor

① Fan

PNU	Meaning in PID control mode	Value	Notes
F01	Setpoint	20	Direct input of "20 °C", as the scaling factor has been set
A01	Frequency setpoint input	02	Keypad
A11	Feedback percentage actual value for lower acceptance threshold (units: %)	100	100 %
A12	Feedback percentage actual value for upper acceptance threshold (units: %)	0	0 %
A13	Lower acceptance threshold for voltage or current on the actual value input (in %)	0	0 %
A14	Upper acceptance threshold for voltage or current on the actual value input (in %)	100	100 %
A21	Digitally adjustable setpoint value 1	30	30 °C
A71	PID control active/inactive	01	PID mode active
A72	P component of the PID control	–	Application-dependent
A73	I component of the PID control	–	
A74	D component of the PID control	–	
A75	Setpoint factor of the PID control	0.5	100 % at 50 °C
A76	Input actual value signal for PID control	01	Feedback from O-L terminal

Automatic voltage regulation (AVR)

The AVR function stabilizes the motor voltage if there are fluctuations on the DC bus voltage. These deviations result from, for example:

- unstable mains supplies or
- DC bus voltage dips or peaks caused by short acceleration and deceleration times.

A stable motor voltage provides a high level of torque, particularly during acceleration.

Regenerative motor operation (without AVR function) results in a rise in the DC bus voltage in the deceleration phase (particularly at very short deceleration times), which also leads to a corresponding rise in the motor voltage. The increase in the motor voltage causes an increase in the braking torque. For this reason, you can deactivate the AVR function for deceleration under PNU A81.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
A81	Characteristic of the AVR function	–	00	AVR function active during entire operation.	02
			01	AVR function is not active.	
			02	AVR function active during operation except for deceleration	
A82	Motor voltage for AVR function	–	200, 220, 230, 240, 380, 400, 415, 440, 460	The settings depend on the device series used: • 200 V series: 200, 220, 230, 240 V • 400 V series: 380, 400, 415, 440, 460 V	230/ 400

If the mains voltage is higher than the rated motor voltage, enter the mains voltage under PNU A82 and reduce the output voltage in PNU A45 to the rated motor voltage.

Example: With 440 V mains voltage and 400 V rated motor voltage, enter 440 under PNU A82 and 91 % (= 400/ 440 × 100 %) under PNU A45.

Time ramps

During operation, you can switch over from the time ramps configured under PNU F02 and F03 to those configured under PNU A92 and A93. This can be done either by applying an external signal to input 2CH at any time or when the frequencies configured under PNU A95 and A96 are reached.

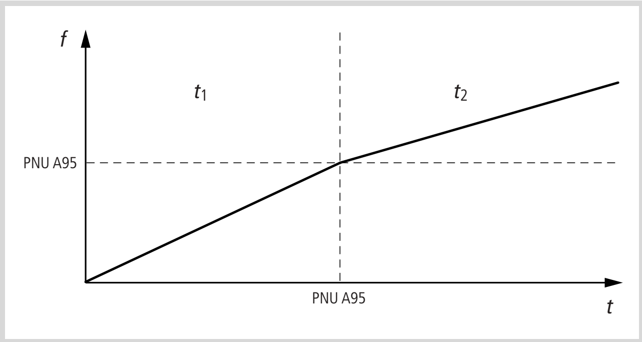
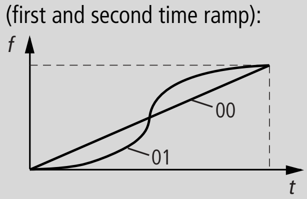


Figure 101:Time ramps

t_1: Acceleration time 1

t_2: Acceleration time 2

PNU	Name	Adjustable in RUN mode	Value	Function	DS
A92	Second acceleration time	✓	0.1 to 3000 s	Setting times for the second acceleration and deceleration time 0.1 to 999.9 s; resolution: 0.1 s 1000 to 3000 s; resolution: 1 s	15
A93	Second deceleration time				
A94	Changeover from the first to the second time ramp	–	00	Changeover to the second time ramp if an active signal is present at digital input 2CH.	00
			01	Changeover to the second time ramp when the frequencies entered in PNU A95 and/or A96 are reached.	
A95	Acceleration time changeover frequency	–	0.0 to 360.0 Hz	Here, set a frequency at which the changeover from the first to the second acceleration time is to take place.	0.0
A96	Deceleration time changeover frequency	–	0.0 to 360.0 Hz	Here, set a frequency at which the changeover from the first to the second deceleration time is to take place.	0.0
A97	Acceleration characteristic	–	Here, you can set a linear or an S-curve acceleration characteristic for motor acceleration (first and second time ramp): 		00
			00	Linear acceleration of the motor from the first to the second time ramp	
			01	S-curve characteristic for acceleration of the motor from the first to the second time ramp	
A98	Deceleration characteristic	–	00	Linear deceleration of the motor from the second to the first time ramp	00
			01	S-curve characteristic for deceleration of the motor from the second to the first time ramp	

Automatic restart after a fault

Warning!
When a fault has occurred, this function initiates an automatic restart of the frequency inverter if a start signal is present after the set waiting time has expired. Ensure an automatic restart does not present a danger for personnel.

With the default settings, each fault triggers a fault message. An automatic restart is possible after the following fault messages have occurred:

- Overcurrent (E01 to E04, up to four restart attempts within ten minutes before a fault message is issued)
- Overvoltage (E07 and E15, up to three restart attempts within 10 minutes before a fault message is issued)
- Undervoltage (E09, up to 16 restart attempts within 10 minutes, then a fault message is issued)

With PNU b01, specify the restarting behaviour.

With PNU b02 and b03, specify the behaviour on mains failure (→ Fig. 102 and Fig. 103).

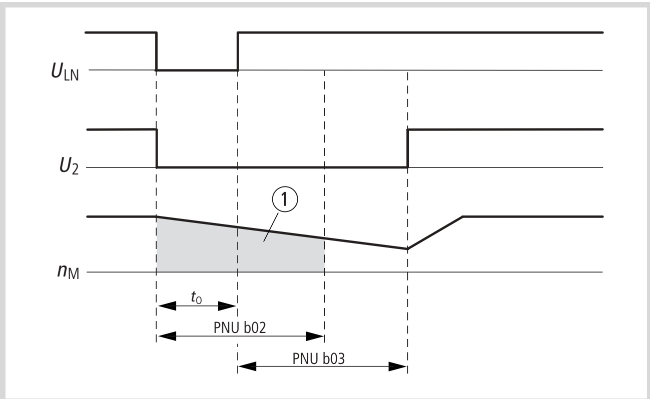


Figure 102:Motor frequency lower than set under PNU b02

ΔU_{LN}:Supply voltage
ΔU_2:Output voltage
n_M: Motor speed
t_0: Duration of supply failure
① Free run stop (coasting)

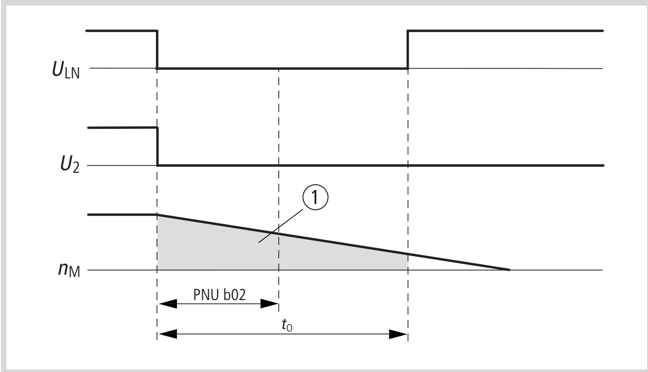
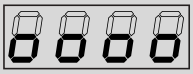


Figure 103:Duration of power failure longer than set under PNU b02

ΔU_{LN}:Supply voltage
ΔU_2:Output voltage
n_M: Motor speed
t_0: Duration of supply failure
① Free run stop (coasting)

If mains power returns after expiry of the time set with PNU b02 and a start signal is applied, a restart is performed.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
b01	Restart mode	–	00	The above fault messages are displayed when the associated fault occurs (restart is not activated).	00
			01	A restart at the starting frequency after the time set under PNU b03 has elapsed.	
			02	After the time set under PNU b03 has elapsed, the inverter synchronizes to the current motor rotation speed and the motor accelerates for the set acceleration time.	
			03	After the time set under PNU b03 has elapsed, the inverter synchronizes to the current motor rotation speed and the motor brakes for the set deceleration time. A fault message is then displayed.	

PNU	Name	Adjustable in RUN mode	Value	Function	DS
b02	Permissible power failure duration	–	0.3 to 25 s	Here, you set a time duration during which the undervoltage condition is met without the corresponding fault message in PNU E09 being initiated.	1.0
b03	Waiting time before restart	–	0.3 to 100 s	Here, set a time which is to expire before an automatic restart is initiated after a fault signal. This time can also be used in conjunction with the FRS function. During the delay, the following message appears on the LED display: 	1.0

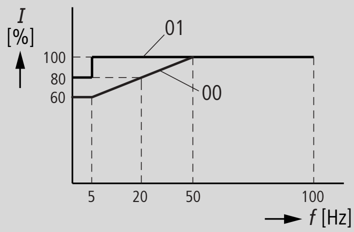
Electronic motor protection

Using an electronically simulated bimetallic strip, the DF5 frequency inverters can provide thermal monitoring of the connected motor. With PNU b12, match the electronic motor protection to the motor's rated current. If the values entered here exceed the rated motor current, the motor cannot be monitored with this function. In this case, PTC thermistors or bimetal contacts in the motor windings must be used.

Adjust the current indicated by PNU d02 to the current drawn by the motor with parameter PNU b32 (→ page104). The current indicated under PNU d02 forms the basis for calibrating the electronic motor protection.

> **Caution!**
> At low motor speeds, the output of the motor cooling fan is diminished, and the motor may overheat despite its electronic overload protection. You should therefore provide protection with PTC thermistors or bimetal contacts.

In PNU b13, set the overload protection according to the applicable motor load.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
b12	Tripping current for electronic motor protection device	–	0.5 to 1.2 × I_e	Setting range of the tripping current as a multiple of the frequency inverter rated current, i.e. the range is given in amperes (A).	I_e[1)]
b13	Characteristic for electronic motor protection device	–	The electronic thermal protection of the motor in the low speed range can be increased to improve thermal monitoring of the motor at low frequencies.  *I*: Output current		01
			00	Enhanced motor protection	
			01	Constant motor protection	

1) Inverter rated current

Limiting motor current

With the current limit setting, the motor current can be limited. To reduce the load current, the frequency rise ends in the acceleration phase or the output frequency is reduced in the static phase, as soon as the output current exceeds the set current limit. The time constant for control at the current limit is entered under PNU b23. As soon as the output current drops below the set current limit, the frequency increases again to the configured setpoint value. To allow higher currents to flow for a brief period, the current limit can be switched off for the acceleration phase (→ PNU b21).

The current limit is not affected by parameter b32 (→ section "Calibrating current indication and motor protection)", page 104).

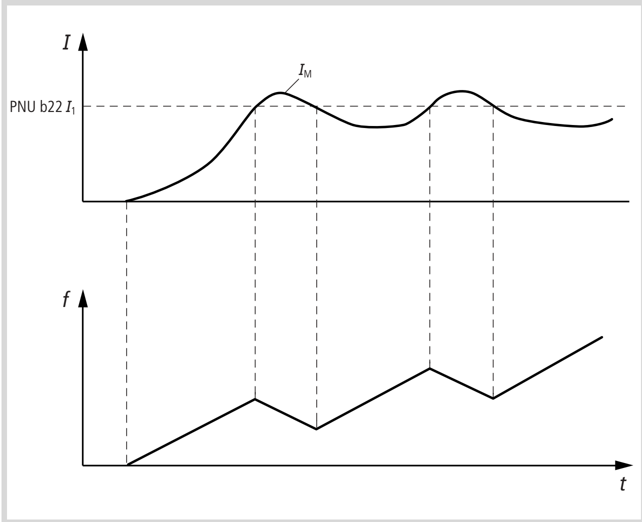


Figure 104:Current limit

I_M: Motor current

I_1: Current limit

Caution!
Note that the current limit cannot prevent a fault message and shutdown due to a sudden overcurrent (e.g. caused by a short-circuit).

PNU	Name	Adjustable in RUN mode	Value	Function	DS
b21	Motor current limitation	–	00	Motor current limit not active	01
			01	Motor current limit active in all operating states	
			02	Motor current limit not active during acceleration	
b22	Tripping current	–	0.5 to 1.5 × Ie	Setting range of the tripping current as a multiple of the frequency inverter rated current, i.e. the range is given in amperes (A).	1.25 × I_e 1)
b23	Time constant	–	0.1 to 30 Hz/s	When specified current limit is reached, the frequency is reduced in the time set here. Caution: If possible, do not enter a value below 0.3 here!	1.0

1) Inverter rated current

Parameter protection

The four following methods of parameter protection are available (SFT = software lock):

PNU	Name	Adjustable in RUN mode	Value	Function	DS
b31	Software-dependent parameter protection	–	00	Parameter protection through SFT input; all functions inhibited	01
			01	Parameter protection through SFT input; all functions inhibited except PNU F01	
			02	Parameter protection without SFT input; all functions inhibited	
			03	Parameter protection without SFT input; all functions inhibited except PNU F01	

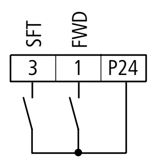


Figure 105: Digital input 3 configured as SFT (software protection)

Calibrating current indication and motor protection)

With this parameter, you can calibrate the current indication (PNU d02) to the actual motor current.

PNU d02 contains the motor current with an accuracy of about ±20 %.

The default setting is for a four-pole three-phase asynchronous motor with the specified shaft output. If, for example, you are using a smaller or a two-pole motor, the motor current indication (PNU d02) may deviate from the actual motor current. You can correct this deviation with PNU b32. In this case the motor is best run in rated load.

▶ With the motor idling at 50 Hz, compare the motor's known load current with the current indicated by PNU d02.

If the indicated current is not the same as the known current, adjust the indication with PNU b32 as follows:

▶ If the indicated current is too low, increase the value in PNU b32.
▶ If the indicated current is too high, reduce the value in PNU b32.

If the motor's load current is unknown, you have to measure it:

▶ Connect the motor under load to the three-phase system.
▶ Measure the load current, for example with a multimeter.

The current indicated by PNU d02 forms the basis for calibrating the electronic motor protection (PNU b12, → page102).Current limitation (PNU b22, → page103) is not affected by PNU b32.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
b32	Calibration factor	–	0 to 1.4 × I_e 1)	Setting range of the motor current in multiples of the inverter's rated current	0.58 × I_e 1)

1) Inverter rated current in A

Other functions

Carrier frequency

High pulse frequencies result in less motor noise and lower power losses in the motor but a higher dissipation in the power amplifiers and more noise in the mains and motor cables. You should therefore set the pulse frequency as low as possible.

Caution!
To prevent overheating of the DF5 frequency inverter, reduce its output current to 80 % of its motor full load current I_e at pulse frequencies over 12 kHz.

PNU	Name	Adjustable in RUN mode	Value	DS
b83	Carrier frequency	–	0.5 to 16 kHz	5

Initialization

Two different types of initialization are available:

- Clearing the fault history register
- Restoring the default parameter settings (default setting)

To delete the fault history register or to restore the factory default settings, proceed as follows:

- ▶ Ensure that the correct country version has been set under PNU b85.
- ▶ Enter 00 or 01 under PNU b84 (initialization).
- ▶ Press the ENTER key to save the value.
- ▶ On the keypad, press both arrow keys and the PRG key at the same time and keep them pressed.
- ▶ While holding the arrow and PRG keys, briefly press the STOP key.
- ▶ Keep the other three keys pressed for three further seconds until the following flashing display appears: d 00.
- ▶ Now release all keys again.

Initialization is now complete.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
b84	Initialization	–	00	Clearing the fault history register	00
			01	Restoring the default parameter settings	

Regional settings

Here you define the country-specific parameter set which will be loaded during initialization (→ PNU b84).

PNU	Name	Adjustable in RUN mode	Value	Function	DS
b85	Regional settings	–	00	Japan	01[1)]
			01	Europe	
			02	USA	
			03	Reserved	

1) 02 for DF5-320-…

Frequency factor for display through PNU d07

The product of the output frequency and this factor is displayed under PNU d07.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
b86	Frequency factor	✓	0.1 to 99.9	The product of the value displayed under PNU d01 and this factor is displayed at PNU d07. This value is also available at the FM terminal.	1.0

OFF key disabled

The STOP key located on the keypad or remote operating unit can be inhibited here.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
b87	STOP key disabled	–	00	STOP key always active	00
			01	STOP key not active with control through the FWD/REV terminals	

Motor restart after removal of the FRS signal

Activation of the digital input configured as FRS (free run stop: coasting) causes the inverter to shut down, leaving the motor to coast freely. Two options are available to determine the frequency inverter's behaviour after deactivation of the FRS input.

PNU	Name	Adjustable in RUN mode	Value	Function	DS
b88	Motor restart after removal of the FRS signal	–	00	0 Hz restart after deactivation of the FRS input	00
			01	Synchronization of the motor to the current motor speed after the waiting time entered under PNU b03.	

Indication using the optional DE5-KEY-RO3 keypad

Selection of possible display values:

PNU	Name	Adjustable in RUN mode	Value	Function	DS
b89	Indication on the keypad	✓	01	Output frequency in Hz	01
			02	Motor current in A	
			03	Direction of rotation	
			04	Actual value × factor	
			05	Status of digital inputs 1 to 5	
			06	Digital outputs 11 and 12 and fault message output	
			07	Output frequency × factor	

7 Messages

This section lists the messages the DF5 frequency inverter issues and explains their meaning.

Fault messages

If a fault is detected, the DF5 frequency inverter disables its output and displays a fault message on the display. To acknowledge the fault message:

- Press the STOP key,
- activate the digital input configured as RST,
- switch off the power supply.

Display	Cause	Description
E 01	Overcurrent in the inverter in static operation	In the following cases, the output current is too high: • The frequency inverter's output is short-circuited • The motor is blocked • An excessive load is suddenly applied to the output.
E 02	Overcurrent in the inverter during deceleration	
E 03	Overcurrent in the inverter during acceleration	
E 04	Overcurrent in the inverter at standstill	
E 05	Overload	The internal electronic motor protection has switched off the output voltage because of an overload.
E 07	Overvoltage	Overvoltage in regenerative mode.
E 08	EEPROM fault	The program memory is not operating reliably due to radio frequency interference, a control voltage short-circuit (P24–L) or excessive temperature. If the supply voltage is switched off while the RST input is active, an EEPROM fault occurs when the supply voltage is reapplied.
E 09	Undervoltage	Insufficient DC voltage (error-free electronics function not possible; potential problems such as overheating of motor and insufficient torque).
E 11	Processor malfunction	Processor is not working correctly, e.g. through RFI or excessive temperature.
E 12	External fault message	An external fault signal is applied to a digital input configured as EXT input.
E 13	Restart inhibit activated	The mains voltage was switched on or an intermittent interruption in the supply voltage has occurred while unattended start protection (input USP) was active.
E 14	Ground fault	Earth faults between the U, V or W terminals and earth are being reliably detected. A protective circuit prevents destruction of the frequency inverter at startup, but does not protect the operating personnel.
E 15	Mains overvoltage	The mains voltage exceeds the permissible value. Shutdown about 100 s after activation of power supply.
E 21	Overtemperature	The built-in temperature sensor in the power section is measuring an operating temperature above the permissible limit value.
E 22	Processor malfunction	Processor is not working correctly, e.g. through RFI or excessive temperature.
E 35	PTC fault message	The resistance of the externally fitted PTC thermistor connected to the PTC input (digital input configured as PTC input) is too high.

Fault history register

The DF5 frequency inverter has a fault history register to which the three most recent fault messages are saved. In addition to fault messages E 01 to E 35, the frequency inverter saves the following information at the time of the last fault:

- Output frequency
- Output current
- Internal DC link voltage

▶ Go to one of the display parameters, PNU d08 to d09.
▶ Press the PRG key.

If a fault message has been saved, it appears on the display, for example E 07. To view all information, keep pressing the PRG key until you return to the display parameter (→ Fig. 106).

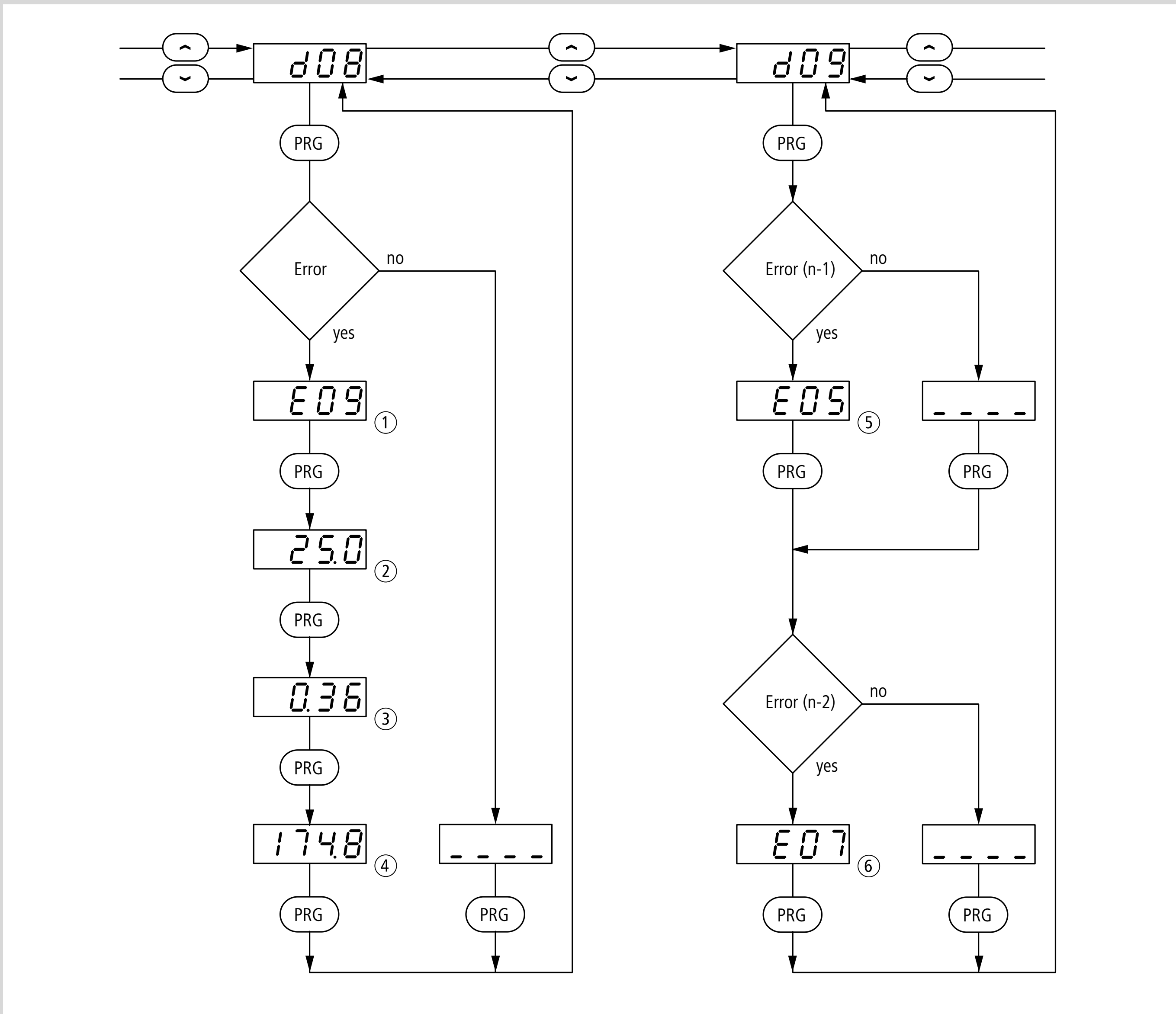
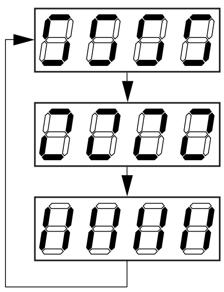
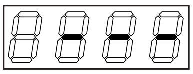
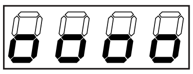
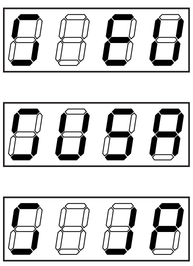
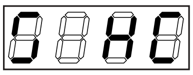
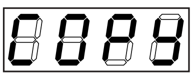
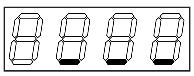


Figure 106: Data in the fault register

① Type of most recent fault message
② Output frequency
③ Output current
④ Internal DC link voltage
⑤ Type of last but one fault message
⑥ Type of last but two fault message

Other messages

This section describes the messages issued by the DF5 frequency inverter, for example in standby mode when mains power is switched off.

Display	Cause
	Initialization after activation of power supply or at active Reset signal (activated digital input configured as RST).
	The mains voltage has been switched off.
	The waiting time before the automatic restart is running (PNU b01 and b03, → section "Automatic restart after a fault", page 100).
	The default setting has been selected and the frequency inverter is in its initialization phase (PNU b84 and b85, → section "Initialization", page 105). The values for the European market (EU) are being initialized. For non-European models, versions for North America (USA) and Japan (JP) are available.
	Initialization of the fault history register
	Copy station – copying in progress.
	No data available, e.g. display under PNU d81 and d86, when the fault history register is empty the display under PNU d04, when PID control is not active.

8 Troubleshooting

Fault	Condition	Possible cause	Remedy
The motor will not start.	There is no voltage present at outputs U, V and W.	Is voltage applied to terminals L, N and/or L1, L2 and L3? If yes, is the ON lamp lit?	Check terminals L1, L2, L3 and U, V, W. Switch on the supply voltage.
		Is the LED display on the keypad indicating a fault message (E … …)?	Analyze the cause of the fault message (→ section "Messages", page 107). Acknowledge the fault message with the reset command (e.g. by pressing the STOP key).
		Has a start signal been issued?	Issue the start signal with the START key or through the FWD/REV input.
		Has a setpoint frequency been entered under PNU F01 (for control through operator panel only)?	Enter a setpoint frequency under PNU F01.
		Are the setpoint definitions through the potentiometer correctly wired to terminals H, O and L?	Check that the potentiometer is connected correctly.
		Are inputs O and OI connected correctly for external setpoint input?	Check that the setpoint signal is correctly connected.
		Are the digital inputs configured as RST or FRS still active?	Deactivate RST and/or FRS. Check the signal on digital input 5 (default setting: RST).
		Has the correct source for the setpoint frequency (PNU A01) been set? Has the correct source for the start signal (PNU A02) been set?	Correct PNU A01 accordingly. Correct PNU A02 accordingly. (→ section "Setting the frequency and start signal parameters", page 81)
	There is voltage present at outputs U, V and W.	Is the motor blocked or is the motor load too high?	Reduce the load acting on the motor. Test the motor without load.
The motor turns in the wrong direction.	–	Are output terminals U, V and W correctly connected? Does the connection of terminals U, V and W correspond with the direction of rotation of the motor?	Connect output terminals U, V and W correctly to the motor according to the required direction of motor rotation (generally the sequence U, V, W causes clockwise operation).
		Are the control signal terminals correctly wired?	Control signal terminal FWD for clockwise operation and REV for anticlockwise operation.
		Has PNU F04 been correctly configured?	Set the desired direction of rotation under PNU F04.
The motor will not start.	–	No setpoint value is applied to terminal O or OI.	Check the potentiometer or the external setpoint generator and replace if necessary.
		Is a fixed frequency accessed?	Observe the sequence of priority: the fixed frequencies always have priority over inputs O and OI.
		Is the motor load too high?	Reduce the motor load as the overload limit will prevent the motor reaching its normal speed if there is an overload.

Fault	Condition	Possible cause	Remedy
The motor does not operate smoothly.	–	Are the load changes on the motor too high?	Select a frequency inverter and motor with a higher performance. Reduce the level of load changes.
		Do resonant frequencies occur on the motor?	Mask these frequencies with the frequency jumps (PNU A63 to A68, → section "Operating frequency range", page 86) or change the pulse frequency (PNU b83, → section "Carrier frequency", page 105).
The drive speed does not correspond with the frequency	–	Is the maximum frequency set correctly?	Check the set frequency range or the set voltage/frequency characteristic.
		Are the rated speed of the motor and the gearbox reduction ratio correctly selected?	Check the rated motor speed or the gearbox reduction ratio.
The saved parameters do not correspond to the entered values.	Entered values have not been saved.	The supply voltage was switched off before the entered values were saved by pressing the ENTER key.	Re-enter the affected parameters and save the input again.
		After the supply voltage was switched off, the entered and saved values are transferred into the internal EEPROM. The supply voltage should remain off for at least six seconds.	Enter the data again and switch off the supply voltage for at least six seconds.
	The values of the copy unit were not accepted by the frequency inverter.	After copying the parameters of the external keypad DEX-KEY-10 into the frequency inverter, the supply voltage was left on for less than six seconds.	Copy the data again and leave the supply voltage on for at least six seconds after completion.
It is not possible to make any inputs.	The motor cannot be started or stopped or setpoint values cannot be set.	Are PNU A01 and A02 set correctly?	Check the settings of PNU A01 and A02 (→ section "Setting the frequency and start signal parameters", page 81).
	No parameters can be set or changed.	Has software parameter protection been activated?	To allow parameter changes, disable parameter protection with PNU b31 (→ section "Parameter protection", page 104).
		Has the hardware parameter protection been activated?	Disable the digital input configured as SFT (→ section "SFT: Software protection"page 70
The electronic motor protection activates (fault message: E 05).		Is the manual voltage boost set too high? Were the correct settings made for the electronic motor protection?	Check the boost setting and the electronic motor protection setting. (→ section "Voltage/frequency characteristic and voltage boost", page 84)

To be observed when saving changed parameters:

After saving changed parameters with the ENTER key, no inputs can be made using the keypad of the frequency inverter for at least six seconds. If, a key is pressed before this time elapses, or if the reset command is issued or the frequency inverter is switched off, the data may not be correctly saved.

Appendix

Technical data

General technical data of the DF5

The table below lists the technical data for all DF5 frequency inverters.

		DF5
Protection class according to EN 60529		IP 20
Overvoltage category		III
Secondary side: Frequency range		0.5 to 360 Hz With motors which are operated at rated frequencies above 50/60 Hz, the maximum possible motor speed should be observed.
Frequency error limits (at 25 °C ±10 °C)		• Digital setpoint value: ±0.01 % of the maximum frequency • Analog setpoint value: ±0.2 % of the maximum frequency
Frequency resolution		• Digital setpoint value: 0.1 Hz • Analog setpoint value: Maximum frequency/1000
Voltage/frequency characteristic		Linear or square-law (constant or reduced torque)
Permissible overcurrent		150% for 60 seconds (once every 10 minutes)
Acceleration/deceleration time		0.1 to 3000 s at linear and non-linear characteristic (applies also for second acceleration/deceleration time)
Inputs		
Frequency setting	Keypad	Setting through keys or potentiometer
	External signals	• 0 to 10 V⎓, input impedance 10 kΩ; • 4 to 20 mA, load impedance 250 Ω • Potentiometer ≧ 1 kΩ, recommended 4.7 kO
Clockwise/anticlockwise operation (start/stop)	Keypad	START key (for Start) and OFF key (for Stop); default setting = clockwise operation
	External signals	Digital control inputs programmable as FWD and REV
Digital control inputs programmable as		• FWD: Start/stop clockwise operation • REV: Start/stop anticlockwise operation • FF1 to FF4: Fixed frequency selection • JOG: Jog mode • AT: Use setpoint value 4 to 20 mA • 2CH: Second time ramp • FRS: Free run stop • EXT: External fault message • USP: Unattended start protection • RST: Reset • SFT: Software protection • PTC: PTC thermistor input
Outputs		
Digital signalling outputs programmable as		• FA1/FA2: Frequency reached/exceeded • OL: Overload • AL: Fault • RUN: Motor operational • OD: PID deviation exceeded
Monitoring of frequency and current		• Connection of an analog display device: 0 to 10 V⎓, up to 1 mA for frequency or current • Connection of a digital frequency meter
Signalling relay		Relay contacts as two-way switch

	DF5
Further features (excerpt)	• Automatic voltage regulation • Unattended start protection • Variable amplification and output voltage reduction • Frequency jumps • Minimum/maximum frequency limitation • Output frequency display • Fault history register available • Freely selectable pulse frequency: 0.5 to 16 kHz • PID control • Automatic torque boost
Safety features	• Overcurrent • Overvoltage • Undervoltage • Overtemperature • Earth fault (on Power On) • Overload • Electronic motor protection
Ambient conditions	
Ambient temperature	–10 to +50 °C From about +40 to +50 °C, the pulse frequency should be reduced to 2 kHz. The output current should be less than 80 % of the rated current in this case.
Temperature/humidity during storage	–25 to 70 °C (for short periods only, e.g. during transport) 20 to 90 % relative humidity (non condensing)
Permissible vibration	Maximum 5.9 m/s^2 (= 0.6 g) at 10 to 55 Hz
Installation height and location	Maximum 1000 m above sea level in a housing or control panel (IP 54 or similar)
Optional accessories	• DEX-KEY-10 remote operating unit • Choke to improve the power factor • RFI filter

Specific technical data of the DF5-322

The table below contains the specific technical specifications of the single- and three-phase 230 V series, such as current, voltage, and torque values.

DF5-322-…		018	037	055	075	1K1	1K5	2K2
Maximum permissible effective motor power in kW, details for four pole three-phase current asynchronous motors		0.18	0.37	0.55	0.75	1.1	1.5	2.2
Maximum permissible apparent motor power in kVA	230 V	0.5	1.0	1.1	1.5	1.9	2.8	3.9
	240 V	0.5	1.0	1.2	1.6	2.0	2.9	4.1
Primary side: Number of phases		Single-phase/three-phase						
Primary side: Rated voltage		180 V ~ –0 % to 252 V ~ +0 %, 47 to 63 Hz						
Secondary side: Rated voltage		Three-phase 200 to 240 V ~ Corresponding to the primary side rated voltage If the primary voltage drops, the secondary voltage also drops.						
Primary side: Rated current in A	Single-phase	3.1	5.8	6.7	9.0	11.2	16.0	22.5
	Three-phase	1.8	3.4	3.9	5.2	6.5	9.3	13.0
Primary side: Rated current in A		1.4	2.6	3.0	4.0	5.0	7.1	10.0
Torque during start		100 % or above (with activated torque boost)						
Braking torque								
with feedback to the capacitors Reduced braking torque at frequencies above 50 Hz.		Approx. 100 %				Approx. 70 %		Approx. 20 %
With DC injection braking		Braking occurs at frequencies below the minimum frequency (minimum frequency, braking time and braking torque are user-definable)						
	External signals	Digital control inputs programmable as FWD and REV						
Fan		–	–	–	–	–	–	✓

Specific technical data of the DF5-320

The table below contains the specific technical specifications of the three-phase 230 V series, such as current, voltage, and torque values.

DF5-320-…		4K0	5K5	7K5
Maximum permissible effective motor power in kW, details for four pole three-phase current asynchronous motors		4.0	5.5	7.5
Maximum permissible apparent motor power in kVA	230 V	6.3	9.6	12.7
	240 V	6.6	9.9	13.3
Primary side: Number of phases		Three-phase		
Primary side: Rated voltage		180 V ~ –0 % to 252 V ~ +0 %, 47 to 63 Hz		
Secondary side: Rated voltage		Three-phase 200 to 240 V ~ Corresponding to the primary side rated voltage If the primary voltage drops, the secondary voltage also drops.		
Primary side: Rated current in A	Three-phase	20.0	30.0	40.0
Primary side: Rated current in A		15.9	24.0	32.0
Torque during start		100 % or above (with activated torque boost)		
Braking torque				

DF5-320-…	4K0	5K5	7K5
with feedback to the capacitors Reduced braking torque at frequencies above 50 Hz.	Approx. 100 %		Approx. 70 %
With DC injection braking	Braking occurs at frequencies below the minimum frequency (minimum frequency, braking time and braking torque are user-definable)		
Fan	✓	✓	✓

Specific technical data of the DF5-340

The table below contains the specific technical specifications of the three-phase 400 V series, such as current, voltage, and torque values.

DF5-340-…	037	075	1K5	2K2	3K0	4K0	5K5	7K5
Maximum permissible effective motor power in kW, details for four pole three-phase current asynchronous motors	0.37	0.75	1.5	2.2	3.0	4.0	5.5	7.5
Maximum permissible apparent motor power in kVA for 460 V	1.1	1.9	3.0	4.3	6.2	6.8	10.3	12.7
Primary side: Number of phases	Three-phase							
Primary side: Rated voltage	342 V ~ –0 % to 506 V ~ +0 %, 47 to 63 Hz							
Secondary side: Rated voltage	Three-phase 360 to 460 V ~ Corresponding to the primary side rated voltage If the primary voltage drops, the secondary voltage also drops.							
Primary side: Rated current in A	2.0	3.3	5.0	7.0	10.0	11.0	16.5	20.0
Primary side: Rated current in A	1.5	2.5	3.8	5.5	7.8	8.6	13.0	16.0
Torque during start	100 % or above (with activated torque boost)							
Braking torque								
with feedback into the capacitors: reduced braking torque at frequencies exceeding 50 Hz.	Approx. 100 %		Approx. 70 %	Approx. 20 %				
With DC injection braking	Braking occurs at frequencies below the minimum frequency (minimum frequency, braking time and braking torque are user-definable)							
Fan	–	–	✓	✓	✓	✓	✓	✓

Weights and dimensions

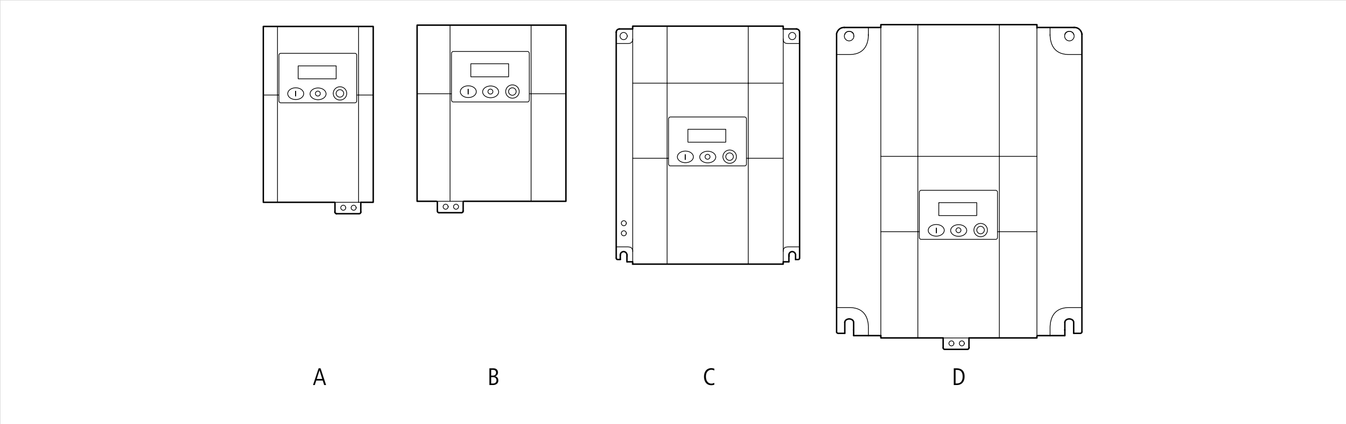


Figure 107:
DF5 frame sizes

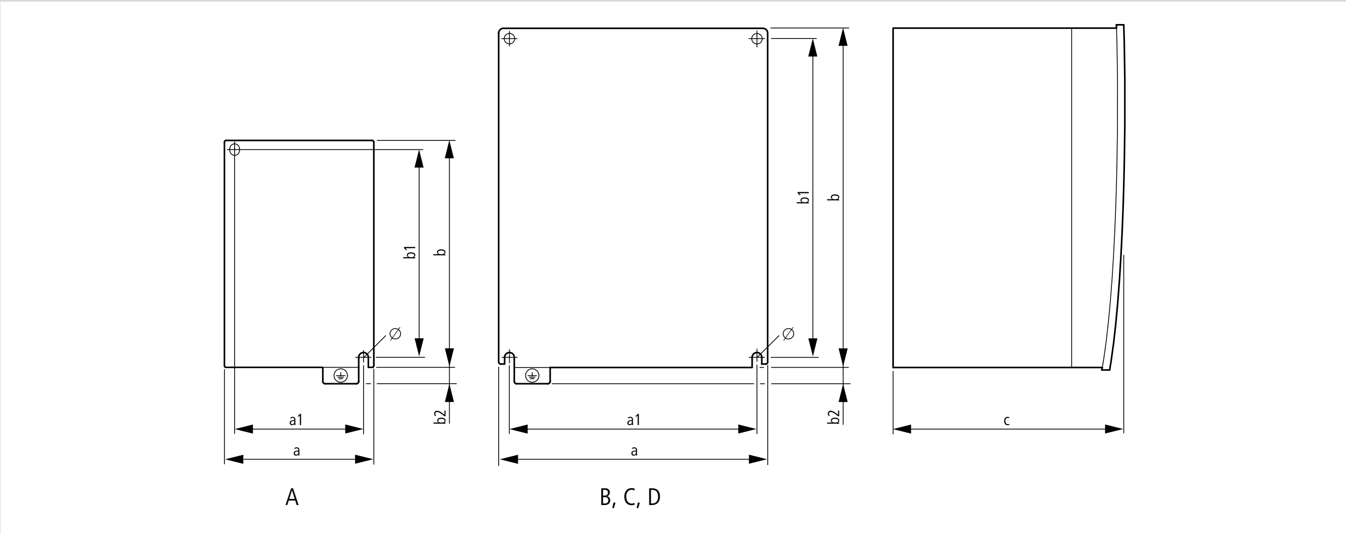


Figure 108: DF5 dimensions

DF5-	a	a1	b	b1	b2	c	∅	[kg]	
320-4K0	140	128	184.5	168	–	175	5	2.8	C
320-5K5	182	160	260	236	13	177	7	5.5	D
320-7K5	182	160	260	236	13	177	7	5.7	D
322-018 322-037	88.5	67	126	110	7	117	5	0.85	a
322-055 322-075 340-037	118	98	136	118	7	140	5	1.3	b
340-075 340-1K5	118	98	136	118	–	167	5	1.7	b
322-1K1 322-1K5	140	128	184.5	168	7	164	5	2.2	C
322-2K2 340-2K2 340-3K0 340-4K0	140	128	184.5	168	–	175	5	2.8	C
340-5K5	182	160	260	236	13	177	7	5.5	D
340-7K5	182	160	260	236	13	177	7	5.7	D

Cables and fuses

The cross-sections of the cables and line protection fuses used must correspond with local standards.

DF5-	Connection to the power supply	VDE	UL1)	Moeller	L1, L2, L3, N, U, V, W, PE (2x) mm2	AWG
320-4K5	3-phase 230 V	M32A	30 A	PKM0-25	6	12
320-5K5		M32A	40 A	PKZM4-40	10	10
320-7K5		M40A	50 A	PKZM4-40	10	8
322-018	1/3-phase 230 V	M10 A	10 A	FAZ-1N-B10, PKZM0-10	1.5	15
322-037	1/3-phase 230 V	M10 A	10 A	FAZ-1N-B10, PKZM0-10	1.5	15
322-055	1/3-phase 230 V	M10 A	10 A	FAZ-1N-B10, PKZM0-10	1.5	15
322-075	1/3-phase 230 V	M16 A	15 A	FAZ-1N-B16, PKZM0-16	2.5	13
322-1K1	1/3-phase 230 V	M20 A	20 A	FAZ-1N-B20, PKZM0-20	2.5	13
322-1K5	Single-phase 230 V	M25 A	25 A	FAZ-1N-B25	4.0	11
	3-phase 230 V	M16 A	15 A	PKZM0-16	4.0	11
322-2K2	Single-phase 230 V	M40 A	40 A	FAZ-1N-B40	4.0	11
	3-phase 230 V	M25 A	25 A	PKZM0-25	4.0	11
340-037	3-phase 400 V	M10 A	10 A	PKZM0-10	1.5	15
340-075		M10 A	10 A	PKZM0-10	1.5	15
340-1K5		M10 A	10 A	PKZM0-10	1.5	15
340-2K2		M10 A	10 A	PKZM0-10	1.5	15
340-3K0		M16 A	15 A	PKZM0-16	2.5	13
340-4K0		M16 A	15 A	PKZM0-16	2.5	13
340-5K5		M25 A	25 A	PKZM0-25	4.0	11
340-7K5		M25 A	25 A	PKZM0-25	4.0	11

1) Tripping characteristic "H" or "K5" (approved fuses and fuse holders)

Use cables with a larger cross-section for supply voltage and motor cables which exceed about 20 m in length.

Control cables should be screened and have a maximum cross-section of 0.75 mm^2.

For the cable which is to be connected to the signal output, use a cable cross-section of 0.75 mm^2. Strip about 5 to 6 mm off the cable ends. The external diameter of the signal cable should be no more than 2 mm, except for the connection to the signalling relay.

Mains contactors

→ The mains contactors listed here assume the network's rated current (I_{LN}) without mains choke or mains filter. Their selection is based on the thermal current (AC-1).

▽ **Caution!**
Jog mode must not be used through the mains contactor (rest period ≧ 180 s between switching off and on)

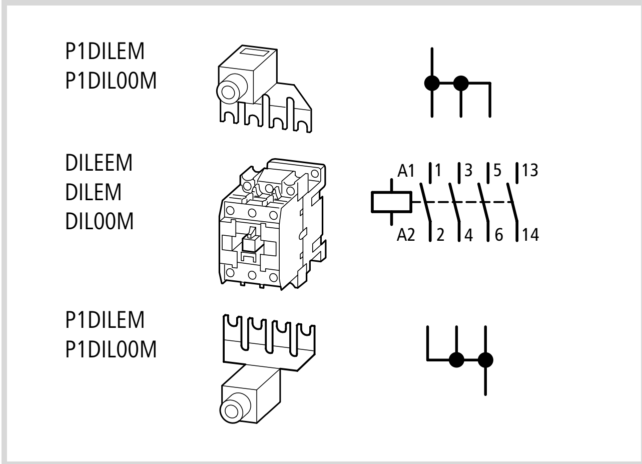


Figure 109: Mains contactor at single-phase connection

DF5	DF5 phase current	DF5 inrush current	Mains contactor		+ Paralleling link[1)]
			Open/enclosed	Model	
	I_{LN} [A]	I_0 [A]	I_{th} AC-1 [A]		
1 ~ 230 V connection					
322-018	3.1	17.7	20/16	DIL00M	P1DIL00M
322-037	5.8				
322-055	6.7				
322-075	9				
322-1K1	11.2				
322-1K5	16				
322-2K2	22.5			DIL0M	P1DIL0M
3 ~ 230 V connection					
320-4K0	22	3	35/30	DIL0M	–
320-5K5	30		35/30	DIL0M	
320-7K5	40		55/44	DIL1M	
322-018	1.8	17.7	20/16	DILEEM	
322-037	3.4				
322-055	3.9			DIL00M	
322-075	5.2				
322-1K1	6.5				
322-1K5	9.3				
322-2K2	13				

DF5	DF5 phase current	DF5 inrush current	Mains contactor		+ Paralleling link[1)]
			Open/enclosed	Model	
	I_{LN} [A]	I_0 [A]	I_{th} AC-1 [A]		
3 ~ 400 V connection					
340-037	2	30.8	20/16	DILEEM	–
340-075	3.3				
340-1K5	5			DIL00M	
340-2K2	7				
340-3K0	10				
340-4K0	11				
340-5K5	16.5		35/30	DIL0M	
340-7K5	20	61.1	35/30	DIL0M	

1) For a single-phase supply connection, use the with the associated parallel connectors in addition to the mains contactors (terminals 135 and 246). The fourth pin can be broken off.

Mains choke

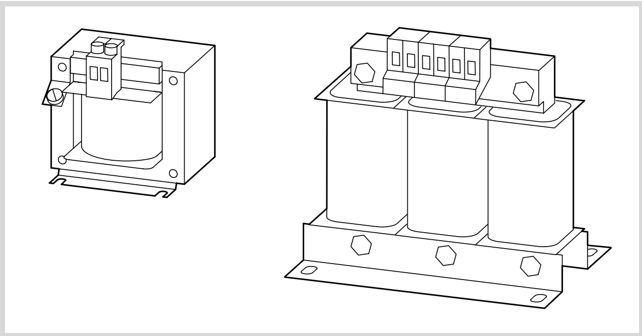


Figure 110: DEX-LN... mains chokes

→ 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}).

DF5-	Mains voltage	Mains current (I_{LN}) of the DF5 without mains choke	Assigned mains choke
320-4K0	3 ~ 230 V	22	DEX-LN3-025
320-5K5		30	DEX-LN3-040
320-7K5		40	DEX-LN3-040
322-018	1 ~ 230 V	3.1	DEX-LN1-006
322-037		5.8	DEX-LN1-006
322-055		6.7	DEX-LN1-009
322-075		9	DEX-LN1-009
322-1K1		11.2	DEX-LN1-013
322-1K5		16	DEX-LN1-018
322-2K2		22.5	DEX-LN1-024
322-018	3 ~ 230 V	1.8	DEX-LN3-004
322-037		3.4	
322-055		3.9	
322-075		5.2	DEX-LN3-006
322-1K1		6.5	DEX-LN3-006
322-1K5		9.3	DEX-LN3-010
322-2K2		13	DEX-LN3-016
340-037	3 ~ 400 V	2	DEX-LN3-004
340-075		3.3	DEX-LN3-004
340-1K5		5	DEX-LN3-006
340-2K2		7	DEX-LN3-010
340-3K0		10	
340-4K0		11	
340-5K5		16.5	DEX-LN3-016
340-7K5		20	DEX-LN3-025

→ For technical data for the DEX-LN series mains chokes, see installation instructions AWA8240-1711

→ Mains chokes reduce the magnitude of the current harmonics up to about 30 % and increase the lifespan of frequency inverters and upstream-connected switching devices.

RFI filters

RFI filters have discharge currents to earth, which, in the event of a fault (phase failure, load unbalance), can be higher than the rated values. To avoid dangerous voltages, the filters must be earthed before use.

For discharge currents ≧ 3.5 mA, VDE 0160 and EN 60335 specify that

- the protective conductor must have a cross-section ≧ 10 mm^2 or
- a second protective conductor must be connected, or
- the continuity of the protective conductor must be monitored.

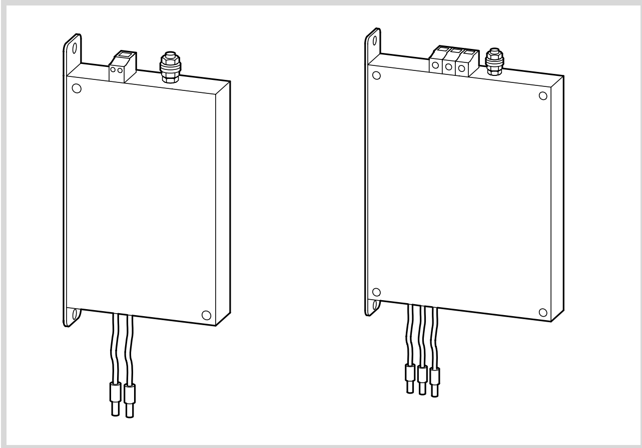


Figure 111: Single- and three-phase RFI filters

→ The DE5-LZ1 and DE5-LZ3 radio interference filters can be fitted to the side or below the frequency inverter.

The table below matches radio interference filters to frequency inverters.

DF5-	Rated mains voltage	RFI filters	Maximum leakage current at rated operation mA	Maximum leakage current under fault conditions mA	Power loss of RFI filter at rated operation W
320-4K0	3 ~ 198 V – 0 % to 252 V + 0 %	DE6-LZ3-032-V4	< 30	280	14
320-5K5		DE6-LZ3-032-V4	< 30	280	14
320-7K5		DE6-LZ3-064-V4	< 30	550	36
322-018 322-037	1 ~ 198 V – 0 % to 252 V + 0 %	DE5-LZ1-007-V2	< 3.5	–	6
322-055 322-075		DE5-LZ1-012-V2	< 3.5	–	7
322-1K1 322-1K5 322-2K2		DE5-LZ1-024-V2	< 15	–	9
340-037 340-075 340-1K5	3 ~ 342 V – 0 % to 506 V + 0 %	DE5-LZ3-007-V4	< 3.5	< 32	7
340-2K2 340-3K0 340-4K0		DE5-LZ3-011-V4	< 3.5	< 62	10
340-5K5 340-7K5		DE5-LZ3-020-V4	< 10	< 120	14

Output boost in 87 Hz operation

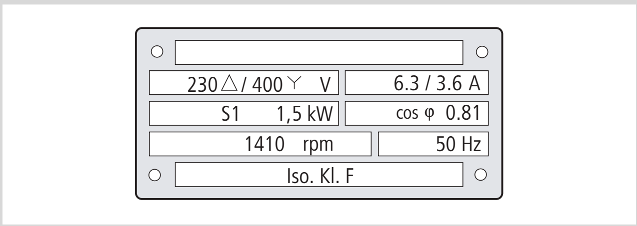


Figure 112: Motor nameplate

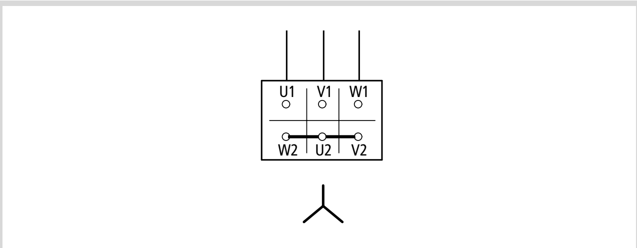


Figure 113: Motor connection to frequency inverter

Mains voltage: 3~ 400 V
Frequency inverter: DF5-340-1K5
Parameters: Default settings

Changing the setpoint value offsets the output frequency and the associated output voltage along the speed/torque characteristic (→ Fig. 114).

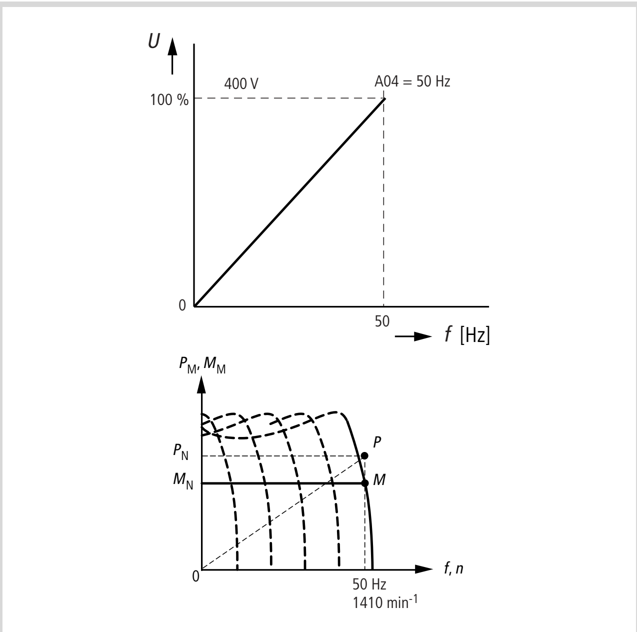


Figure 114: Speed/torque characteristic

P_M: Motor power
P_N: Rated power
M_M: Motor torque
M_N: Rated torque

The same motor can have a higher power of voltage and frequency are higher than the values given on the nameplate. The electrical rated values must not be exceeded, however. Because of the higher thermal load, the motor must have temperature class (insulation class) F.

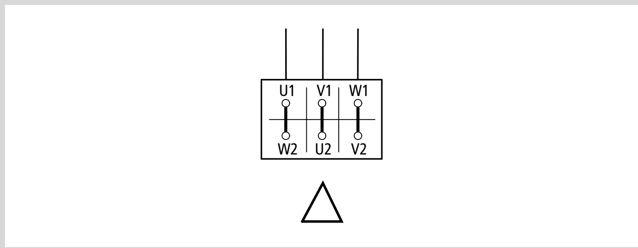


Figure 115: Motor connection for 87 Hz operation

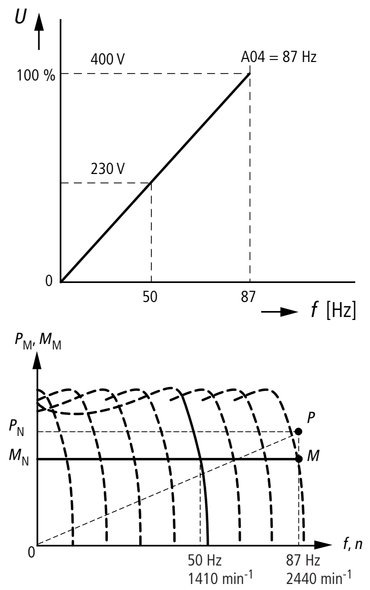


Figure 116: Speed/torque characteristic in 87 Hz operation

P_M: Motor power
P_N: Rated power
M_M: Motor torque
M_N: Rated torque

$$\frac{400\ V}{230\ V} = 1.73$$

50 Hz × 1.73 = 87 Hz
1410 min^{-1} × 1.73 = 2440 min^{-1}
1.5 kW × 1.73 = 2.6 kW
3.4 A × 1.73 = 6.3 A

The motor's rating (1.5 kW) is increased to about 2.6 kW at 87 Hz in the delta circuit. The required frequency inverter must be able to supply a current of at least 6.3 A: DF5-340-3K0

In 87 Hz operation, the stalling and rated torque values are the same as for mains operation at 50 Hz.

Abbreviations of parameters and functions

Designation Message	Function, description German	English
2CH	Second time ramp	2-stage Acceleration and Deceleration
AL	Fault signal	Alarm signal
AT	Selection of the analog setpoint source (AT = current setpoint value 4 to 20 mA)	Analog input voltage/current select
AVR	Automatic voltage regulation	Automatic voltage regulation
EXT	Input for external malfunction signals	External Trip
FA…	Frequency arrival signal (set value reached or exceeded)	Frequency arrival
FF…	Fixed frequency (fixed setpoint value)	Fixed Frequency
FRS	Controller inhibit (the motor coasts to a stop)	Free-run Stop
FWD	Clockwise rotating field (forward)	Forward Run
JOG	Jog mode	Jogging
OD	PID control deviation signal	Output deviation for PID control
OL	Overload signal	Overload advance signal
FM	Frequency display	Frequency monitor
PTC	Thermistor, PTC thermistor	Positive temperature coefficient
REV	Reverse (backwards, anticlockwise rotating field)	Reverse Run
RST	Reset command	Reset
RUN	Run signal	Running signal
SFT	Software protection to prevent overwrite of parameters	Software lock function
USP	Unattended start protection	Unattended start protection

Standard form for user-defined parameter settings

The DF5 frequency inverters have programmable parameters. The values in square brackets [xx] are the default settings for the USA. The DF5-320-… frequency inverters are supplied with the US default settings. In the free Setpoint columns below, you can list the changes you have made from the default settings.

PNU	Function	Value range	DS	Page	Setpoint		
A01	Frequency setpoint input	• 00: Potentiometer • 01: Input O/OI • 02: PNU F01 and/or A20	01	81			
A02	Start signal input	• 01: Input FWD/REV • 02: START key	01	82			
A03	Base frequency	50 to 360 Hz	50 [60]	82			
A04	Maximum end frequency	50 to 360 Hz	50 [60]	82			
A11	Frequency with minimum setpoint value	0 to 360 Hz	0	83			
A12	Frequency with maximum setpoint value	0 to 360 Hz	0	83			
A13	Minimum setpoint value	0 to 100 %	0	83			
A14	Maximum setpoint value	0 to 100 %	100	83			
A15	Starting frequency	• 00: Apply PNU A11 to motor • 01: Apply 0 Hz to motor	01	83			
A16	Analog input filter time constant	0 to 8	8	83			
A20	Frequency setpoint definition. PNU A01 must be 02.	0.5 to 360 Hz	0.0	61			
A21	First fixed frequency	0.5 to 360 Hz	0.0	61			
A22	Second fixed frequency	0.5 to 360 Hz	0.0	61			
A23	Third fixed frequency	0.5 to 360 Hz	0.0	61			
A24	Fourth fixed frequency	0.5 to 360 Hz	0.0	61			
A25	Fifth fixed frequency	0.5 to 360 Hz	0.0	61			
A26	Sixth fixed frequency	0.5 to 360 Hz	0.0	61			
A27	Seventh fixed frequency	0.5 to 360 Hz	0.0	61			
A28	Eighth fixed frequency	0.5 to 360 Hz	0.0	61			
A29	Ninth fixed frequency	0.5 to 360 Hz	0.0	61			
A30	Tenth fixed frequency	0.5 to 360 Hz	0.0	61			
A31	Eleventh fixed frequency	0.5 to 360 Hz	0.0	61			
A32	Twelfth fixed frequency	0.5 to 360 Hz	0.0	61			
A33	13th fixed frequency	0.5 to 360 Hz	0.0	61			
A34	14th fixed frequency	0.5 to 360 Hz	0.0	61			
A35	15th fixed frequency	0.5 to 360 Hz	0.0	61			
A38	Frequency in jog mode	0.5 to 9.99 Hz	1.0	68			
A39	Motor stop in jog mode through	• 00: Free run • 01: Deceleration ramp • 02: DC braking	00	68			
A41	Voltage boost characteristics	• 00: Manual • 01: Automatic	00	84			

PNU	Function	Value range	DS	Page	Setpoint		
A42	Percentage voltage increase with manual boost	0 to 99 %	11	84			
A43	Maximum boost at x % of the base frequency	0 to 50 %	10.0	84			
A44	*U f* characteristic	• 00: Constant torque curve • 01: Reduced torque curve	00	84			
A45	Output voltage	50 to 100 %	100	84			
A51	DC braking	• 00: Inactive • 01: Active	00	85			
A52	DC braking starting frequency	0.5 to 10 Hz	0.5	85			
A53	DC braking waiting time	0.0 to 5 s	0.0	85			
A54	DC braking torque	0 to 100 %	0	85			
A55	DC braking duration	0.0 to 60 s	0.0	85			
A61	Maximum operating frequency	0.5 to 360 Hz	0.0	86			
A62	Minimum operating frequency	0.5 to 360 Hz	0.0	86			
A63	1st frequency jump	0.1 to 360 Hz	0.0	86			
A64	Jump width of the 1st frequency jump	0.1 to 10 Hz	0.5	86			
A65	Second frequency jump	0.1 to 360 Hz	0.0	86			
A66	Jump width of the second frequency jump	0.1 to 10 Hz	0.5	86			
A67	Third frequency jump	0.1 to 360 Hz	0.0	86			
A68	Jump width of the third frequency jump	0.1 to 10 Hz	0.5	86			
A71	PID control	• 00: Inactive • 01: Active	00	90			
A72	P component of the PID control	0.2 to 50	1.0	91			
A73	I component of the PID control	0.0 to 150 s	1.0	91			
A74	D component of the PID control	0.0 to 100 s	0.0	91			
A75	Setpoint factor of the PID control	0.01 to 99.99	1.00	91			
A76	Input actual value signal for PID control	• 00: Input OI • 01: Input O	00	91			
A81	AVR function	• 00: Active • 01: Inactive • 02: Inactive during deceleration	02	98			
A82	Motor voltage for AVR function	• 200, 220, 230, 240 V • 380, 400, 415, 440, 460 V	230/400 [230/460]	98			
A92	Second acceleration time	0.1 to 3000 s	15.0	99			
A93	Second deceleration time	0.1 to 3000 s	15.0	99			
A94	Switchover from the first time ramp to the second time ramp	• 00: Input 2CH • 01: PNU A95 or A96	00	99			
A95	Changeover frequency from first to second acceleration time	0.0 to 360 Hz	0.0	99			
A96	Changeover frequency from first to second deceleration time	0.0 to 360 Hz	0.0	99			

PNU	Function	Value range	DS	Page	Setpoint
A97	Acceleration characteristic	• 00: Linear • 01: S-curve	00	99	
A98	Deceleration characteristic	• 00: Linear • 01: S-curve	00	99	

PNU	Function	Value range	DS	Page	Setpoint
b01	Restart mode	• 00: Fault message • 01: 0 Hz Start • 02: Synchronization to current motor speed and acceleration • 03: Synchronization and deceleration	00	100	
b02	Permissible power failure duration	0.3 to 25 s	1.0	101	
b03	Waiting time before restart	0.3 to 100 s	1.0	101	
b12	Tripping current for electronic motor protection device	0.5 to 1.2 × I_e [A]	I_e (inverter)	102	
b13	Characteristic for electronic motor protection device	• 00: Enhanced protection • 01: Continuous protection	01	102	
b21	Motor current limitation	• 00: Inactive • 01: Active in every operating status • 02: Inactive during acceleration, otherwise active	01	103	
b22	Tripping current for motor current limitation	0.5 to 1.5 × I_e [A]	I_e × 1.25	103	
b23	Time constant of motor current limitation	0.1 to 30 Hz/s	1.0	103	
b31	Software-dependent parameter protection	• 00: With SFT input; all functions inhibited • 01: with SFT input; all functions except F01 inhibited • 02: Without SFT input; all functions inhibited • 03: without SFT input; all functions except F01 inhibited	01	104	
b32	Calibration factor	0 to 1.4 × I_e [A]	I_e × 0.58	104	
b81	Calibration value for voltmeter on FM terminal	0 to 255	80	56	
b82	Increased starting frequency (e.g. with high level of friction)	0.5 to 9.9 Hz	0.5	74	
b83	Carrier frequency	0.5 to 16 kHz	5.0	105	
b84	Initialization causes	• 00: Clearing of the fault history register • 01: Selection of the default settings	00	105	
b85	Operating system	• 00: Japan • 01: Europe version • 02: USA • 03: Reserved	01 [02]	105	
b86	Frequency factor for indication through PNU d07	0.1 to 99.9	1.0	106	
b87	STOP key	• 00: Always active • 01: Not active with control through the FWD/REV terminals	00	106	

PNU	Function	Value range	DS	Page	Setpoint	
b88	Motor restart after removal of the FRS signal	• 00: With 0 Hz • 01: With current motor speed	00	106		
b89	Display when a remote operating unit is used	• 01: Actual frequency • 02: Motor current • 03: Direction of rotation • 04: PID actual value • 05: Status of the digital inputs • 06: Status of the digital outputs • 07: Actual frequency multiplied by the frequency factor	01	106		

PNU	Function	Value range	DS	Page	Setpoint	
C01	Function of digital input 1	• 00: FWD, clockwise operation • 01: REV, anticlockwise operation • 02: FF1, first fixed frequency input • 03: FF2, second fixed frequency input • 04: FF3, third fixed frequency input • 05: FF4, fourth fixed frequency input • 06: JOG, jog mode • 09: 2CH, second time ramp • 11: FRS, controller inhibit • 12: EXT, external fault • 13: USP, unattended start protection • 15: SFT, parameter protection • 16: AT, input OI is used • 18: RST, reset • 19: PTC, thermistor input (only digital input 5)	00	58		
C02	Function of digital input 2	Values → PNU C01	01	58		
C03	Function of digital input 3	Values → PNU C01	02 [16]	58		
C04	Function of digital input 4	Values → PNU C01	03 [13]	58		
C05	Function of digital input 5	Values → PNU C01	18 [9]	58		
C11	Digital input 1	• 00: Make contact • 01: Break contact	00	58		
C12	Digital input 2	Values → PNU C11	00	58		
C13	Digital input 3	Values → PNU C11	00	58		
C14	Digital input 4	Values → PNU C11	00	58		
C15	Digital input 5	Values → PNU C11	00	58		
C21	Signal on digital output 11	• 00: RUN signal • 01: FA1, frequency reached • 02: FA2, frequency exceeded • 03: OL, overload • 04: OD, PID deviation exceeded • 05: AL, fault	01	71		
C22	Signal at digital output 12	Values → PNU C21	00	71		
C23	Indication through FM output	• 00: Frequency, analog • 01: Motor current, analog • 02: Output frequency, pulse signal	00	56		
C31	Digital output 11	• 00: Make contact • 01: Break contact	01	71		

PNU	Function	Value range	DS	Page	Setpoint	
C32	Digital output 12	• 00: Make contact • 01: Break contact	01	71		
C33	Relay output K11-K12 (signalling relay)	• 00: Make contact • 01: Break contact	01	78		
C41	Threshold for overload alarm at digital outputs 11 and 12	0 to 2 × I_e [A]	I_e	75		
C42	Frequency from which FA2 is switched on during acceleration	0 to 360 Hz	0.0	73		
C43	Frequency from which FA2 is switched off during deceleration	0 to 360 Hz	0.0	73		
C44	PID control deviation (from the maximum setpoint value)	0 to 100 %	3.0	76		

PNU	Function	Value range	Page	Setpoint		
d01	Output frequency display	–	46			
d02	Output current display	–	46			
d03	Direction of rotation display	–	46			
d04	PID feedback display	–	46			
d05	Digital inputs 1 to 6 status	–	46			
d06	Status of digital outputs 11 and 12	–	46			
d07	Scaled output frequency	–	46			
d08	Display of last alarm	–	46			
d09	Display of second and third to last alarm	–	46			

PNU	Function	Value range	DS	Page	Setpoint		
F01	Frequency setpoint value	0.5 to 360 Hz	0.0	80			
F02	Acceleration time 1	0.1 to 3000 s	10.0	80			
F03	Deceleration time 1	0.1 to 3000 s	10.0	81			
F04	Direction of rotation	• 00: Clockwise • 01: Anticlockwise	00	81			

UL® cautions, warnings and instructions

Preparation for wiring

Warning!
"Use 60/75 °C Cu wire only" or equivalent.

Warning!
"Open Type Equipment".

Warning!
"A Class 2 circuit wired with Class 1 wire" or equivalent.

Warning!
"Suitable for use on a circuit capable of delivering not more than 5000 r.m.s. symmetrical amperes, 240 V maximum". For models DF5-322.

Warning!
"Suitable for use on a circuit capable of delivering not more than 5000 r.m.s. symmetrical amperes, 480 V maximum". For models DF5-340.

Determination of wire and fuse sizes

The maximum motor currents in your application determines the recommended wire size. The following table gives the wire size in AWG. The "Power Lines" column applies to the inverter input power, output wires to the motor, the earth ground connection, and any other component. The "Signal Lines" column applies to any wire connecting to the two green 7 and 8-position connectors just inside the front enclosure panel.

DF5-	Motor Output		Wiring		Applicable equipment
	kW	HP	Power Lines	Signal Lines	Fuse (class J) rated 600 V
320-4K0	4.0	5	AWG 12/3.3 mm2	18 to 28 AWG/0.14 to 0.75 mm^2 shielded wire. Use 18 AWG/ 0.75 mm^2 wire for the alarm signal wire (K11, K12, K14 terminals).	30 A
320-5K5	5.5	7 ½	AWG 10/5.3 mm^2		40 A
320-7K5	7.5	10	AWG 8/8.4 mm^2		50 A
322-018	0.18	¼	AWG 16/1.3 mm2		10 A
322-037	0.37	½			
322-055	0.55	¾			
322-075	0.75	1	AWG 14/2.1 mm2		15 A
322-1K1	1.1	1 ½	AWG14/2.1 mm^2		15 A
322-1K5	1.5	2	AWG12/3.3 mm^2		20 A (single ph.) 15 A (three ph.)
340-037	0.37	½	AWG16/1.3 mm^2		3 A
340-075	0.57	1			6 A
340-1K5	1.5	2			10 A
340-2K2	2.2	3			10 A
340-3K0	3.0	4	AWG14/2.1 mm^2		15 A
340-4K0	4.0	5	AWG14/2.1 mm^2		15 A
340-5K5	5.5	7 ½	AWG12/3.3 mm^2		20 A
340-7K5	7.5	10	AWG12/3.3 mm^2		25 A

→ Field wiring must be made by a UL-listed and CSA-certified closed-loop terminal connector sized for the wire gauge involved. Connector must be fixed by using the crimping tool specified by the connector manufacturer.

→ Be sure to consider the capacity of the circuit-breaker to be used.

→ Be sure to use larger wires for the power lines if the distance exceeds 20 meters.

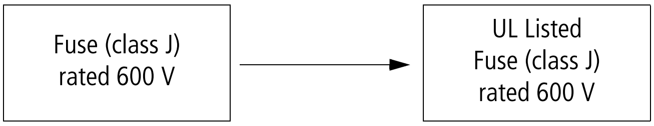
Terminal dimensions and tightening torque

The terminal screw dimensions for all DF5 inverters are listed in Table 3 (→ page 31) and Table 5 (→ page 37). This information is useful in sizing spade lug or ring lug connectors for wire terminations.

When connecting wiring, use the tightening torque listed in the above mentioned tables to safely attach wiring to the connectors.

Warning!
When PNU b12 (level of electronic thermal setting) is set to device FLA, device provides Solid State motor overload protection at 115 % of device FLA or equivalent.

This PNU b12 (level of electronic thermal setting) is a variable parameter (→ section "Electronic motor protection", page 102).



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