BERGES

Operating Instructions

Part 1

UD UNIVERSAL Drive 7000

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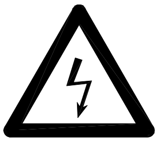
1 General Information

1.1 Explanation of Symbols and Notes

Work Safety Symbol

You will find this symbol next to all work safety notes in this operating manual if there is a risk of injury or death for persons involved. Pay attention to these notes and observe particular caution in such cases. Also pass on all work safety instructions to other users.



Voltage Warning

This symbol is shown wherever particular caution is necessary owing to occurring or applied voltages (e.g. DC voltages up to 650 V) and where special precautionary measures have to be taken. The drive converter must always be isolated from the line when working on it.

ATTENTION!

Caution Note

This note is shown in all parts of this operating manual to which particular attention must be paid to ensure that the guidelines, specifications, notes and the correct sequence of work will be obeyed and to prevent damage or destruction of the drive converter and/or systems.

1.2 Safety and Operating Instructions for Drive Converters

1. General

In operation, drive converters, depending on their degree of protection, may have live, unisolated, and possibly also moving or rotating parts, as well as hot surfaces.

In case of inadmissible removal of the required covers, of improper use, wrong installation or maloperation, there is the danger of serious personal injury and damage to property.

For further information, see documentation.

All operations serving transport, installation and commissioning as well as maintenance are to be carried out by **skilled technical personnel** (Observe IEC 364 or CENELEC HD 384 or DIN VDE 0100 and IEC 664 or DIN/VDE 0110 and national accident prevention rules!).

For the purposes of these basic safety instructions, “skilled technical personnel” means persons who are familiar with the installation, mounting, commissioning and operation of the product and have the qualifications needed for the performance of their functions.

We draw attention to the fact that no liability can be assumed for damage and malfunctions resulting from failure to observe the operating manual.

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2. Intended Use

The application of the drive converter described in this operating manual exclusively serves the purpose of continuously variable speed control of three-phase motors.

Drive converters are components designed for inclusion in electrical installations or machinery.

The drive converters are designed for installation in a switchgear cabinet and for permanent connection.

The operator of the system is solely liable for damage resulting from improper use of the drive converter.

Only items expressly approved by BERGES (e.g. line filter, choke, external braking choppers and braking resistors etc.) may be used as accessories.

The installer of the system is liable for any damage resulting from the use of accessories that have not been approved expressly by BERGES. Please consult us in case of doubt.

In case of installation in machinery, commissioning of the drive converters (i.e. the starting of normal operation) is prohibited until the machinery has been proved to conform to the provisions of the directive 89/392/EEC (Machinery Safety Directive – MSD). Account is to be taken of EN 60204.

Commissioning (i.e. the starting of normal operation) is admissible only where conformity with the EMC directive (89/336/EEC) has been established.

The drive converters meet the requirements of the low-voltage directive 73/23/EEC. They are subject to the harmonized standards of the series prEN 50178/DIN VDE 0160 in conjunction with EN 60439-1/DIN VDE 0660, part 500, and EN 60146/DIN VDE 0558.

The technical data as well as information concerning the supply conditions shall be taken from the name plate and from the documentation and shall be strictly observed.

3. Transport, Storage

The instructions for transport, storage and proper use shall be complied with.

Damage established after delivery must be notified to the transport company immediately. Where necessary, the supplier must also be notified before the damaged drive converter is put into operation.

The climatic conditions shall be in conformity with prEN 50178.

4. Installation

The installation and cooling of the appliances shall be in accordance with the specifications in the pertinent documentation.

The drive converters shall be protected against excessive strains. In particular, no components must be bent or isolating distances altered in the course of transportation or handling. No contact shall be made with electronic components and contacts.

Drive converters contain electrostatic sensitive components which are liable to damage through improper use. Electric components must not be mechanically damaged or destroyed (potential health risks).

5. Electrical connection

When working on live drive converters, the applicable national accident prevention rules (e.g. VBG 4) must be complied with.

The electrical installation shall be carried out in accordance with the relevant requirements (e.g. cross-sectional areas of conductors, fusing, GND connection). For further information, see documentation.

Instructions for the installation in accordance with EMC requirements, like screening, earthing, location of filters and wiring, are contained in the drive converter documentation. They must always be complied with, also for drive converters bearing a CE marking. Observance of the limit values required by EMC law is the responsibility of the manufacturer of the installation or machine.

6. Operation

The components of the power section and certain elements of the control section are connected to the line voltage when the drive converter is connected to the line voltage. **Touching these components involves mortal danger!**

Always isolate the drive converter from the line supply before performing any work on the electrical or mechanical part of the system.

Disconnect the drive converter from the line voltage before removing the terminal cover or the housing (e.g. by removing or deactivating on-site fuses or by deactivating a master switch isolating all poles etc.).

After disconnection of the drive converters from the voltage supply, live appliance parts and power terminals must not be touched immediately because of possibly energized capacitors. In this respect, the corresponding signs and markings on the drive converter must be respected. After switching off the line voltage, wait **for at least 5 minutes** before beginning work on or in the drive converter. Dangerous voltages are still present as long as the “BUS CHG” lamp is still lit. Ensure that no DC injection (e.g. by a DC link coupling) is performed. In the event of malfunctions, the discharge time of 5 minutes may be exceeded **substantially.**

The drive converter contains protective facilities that deactivate it in the event of malfunctions, whereby the motor is de-energized and comes to a standstill (so-called “coasting” of the motor is possible depending on the rotating mass of the type of drive involved). Standstill of the motor can, however, also be produced by mechanical blockage. Voltage fluctuations, and particularly line power failures, may also lead to deactivation. In certain circumstances, the drive may start up automatically once the cause of the fault has been remedied. As a result of this, certain systems may be damaged or destroyed and there may be a risk for operators working on the system. Installations which include drive converters shall be equipped with additional control and protective devices in accordance with the relevant applicable safety requirements, e.g. Act respecting technical equipment, accident prevention rules etc. Changes to the drive converters by means of the operating software are admissible.

The motor may be stopped during operation by disabling it or by deactivating the setpoint, whereby the drive converter and motor may remain live. **If inadvertent start-up of the motor must be excluded to protect operating personnel, electronic interlocking by disabling the motor or by deactivating the setpoint is inadequate. This is why the drive converter must be isolated from the line voltage.**

During operation, all covers and doors shall be kept closed.

Measuring instruments must be connected and disconnected only in de-energized condition.

Unauthorized conversions or modifications on or in the drive converter and its components and accessories will render all warranty claims void.

When installing an option board, observe the installation specification valid for this board.

Please contact BERGES if conversions or modifications are necessary, particularly if electrical components are involved.

7. Maintenance and Servicing

The manufacturer’s documentation shall be followed.

KEEP SAFETY INSTRUCTIONS IN A SAFE PLACE!

Before you read on, please check whether technical changes are attached in the annex to this operating manual!

1.3 Preface

The standard documentation covers a set of Operating Instructions (Part 1) and the Parameter Description (Part 2). A prefix (1- resp. 2-, corresponding to Part 1 or Part 2) has been added to the page numbers in order to allow cross-references to page information in Part 1 and in Part 2 to be distinguished.

These Operating Instructions (Part 1) cover general information, installation, technical data, a detailed description of the drive variants and the Annex with parameter overview and error states.

The Parameter Description (Part 2) contains commissioning instructions, the description of the keys and displays/indicators, a detailed parameter description, the error states and, in the Annex, the parameter overview.

Please read through these operating instructions conscientiously before installing the drive in order to guarantee correct installation and maximum performance capabilities.

The four groups in the converter series are (please refer to Chapter 4 for a detailed description of the drive variants):

- V/Hz controller; inverter with voltage/frequency control for induction motors.
- FO controller; servo inverter with field-oriented control for induction motors.
- EC controller; servo inverter for permanently excited brushless servo machines.
- *SLV*②; sensorless control for induction motors.

1.4 Description of Functions

The UD 7000 inverter series enables low-loss speed control of a three-phase motor by independent control of the output frequency and output voltage. The speed/torque response of the motor remains unchanged thanks to automatic control of the V/Hz ratio.

The UD 7000 inverters consist of the two function groups of the power section and inverter control.

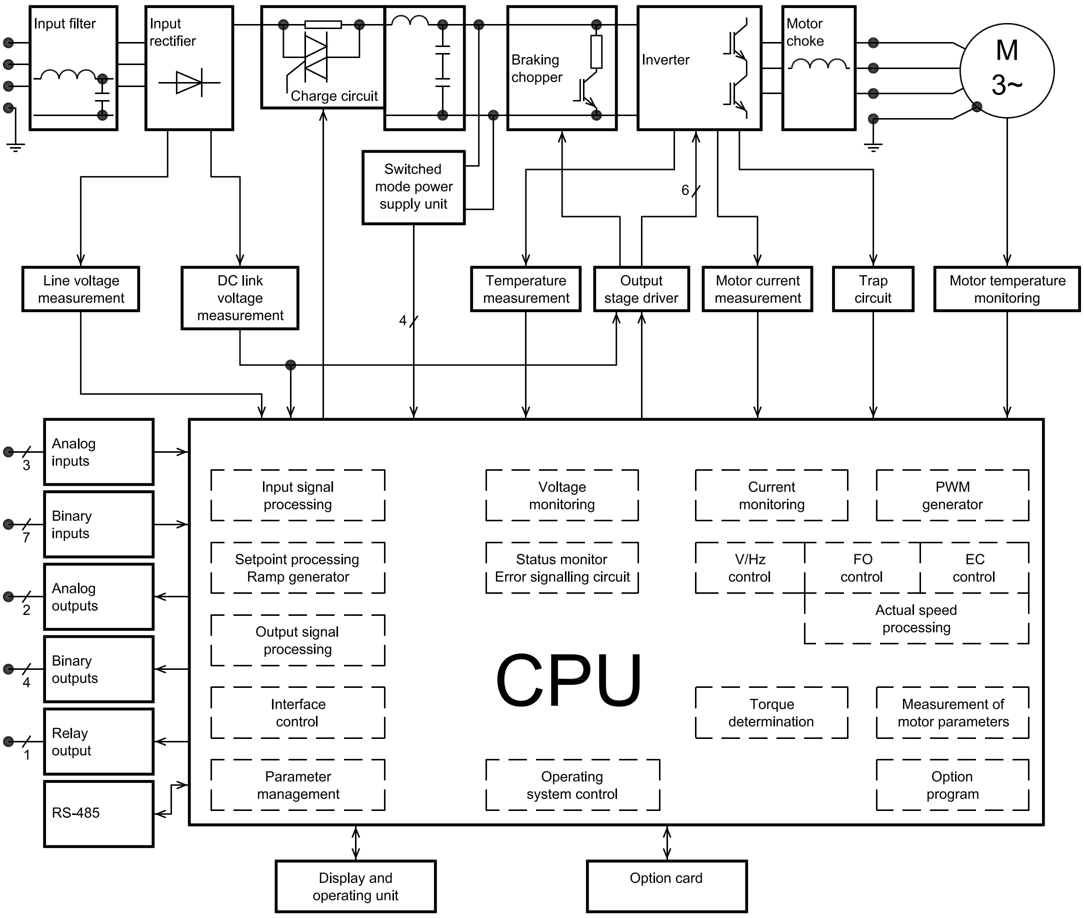


Figure 1.1

1.5 Power Section

The input rectifier converts the three-phase line voltage to a pulsating DC voltage. The subsequent DC link capacitor serves as an energy buffer that partly smoothes the pulsating DC voltage. When the line is connected, the charging unit ensures smooth charging of the capacitor. Figure 1.1 shows a triac for bridging the load resistor. Dependent on output, the charging circuit may vary. For instance, relays or also half-controlled bridge-connected rectifiers are also used. The complete inverter bridge, consisting of IGBTs (insulated gate bipolar transistors) is integrated in an intelligent power module (IPM). This converts the DC voltage of the DC link back to a three-phase voltage. By control of the IGBTs with suitable pulse patterns (PWM signals), it is possible to control both the output frequency and the output voltage continuously.

For regenerative operation of the drive, the chopper transistor switches a ballast resistor into the DC link in order to convert the accumulating brake energy to heat.

The line voltage input filter and the DC link choke serve the purpose of radio frequency interference suppression.

The switched mode power supply unit connected to the DC link generates all necessary supply voltages. The power supply unit operates provided the DC link voltage does not drop below 310 V.

The DC link circuits can be electrically connected when operating several inverters in one system. In this way, regeneratively operating inverters may supply the energy for motive-power inverters, thus extracting less energy from the line and simultaneously relieving the braking resistor. However, BERGES should be consulted in this case.

When it lights up, a voltage pilot lamp (BUS CHG, incandescent bulb) signals that the DC link voltage is higher than 80 VDC. The voltage pilot lamp is visible through a hole above the power terminals.

1.6 Inverter Control

The core of the inverter control is a powerful 16-bit microcontroller with a non-volatile parameter memory. In conjunction with further circuit components, it controls all necessary inverter functions. In particular, the microcontroller generates the pulse width modulated pulses for control of the IGBTs.

The inverter has the possibility of limiting the emitted motor torque. The frequency setpoint is reduced automatically when the limit is reached. The data required for this purpose is obtained from measured values and the rated data of the motor (as specified on the motor name plate).

With the aid of slip compensation, it is possible to operate the motor at a constant speed independently of the load.

The inverters feature a trap circuit that makes it possible to connect the inverter to a still rotating motor and to start it up to the frequency setpoint.

To suppress drive-specific resonance frequencies, it is possible to program four different stop frequency bands, i.e. the inverter does not realise these frequencies statically.

The functional scope if the inverters can be expanded with option cards for:

- FO controller; converter with field-oriented control for asynchronous motors.
- EC controller; converter for permanently excited synchronous motors.

A detailed description is provided in the application manuals.

With the LC display of the display and operating unit (ABE), all operating variables such as the frequency, current and voltage and all drive parameters can be displayed as absolute or percentage values.

The inverters can be controlled both through the control terminals, the serial RS-485 interface and also with the keys. The required possibility is selected by parameter. The same applies to the form of frequency input.

The control terminal LIM is assigned a double function. It serves as a frequency input or as a further analog input. Depending on parameter definitions, the inverter control processes the analog signal as an additional setpoint or as a torque limit (0–100%).

The control features six binary inputs (FWD, REV, R/J, PS1–PS3), which can be programmed for various functions for the control of the inverter, e.g. start/stop, left/right rotation or frequency input.

The inverter features software I^2t monitoring for thermal protection of the motor. For direct thermal motor monitoring, the inverter control is capable of evaluating a temperature sensor (PTC or normally-closed contact).

A relay output (changeover contact) and three transistor outputs with an open collector, which are switched depending on operating states of the inverter, are available for the output of binary signals. The choice is made by a parameter.

The inverter control possesses a frequency output (open collector), which is adapted to the frequency input so as to enable master/slave control.

Two analog outputs are available for the connection of indicating instruments. The measured variables that can be output with them can be programmed by the user.

Within the scope of status monitoring, the control controls important operating variables of the inverter. Warnings or error messages are issued if deviations from the specified tolerance range occur. In the event of a fault, control of the complete IGBT inverter bridge is disabled to protect the inverter.

Important operating variables of the inverter are:

- Line voltage.
- DC link voltage.
- Output current.
- Heat sink temperature.

The inverters are resistant to earth faults and short circuits at their motor connection terminals.

The ABE indicates the current error or warning message. The last five occurring faults are stored in the fault memory (parameter memory) in chronological order.

HINT!

If the PROG, SHIFT or ENTER key is pressed, the message is reset on the ABE (display and operator-control unit). Acknowledgement of the error message does not cancel the cause of the error. Errors may be also still be pending after reset.

2 Installation

2.1 Inspection of Unit after Delivery

A. Upon receipt, unpack and carefully inspect for any damage sustained in transit (depression in the enclosure, damage to parts, missing parts).

B. Check information on the name plate to ensure that the rated power and rated voltage of the unit are suitable for the desired application. If necessary, check whether the unit's EMC filters (installed as standard in unit classes 1.5–11) correspond to the order.

C. If the inverter is to be stored for a long period of time, repack and store in a clean, dry place, free from direct sunlight or corrosive fumes, and in a location where the ambient temperature will not be less then –20 °C nor more than +60 °C.

2.2 General Installation Instructions

Improper installation of the inverter will greatly effect its life. Be sure to observe the following points when selecting a mounting location. **Violating the conditions listed below may void the warranty!**

A. Install the unit vertically. At the same time, an unobstructed flow of air through the cooling slots on the top and bottom must be guaranteed. Any restriction in the air flow will reduce the useful life of the inverter and will lead to deactivation as a result of excess temperature.

B. The UD inverter generates heat and so there must be adequate space around the unit (see Figure 2.1). The inverters can be placed together in rows in their bookshelf housings. If the unit is accommodated in a housing together with another unit, the prescribed minimum clearances must be observed in order to guarantee corresponding ventilation.

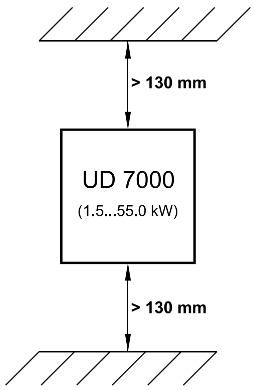


Figure 2.1

C. If the inverter has to be installed in a different position, external cooling is required for full capacity utilization. In certain circumstances, the internal air circulation does not suffice when installing the unit in a control cabinet with a small volume. Therefore, when installing the unit, you must ensure that a heat buildup is prevented.

D. Do not mount the UD 7000 near heat generating equipment, or in direct sunlight. The UD inverters are generally designed so that they can be operated at ambient temperatures of 0 °C to +45 °C and at a relative humidity of up to 90%.

   The occurrence of condensate must be avoided!

E. Do not install the inverter in a place subjected to high temperature, high humidity, or excessive vibration (see Chapter 3.8).

F. The units should never be installed in the proximity of corrosive or flammable gases, conductive dust or large magnetic and electric fields.

G. Pay close attention during installation to ensuring that no objects (such as drilling swarf, wire or anything else) fall into the unit. Otherwise, a device fault cannot be excluded, even after longer periods of operation.

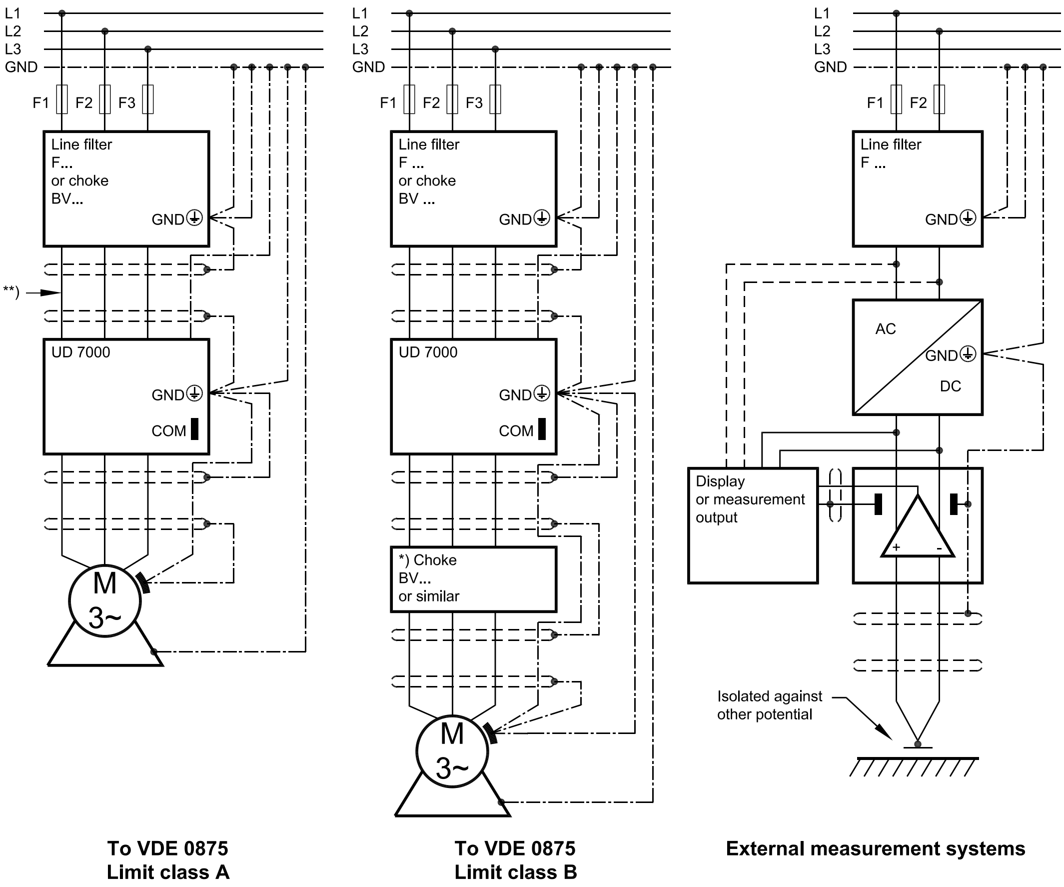
2.3 EMC (Electromagnetic Compatibility)

2.3.1 Limit Classes

With regard to interference suppression of machines or installations in conformity with EN 50081 Parts 1 and 2, or EN 55011, a distinction must be made between the limit classes “A” (industrial networks) and “B” (domestic networks).

In the case of “limit class A”, a line filter (1) must be wired before every frequency inverter. In the case of “limit class B”, a filter must also be wired before it.

The inverters and accessories must be wired as shown in the following schematic. If applied consistently, the following suggested circuit will successfully render harmless the residual noise voltage on the GND conductor potential for “external measurement systems”.



NOTES:

*) Choke only if required (e.g. owing to motor cable length >30 m). Please consult BERGES.

**) For cables shorter than 20 cm, an unscreened cable can be used between filter and inverter.

(1) In the case of unit classes 1.5-11.0, EMC filters are installed as standard (limit class A). The unit can also be supplied without filter. See also Table 3.2 (EMC filter).

2.3.2 Filter Components

The following interference-suppression components are available for the UD 7000 Series of equipment:

Inverter type	Size	Article number	Filter for limit curve A	
			Filter type	Article number
7001-5	II	365F3502	Device-internal	See device article number
7002-2	II	365F3511	Device-internal	See device article number
7003-0	II	365F3521	Device-internal	See device article number
7004-0	II	365F3531	Device-internal	See device article number
7005-5	II	365F3541	Device-internal	See device article number
7007-5	III	365F2550	Device-internal	See device article number
7011-0	III	365F2560	Device-internal	See device article number
7015-0	IV	36502570	BE 7322	32501918
7022-0	IV	36502580	BE 7322	32501918
7030-0	V	36501590	BE 7355	32502255
7037-0	V	36501600	BE 7355	32502255
7045-0	V	36502610	BE 7355	32502255
7055-0	VI	36502710	BE 7355	32502255

NOTE:

Additional filters available on request must be used in order to comply with limit curve B.

2.3.3 Interference Suppression Measures

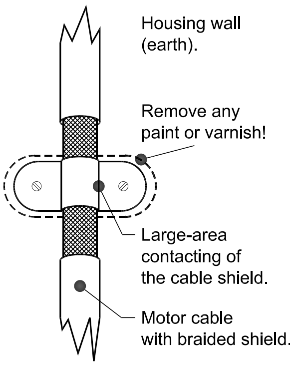
Electrical/electronic devices are capable of influencing or disturbing each other through connecting cables or other metallic connections. “Electromagnetic compatibility” consists of the factors “interference resistance” and “interference emission”. **Correct installation of the inverter in conjunction with any possible local interference suppression measures has a crucial effect on minimizing or suppressing mutual interference.**

The scope of noise suppression measures depends on the limit value class, the local situation and the application.

The following notes refer to a line power supply that is not “contaminated” by high frequency interference. Other measures may be necessary to reduce or suppress interference if the line voltage is “contaminated”. No generally valid recommendations can be given in such cases. Please consult BERGES if all recommended interference suppression measures should not produce the desired result.

Basically, it is **not the cross section** of the conductor that is important for radio-frequency interference suppression **but the surface area.** Since the high-frequency interference does not flow through the entire cross section but mainly on the outer surface of the conductor (skin effect), **braided copper tapes of corresponding cross section** should be used.

The inverter and all other components used for interference suppression (especially also the shield of the motor cable) should be contacted over as large an area as possible when connected to metal (control panels, switchgear cabinets and similar) (skin effect). **Remove the paint at the respective areas to ensure good contacting over a large area!**



A central earthing point should be used for interference suppression (e.g. equipotential bonding strip or centrally at an interference suppression filter). The earthing lines are routed to the respective terminals **radially** from this point. Conductor loops of the earthing lines are impermissible and can lead to unnecessary interference.

The shield cross section must not be reduced when the shield is connected to continuing lines. This would give rise to RF resistance at a cross section reduction, and the resulting RF energy would consequently not be discharged but radiated. Shields – particularly shields of control lines – must not be contacted through pin contacts of plug connectors. In these cases, the metallic hand guard of the plug connector should be used for large-area connection of the shield.

Use a shielded motor cable (earthed over a large area at both sides). The shield should be routed **uninterrupted** from the GND terminal of the inverter to the GND terminal of the motor. If a shielded motor line cannot be used, the unshielded motor line should be laid in a metal duct. The metal duct must be uninterrupted and adequately earthed. The following points are prescribed if radio interference suppression is to be realized in accordance with EN 55011, EN 55014 and EN 50081-1:

- Preceding the unit by a line filter (1) or a line filter and a output choke (line filter (1) and output choke not included in the scope of delivery).
- Laying the motor cable in a shielded configuration.
- Laying the control cable in a shielded configuration.
- Observe general RFI suppression measures (refer to the Chapter 2.3, “EMC (Electromagnetic Compatibility)”).

Lay motor, line power and signal cables as far away from each other as possible and separately.

If a line filter (1) is used, the **smallest possible** spatial distance from the frequency inverter must be selected so that both units can be connected by short connection leads.

If an output choke is used (option), it must be fitted **in the direct vicinity** of the inverter and connected to the inverter through screened cables earthed at both ends.

Screened signal cables should not be routed in parallel with power cables. An earthed metal cable duct is recommendable for these signal cables. If signal cables have to cross a power cable, they should cross at an angle of 90°.

Control lines longer than 1 m must be laid with a screen, and one side of the screen must be connected to COM on the frequency inverter.

Other loads connected to the line can cause voltage spikes which can impair the function of the inverter and can even damage it. Chokes or line filters (1) can be additionally used on the line side to protect the inverter against voltage spikes (resulting from the switching of large loads on the line). These chokes and filters are available as accessories.

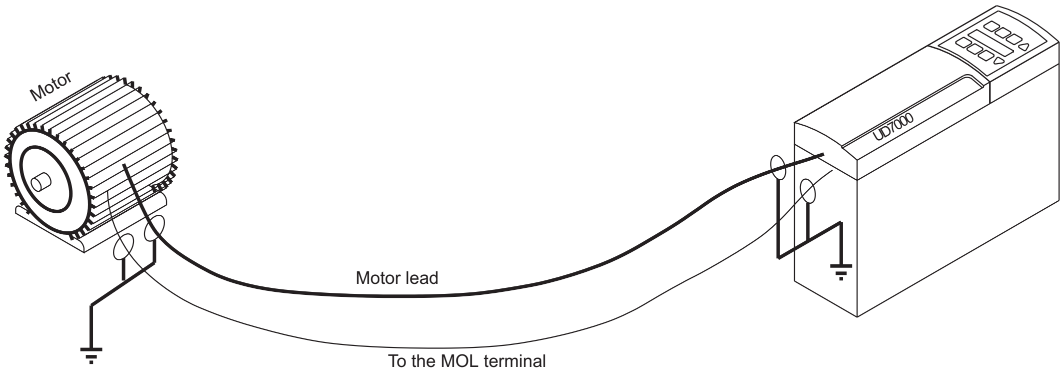
If inverters are operated in switchgear devices or in their close proximity (e.g. in one common control cabinet) in connection with the same power line, we recommend the following precautionary measures to suppress interference in the switchgear:

- Wire the coils of contactors, switchgear devices and relay combinations with “RC elements” or with free-wheel diodes.
- Use shielded cables for external control and measuring cables.
- Lay disturbing cables (e.g. power and contactor control circuits) separately and at a distance from the control cables.

(1) In the case of unit classes 1.5–11.0, EMC filters are installed as standard (limit class A); here, interference suppression refers to the AC input terminals (L1, L2, L3) and not to the DC input terminals (+/–). The unit can also be supplied without filter. See also Table 3.2 (EMC filter).

Special case: MOL input

The MOL input is particularly critical from the point of view of EMC: if the input is used to evaluate PTCs or klixons fitted in the motor, this will result in high crosstalk on its connection leads owing to the high edge steepness (dU/dt) of the motor voltage. This may lead to voltage peaks exceeding 100 V at the MOL input. Consequently, this lead must be shielded separately. The shield should **not** be connected to the COM terminals but to earth (⏚). The best result can be achieved by earthing the shield at **both ends.**



2.3.4 EMC Ordinance (EMC Directive, 89/336 EEC)

The frequency inverters were tested in the form of a practical test set-up in a switchgear cabinet (in accordance with our interference suppression measures in these operating instructions: “EMC (electromagnetic compatibility)”. The limit values of the standards below were fulfilled under these conditions:

EMA (Electromagnetic Emission)

EN 50081-1 Basic specification “Emitted interference” (Limit value class A)
or
EN 50081-2 Basic specification “Emitted interference” (Limit value class B, optional)
EN 55011 Emitted interference

EMB (Electromagnetic Interference)

EN 50082-2 Basic specification “Interference immunity”
EN 50140 Electromagnetic fields
EN 60801 Static discharge (ESD)
IEC 801-4 Burst on line lead/data line

HINT!

At least the following conditions must be fulfilled for compliance with the limit values of the aforementioned standards:

- Preceding the unit by a line filter (1) or a line filter and a output choke (line filter (1) and output choke not included in the scope of delivery).
- Laying the motor cable in a shielded configuration.
- Laying the control cable in a shielded configuration.
- Observe general RFI suppression measures (refer to the Chapter 2.3, “EMC (Electromagnetic Compatibility)”).

(1) In the case of unit classes 1.5–11.0, EMC filters are installed as standard (limit class A); here, interference suppression refers to the AC input terminals (L1, L2, L3) and not to the DC input terminals (+/–). The unit can also be supplied without filter. See also Table 3.2 (EMC filter).

As the aforementioned interference immunity tests are based on standardised line conditions, a loss of the inverter function can occur in extreme cases (minimum operational quality). This malfunction generally can be remedied with an inverter RESET. See “Example 11: Confirmation of an Error”, Page 2-32.

Detailed information and technical data about adapted line filters (1) and chokes can be found in the publication “Choke/filter application”.

2.4 Wiring Practices

2.4.1 Applicable Codes

Pay conscientious attention to ensuring that the installation wiring is installed at least in conformity with the NEC standards. Where local codes exceed these requirements, they must be followed.

2.4.2 Power Wiring

Power wiring are those wires which are connected during installation to the power circuit terminals, L1, L2, L3, +, –, BR, BR, U, V, and W. Power wiring must be selected as follows:

1. Use only VDE, UL or CUL recognized wire.
2. Wire voltage rating must be a minimum of 600 V for 400 VAC systems.
3. The core cross section and the associated fuse are given in the tables in Chapter 2.5.2, Page 1-17. The wires must consist of copper and be designed for insulation temperatures of 60 °C or 75 °C.
4. Grounding must be in accordance with VDE, NEC and CEC.

NOTES:

ATTENTION!

Never connect input AC power to the motor output terminals U, V and W or damage to the drive will result.

The output voltage of variable-frequency controllers contains high-frequency components that might cause disturbances in other installations. Therefore, avoid laying control cables and line input cables in the same cable duct or conduit together with the output cables from the converter to the motor (see also Chapter 2.3.3, “Interference Suppression Measures”).

2.4.3 Control Lines/Interface

All interfaces and control inputs and outputs are **double isolated** from the line.

Control lines include the lines connected with the inverter controller (32 terminals). The control lines must be designed as described below:

1. Shielded wire is recommended to prevent electrical noise interference from causing improper operation or nuisance tripping. Only connect the screen on one end to the “GND” terminal on the converter’s control terminal strip (see also Chapter 2.3.3, “Interference Suppression Measures”).
2. Use only VDE, UL or CUL recognized wire.
3. The rated voltage of the lines must be designed for 50 VDC or 120 VAC. These are class-2 lines.
4. The lines of the relay (terminals NO, C, NC) must be designed for at least 400 V if wired into 230 V line circuits.

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(1) In the case of unit classes 1.5–11.0, EMC filters are installed as standard (limit class A). The unit can also be supplied without filter. Upon delivery of inverters, check whether the unit corresponds to the order in this respect if necessary. In unit classes 15–55 kW, the EMC Directive can be observed only if external filters are used. See also Table 3.2 (EMC filter).

5. Never run the control wiring in the same conduit or raceway with power wiring.

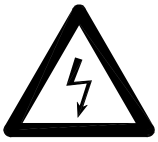
2.5 Line Power Connection

The frequency inverters are designed for installation in a switchgear cabinet and for permanent connection.

To guarantee lasting operating safety and reliability, the inverter must be connected expertly in accordance with the valid electrical standards. Attention must be paid to good insulation from earth potential on the power terminals.

An three-phase system with a nominal voltage of 400 V (50/60 Hz) must be connected to line terminals L1, L2, L3 and GND (pay attention to name plate). The neutral point must be earthed (TN-C system).

Ensure a voltage balanced to earth or phase to phase when feeding in the line power through an isolating transformer (star point must be earthed).



Frequency inverters must not be connected through a residual-current-operated circuit-breaker as the sole protective measure!

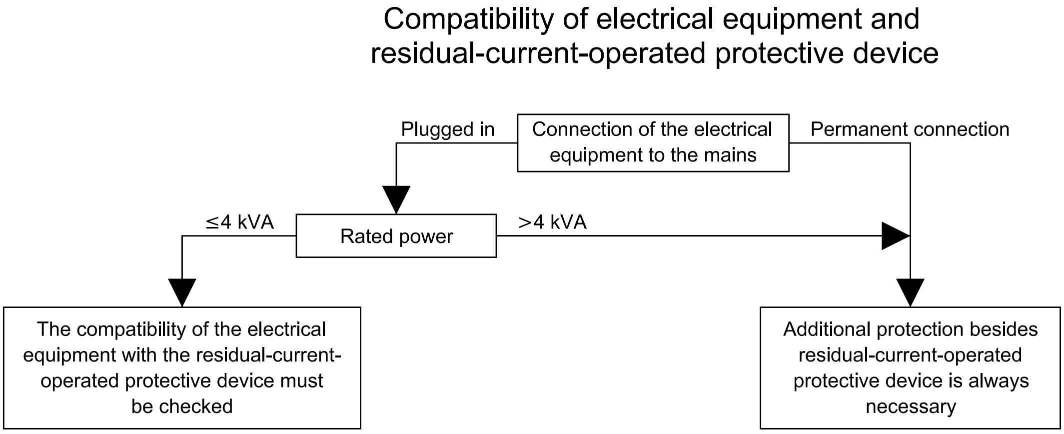
The single exception below permits connection of a frequency inverter through a residual-current-operated circuit-breaker as the sole protective measure:

- Installation of a residual-current-operated circuit-breaker of the newest design **for frequency inverters up to 4 kVA (input voltage 1 × 230 V) with MOBILE connection.** This residual current-operated circuit breaker must be suitable for alternating and pulsating DC leakage current. Residual-current-operated circuit-breakers of this type bear the symbol .

Reliable tripping of the residual-current-operated circuit-breaker is not ensured in the case of frequency inverters up to 4 kVA (input voltage 3 × 400 V) with MOBILE connection; an additional protective measure must be used for this reason. Also see the diagram below.

In the case of frequency inverters with PERMANENT connection (input voltage 1 × 230 V and 3 × 400 V), another protective measure must always be used in addition to the residual-current-operated protective device. Also see the diagram below.

The protective function of the residual-current-operated circuit-breaker is no longer ensured due to leakage currents from interference suppression capacitors in the inverter and DC components in the fault current. All devices connected to this residual-current-operated circuit-breaker (and persons touching them) are no longer protected in the event of a fault.



Flow diagram of the requirements relating to the combination of frequency inverter and residual-current-operated protective device

The inverter will be destroyed if the line feeder is confused with the motor cable.

The DC link capacitors must be reformed if the inverter you wish to connect has been out of operation for more than a year. To do this, connect the inverter to voltage for approx. 30 minutes. The inverter should not be loaded by connected motors during forming.

2.5.1 Line Conditions

The permissible fluctuation in the line voltage is between ±15% of the nominal voltage. If the voltage exceeds or falls short of the nominal voltage by 25%, the inverter is switched off automatically because the voltage is too high or too low.

Adaptation to rated line voltages outside the permissible range is possible by means of autotransformers. Calculation according to the formula below is recommend:

$$P_T = P_D \left(1 - \frac{V_2}{V_1}\right)$$

$$P_D = V_2 \times I_2 \times \sqrt{3}$$

P_T = Equivalent two-winding kVA rating (kVA)
P_D = Continuous output (kVA)
V_1 = Rated line voltage (V)
V_2 = Rated voltage, frequency inverter (V)
I_2 = Input current (A) as per Table 3.2 “Input current for setting a PKZ”

NOTE:

Exercise caution when using the UD 7000 under the conditions of a low-voltage network. An inverter from the UD 7000 series is fully functional when connected to an alternating current of 370 V, for example. However, the maximum output voltage is limited to 370 VAC. If the motor is rated for a line voltage of 400 VAC, this can lead to higher motor currents and overheating of the motor.

If the output frequency is supposed to be higher or lower than 50 Hz, the inverter can be programmed for the appropriate relationship between the voltage and frequency by means of the parameters 21 and 23. Further information on these functions is available in Chapter 8.2.

Phase voltage imbalance of the input AC source can cause unbalanced currents and excessive heat in the input rectifier diodes and in the DC bus capacitors of the UD. Phase imbalance is calculated by the following method:

Assume:
The voltage from L1 to L2 = L_a
The voltage from L2 to L3 = L_b
The voltage from L1 to L3 = L_c
The average line voltage = L_{avg}

$$L_{avg} = \frac{L_a + L_b + L_c}{3} = \frac{395 + 400 + 405}{3} = 400$$

Determine the absolute value of the difference between each of the line voltages (L_a, L_b and L_c) and L_{avg}. (Subtract the two values and disregard the sign of the result.) Consider the results of this calculation to be L_{aa}, L_{ba}, and L_{ca}.

$$\text{Phase Imbalance} = \frac{L_{aa} + L_{ba} + L_{ca}}{2\,(L_{avg})} \times 100\% = \frac{5 + 0 + 5}{2 \times 400} \times 100\% = 1.25\%$$

EXAMPLE: measured phase voltages of 395, 400, and 405 would result in a calculated phase imbalance of 1.25%.

If the resulting phase imbalance exceeds 2%, consult your local power company or plant maintenance personnel and ask them to investigate this problem and recommend methods of correcting this condition.

Phase imbalance can also cause damage to motors running direct on line. A 2% imbalance requires a 5% derating factor on the motor, 3% imbalance requires a 10% derating. 4% requires an 18% derating.

ATTENTION!

Never use power-factor improvement capacitors on the UD 7000 motor terminals, U, V, and W, or damage to the inverter's semiconductors will result.

2.5.2 Line Fusing

The user must install either device protection fuses or an overload isolator in the line input line in conformity with the applicable stipulations of the national electric code (NEC) and all local regulations. The following must be observed in relation to the correct design of input fuses or of the overload isolator.

A. Dimensioning

The UD 7000 inverters can be operated for 1 minute with 50% overload, and the cycle time must be at least 30 minutes. If such load cases occur on the drive, the fuses or circuit-breakers must be dimensioned accordingly higher.

B. Fuse Types

To guarantee a maximum protection of the inverter fuses should be used for current Limitation. These fuses should have a breaking capacity of 200,000 A_{eff}. The following table shows the recommended values in amps for all UD 7000-inverters.

ATTENTION!

For 400 V line supplies we recommend time-lag type NEOZED-fuses.

INVERTER INPUT VOLTAGE 3 × 400 V													
Type of unit	7001-5	7002-2	7003-0	7004-0	7005-5	7007-5	7011-0	7015-0	7022-0	7030-0	7037-0	7045-0	7055-0
Inverter power (kW)	1.5	2.2	3.0	4.0	5.5	7.5	11.0	15.0	22.0	30.0	37.0	45.0	55.0
Rated current, fuse (A)	4	6	6	10	16	16	25	32	50	63	80	100	125
Cable cross section, line supply line (mm^2)	1.5	1.5	1.5	1.5	1.5	2.5	4	6	10	16	25	35	50
Cable cross section, motor line (mm^2)	1.5	1.5	1.5	1.5	1.5	2.5	4	6	10	16	25	35	50

The medium time-delay fuses of type “Bussmann FRS-R”, for example, are recommended in networks with nominal voltages greater than 415 V. The typical operating times are 150 to 250 s for 2× overcurrent and 180 to 1500 ms in the case of 10× overcurrent.

2.5.3 Using Line Filters

Special protective measures must be observed when using line filters:

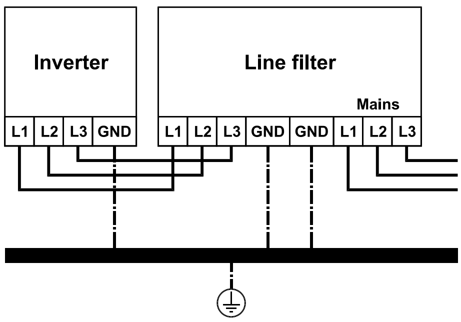
Owing to the leakage current involved (>3.5 mA), attention must be paid to EN 50178 when using BERGES line filters. **One** of the following protective measures **must** be taken:

- The line filter must be connected separately by laying a second cable that is electrically parallel with the GND conductor; this conductor must meet the requirements of IEC 364-5-543 on its own.
- The GND conductor must have a cross section of at least 10 mm^2 (refer to the following diagrams).
- The GND conductor must be monitored by a facility that isolates the inverter from the line in the event of a fault (GND conductor monitoring).

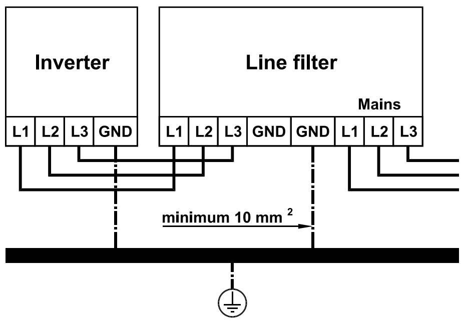
ATTENTION!

The inverter must always be connected permanently (EN 50178) when using line filters (leakage current >3.5 mA).

NOTE:
For cables shorter than 20 cm, an unscreened cable can be used between filter and inverter.



Line filter connection with a second parallel GND conductor



Line filter connection with at least 10 mm^2 GND conductor cross section

2.5.4 Start-Up on the Line

The UD 7000 units are designed for controlled starting and stopping of three-phase motors by means of the keypad or external contacts (latching switches or relays). As standard, the inverter features a line start-up lock to prevent unintentional starting of the motor after a power failure. This facility can be cancelled out by programming parameter 71 (see Page 2-77).

2.5.5 Reducing Current Surges and Voltage Transients

Voltage spikes caused by coils (inductors operated on the same line as the inverter) can lead to malfunctions of the inverter. In cases of this kind, the affected windings of contactors and relays operated on the 230 VAC line must be damped by fuses in the form of an RC series circuit:

- Main Circuit Contactors and Solenoids: C = 0.2 MFD, 500 VDC; R = 500 W, 5 Watts.
- Auxiliary Control Circuit Relays: C = 0.1 MFD, 500 VDC; R = 200 W, 2 Watts.

Connection Diagram for AC and DC Relay Coils and Solenoids:

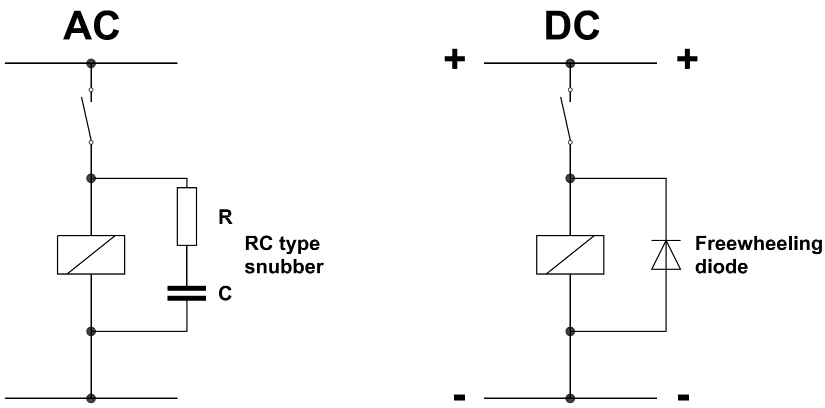


Figure 2.2

Free-wheeling diodes must be used on contactors, relays and solenoid coils operated with direct current. The diodes in question should be fast types with short recovery time. The diode must be connected in blocking direction in parallel with the winding (see Figure 2.2). The rated current and voltage of the diode can be calculated using the formulae below:

$$\text{Diode Current Rating (A)} \geq \frac{\text{Coil Capacity (VA)}}{\text{Rated Voltage of Coil (V)}}$$

$$\text{Diode Voltage Rating (V)} \geq \text{Rated Voltage of Coil (V)} \times 2$$

2.6 Motor Connection

Connect the motor cable to the “U, V, W” and “GND” terminals.

The inverter will be deactivated if shorted to the motor terminals.

ATTENTION!

The output of the drive will always be three phase. Do not connect single-phase motors to the inverter output terminals U, V or W.

Never use power factor correction capacitors on the motor terminals U, V and W, or damage to the semi-conductors will result.

We recommend the connection of a PTC resistor or a motor clixon to achieve full protection of the motor. The UD 7000 features corresponding connection terminals. Adapt to the protective element by way of parameter 81.

If interrupting contacts (e.g. contactors or motor circuit-breakers etc.) have to be installed between the motor and inverter, make sure that the output stages are de-energised (motor current = 0) before the inverter/motor connection is interrupted.

The inverter and motor are adapted by way of parameter groups 1 and 2.

2.7 Brake Resistor

The UD 7000 is provided with a standard brake resistor. The type and size of the mounted brake resistor depends on the Inverter's power rating. For power rating details please see Table 3.5, Page 1-30.

Brake Resistor Protection

The mounting area can become hot on the inverter's back side. The brake resistor is mounted in such a way, that a part of its heat can be transferred to the enclosure. The brake resistor is protected by the inverter in the following ways:

1. The inverter computes a thermal model of the resistance. The software is matched to the incorporated standard resistor fitted on the rear side of the inverter. The default settings of the parameters ensure that the exterior of the unit does not increase in temperature to above 70 °C. A change in these model parameters (parameters 7A, 7E and 7D) may cause higher temperatures.
2. A heat sensor is fitted on the heat sink. Temperatures exceeding 70 °C at the heat sink generate an error message (Error No. 02). From case to case, temperatures of 90–100 °C may be anticipated.

HINT!

If the maximum permitted power loss of the default braking resistor is exceeded, an external braking resistor will be required (see also Chapter 3.5, Tables 3.5 and 3.6). Braking resistors are available as optional packages.

2.8 Functions and Use of the Terminals

HINT!

When the unit is delivered, the displays are in German. Redefine parameter 78 to change the language.

Removing the Protective Terminal Cover

Switch off the line voltage before opening or working on the frequency converter.
Also ensure that there is no DC infeed (e.g. by a DC link coupling).
Hazardous voltages are still present if lamp “BUS CHG” is still lit.

The power and control terminals are covered by one or two covers (dependent on size). After undoing the securing screws, the front panel can be detached by lifting it slightly and swivelling it to the top.

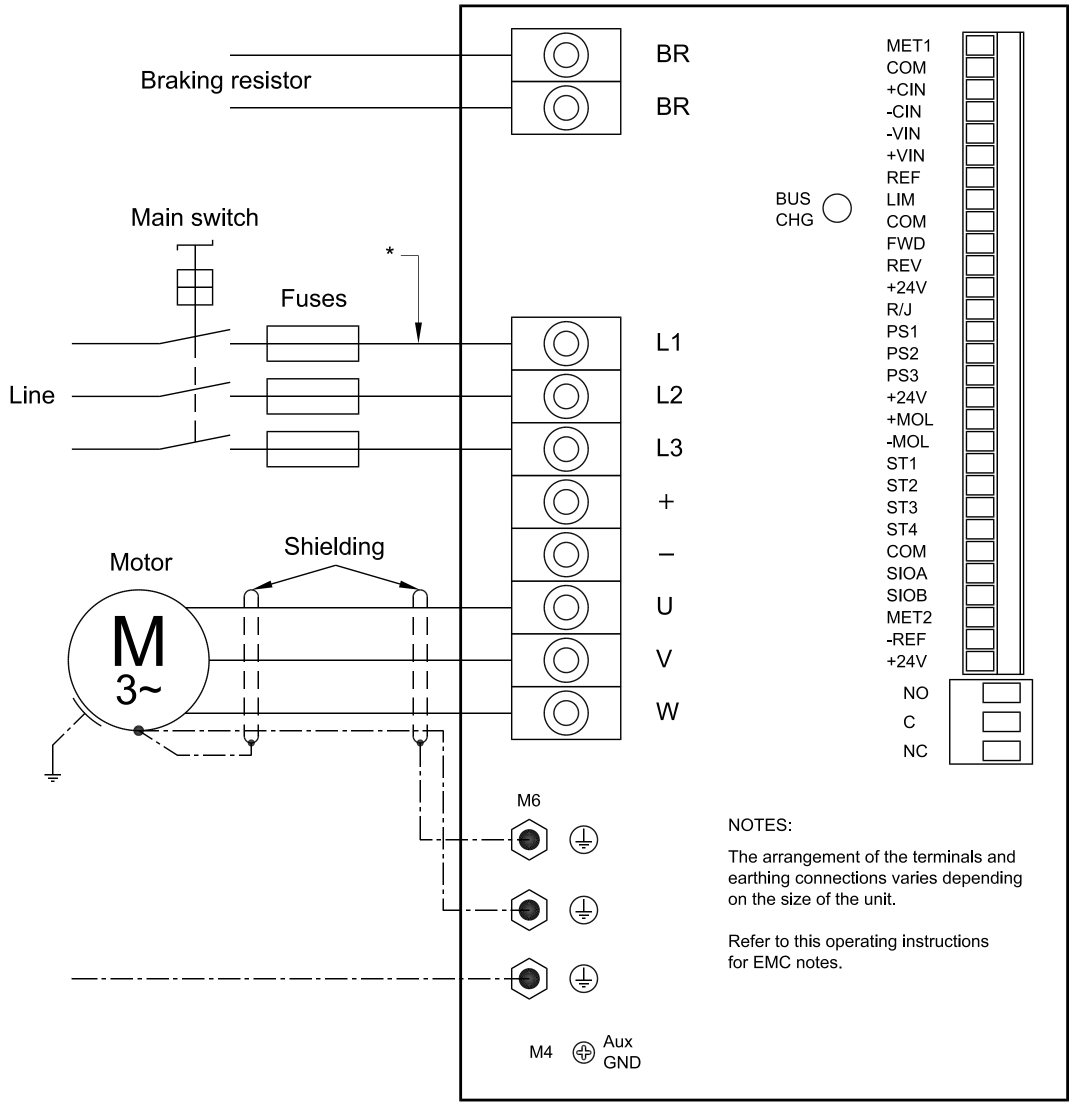


Figure 2.3
Connection terminals, size II–VI

NOTE:

* If it is necessary to comply with the EMC regulations, an EMC filter must be connected between the line-circuit fuse and the inverter. On sizes 2 and 3, these filters are already fitted internally. These filters are available as options for the other sizes (see also Chapter 2.3 and 2.3.2).

2.8.1 Power Terminals

TYPE	TERMINAL	DESCRIPTION
Line connection	L1 L2 L3	**Line connection terminals.** Check that the available line voltage corresponds to the information specified on the rating plate of the inverter. The rating of the back-up fuses and the cable cross-sections are listed in Chapter 2.5.2. If residual-current-operated circuit-breakers are used for fusing, only DC/AC-capable types may be used which have been designed specifically for rectifier loads (see Chapter 2.5, “Line Power Connection”). **CAUTION:** the number of line Off/On cycles is limited owing to the capacitor charging circuit. Maximum four cycles are permitted per minute. A waiting time of min. 15 seconds until switching back on must always be complied with. If this time is not complied with, this may lead to destruction of the inverter. Brief line interruptions (lasting a few milliseconds) causing the DC link voltage to drop below 300 VDC my lead to switch-off of the processor. In this case, the processor reverts to “Sleep mode” which sets the inputs and outputs to their zero-voltage state. This error must be acknowledged by one line Off/On cycle. Sleep mode can be seen from the fact that the display LED’s blink simultaneously.
Motor connection	U V W	**Motor connection terminals.** Three-phase, variable-frequency and variable-voltage alternating voltage. The rating of the cable cross-sections is listed in Chapter 2.5.2. **CAUTION:** switch-off of the output stages electronically (e.g. via the MOL control input) is not considered as safe isolation. The inverter must be disconnected from the line if work is to be conducted on these terminals.
DC connection	+ –	**DC link connection terminals.** These terminals may be used for several purposes: 1. For connection of an external braking chopper. The chopper must feature its own control circuitry and a power switching transistor. Please consult BERGES if necessary. 2. For DC powering of the inverter. L1–L3 are not connected in this case. The DC link capacitors are then pre-charged by the external DC power feed module. If this is not done, this may lead to destruction of the DC link capacitors. Please consult BERGES (application information). 3. For DC link coupling of several inverters. Typically, one or more inverters is or are powered by one inverter. This means that one inverter is connected to the line (L1–L3) and all other inverters are powered via these terminals. Energy exchange is able to occur between the inverters. In applications in which the inverters are operating in braking mode and the rest of the inverters are operating in motor mode, this may lead to a substantial energy saving. Please consult BERGES (application information). **CAUTION:** on no account may you design the inverters yourself! Incorrect design may lead to destruction of the inverters. The maximum voltage (measured with respect to earth potential) may be up to + (–) 400 VDC. A voltage of up to 800 VDC may be measured across the terminals (risk of lethal injury).
Braking resistor	BR BR	**Connection terminals of the braking resistor.** On the standard version, the inverter features a braking resistor. It is connected to terminals BR and BR which are located on the underside of the unit. If it is necessary to use an external resistor (if, for instance, the power loss of the fitted resistor is insufficient), this resistor must be connected in place of the standard resistor at these terminals. The permitted minimum impedance is specified in the table in Chapter 3.5, “Brake Chopper Power Dissipation”. Parameters 7A, 7D and 7E must be adapted to the new resistor in order to protect the resistor accordingly. **CAUTION:** the maximum voltage (measured with respect to earth potential) may be up to + (–) 400 VDC (risk of lethal injury).
PE	⏚	**The earth terminals.** They are also located on the front side of the unit. Three stud bolts are provided for connection of the earthing connections. Ring cable lugs are advisable for reasons relating to EMC.

Table 2.1
Terminal assignment, power terminals

2.8.2 Control Terminals

The control terminals are also located on the front of the unit.

ATTENTION!

All control terminals are potential-free (double isolated). Make sure that the potential difference between earth and the control terminals does not exceed a value of 230 VAC. This does not include the relay terminals NO, C and NC.

The Aux/GND terminal (cross head recess M4 screw) is isolated from the housing and can be used as a star point for the COM terminals, for example.

TYPE	DESIGNATION	DESCRIPTION
Analog inputs	+VIN	Frequency setpoint (difference input for –VIN). 0–10 VDC, 2–10 VDC or ±10 VDC, input resistance 100 kΩ. Function selection in parameter group 3. (1) (2)
	–VIN	Reference level for +VIN (difference input), input resistance 100 kΩ. Input can be connected to COM level with jumper X57. (1) (2)
	+CIN	Frequency setpoint (current input for –CIN). 0–20 mA, 2–20 mA, ±20 mA, load impedance 50 Ω. Function selection in parameter group 3. This setpoint is also added from the +VIN input. (1) (3)
	–CIN	Reference level for +CIN. (1) (3)
	LIM	0–10 VDC, COM is the reference potential. Input has 100 kΩ pull-up resistor for the signal REF (+10 V). Input with double function. 1. Analog torque limit or additional setpoint. 2. Binary frequency input up to 100 kHz. Function selection in parameter group 3.
	+MOL	Connection of the normally-closed contactor PTC for thermal motor protection or alternatively as an input for “hardware pulse locking”. Please also refer to what is said in Chapter 2.3.3, “Interference Suppression Measures”. **CAUTION:** the MOL inputs may not be connected either to COM or to the +24 V terminals of the inverter since, otherwise, the MOL inputs would be destroyed.
	–MOL	Reference potential for +MOL. **CAUTION:** the –MOL input is **not** connected to COM. The MOL inputs may not be connected either to COM or to the +24 V terminals of the inverter since, otherwise, the MOL inputs would be destroyed.
Analog outputs	MET1	Metre 1, output signal for indication purposes. 0–10 VDC or ±10 VDC, I_{max} = 20 mA, COM is the reference potential. Level and output quantity and its scaling can be selected in parameter group A.
	MET2	Metre 2, output signal for indication purposes. 0–10 VDC (I_{max} = 20 mA) or 0–20 mA, COM is the reference potential. Signal type and output quantity and their scaling can be selected in parameter group A.

Table 2.2
Terminal assignment, control terminals

TYPE	DESIGNATION	DESCRIPTION
Binary inputs		**Applicable to all binary inputs:** Voltage range 0–30 VDC; low = 0–0.2 VDC; high = 2–30 VDC. The active level, i.e. high or low, can be changed over in parameter group 9.
	FWD	Start or start right rotation.
	REV	Change of direction or start left rotation.
	RUN/JOG	Normal/jog mode changeover in the LOCAL mode. Jog mode: drive runs at the jog frequency (fixed frequency 1) for as long as the FWD or REV key is pressed. This input is programmable for further functions (select in parameter group 9).
	PS1–PS3	Selection of fixed frequencies. These inputs are programmable for further functions (selection in parameter group 9).
Binary outputs		**Applicable to all binary outputs:** Transistor stage with open collector and emitter on COM. Transistor forward biased → V_{CE} = 0–1 VDC (I_{max} = –50 mA) → signal level low. Transistor reverse biased → external voltage (V_{CEmax} = 30 VDC) → signal level high.
	ST1–ST3	Binary output; select function in parameter group 9.
	ST4	Binary output (frequency output). Select function in parameter group 9.
Relay terminals		Relay output; select function in parameter group 9.
	NO	Normally-open contact. 250 VAC/0.2 A; 30 VDC/2 A.
	C	Mid-position contact.
	NC	Normally-closed contact. 250 VAC/0.2 A; 30 VDC/2 A.
Serial interface	SIO A	Connection of the RS 485 interface.
	SIO B	Connection of the RS 485 interface.
	D-SUB-5	Earth (COM).
Control and reference voltages	+24V	+24 V control voltage output (I_{max} = 500 mA) for binary inputs or binary outputs with open collector.
	REF	+10 V reference voltage output (I_{max} = 10 mA) for external setpoint source.
	–REF	–10 V reference voltage output (I_{max} = –10 mA) for external setpoint source.
	COM	Reference potential for analog and binary input and output signals.
GND	Aux/GND	The Aux/GND terminal (cross head recess M4 screw) is isolated from the housing and can be used as the star point of the COM ports, for example. The securing stud is particularly suitable, in particular for connecting the cable shields using ring cable lugs. If interference problems occur on the signal leads, it is frequently practical to connect the shield either to COM **or** to system earth. This can be tested very quickly with the aid of the AUX terminal stud.
PE	⏚	3 earthing terminals (M6 threaded bolts).

Table 2.2
Terminal assignment, control terminals

NOTES:

(1) **The setpoint inputs Vin and Cin:**
The V_in and C_in inputs are additively gated. This means that the signals – generated from the voltages at the V_in inputs resp. the current at the C_in input – are processed summed by the microprocessor. The two inputs are difference amplifier inputs. There is a jumper (X57) directly behind the control terminals on the control card, and this jumper can used to make a direct connection between the –Vin input and COM potential if necessary. This jumper is inserted at the works.

Jumper X57 inserted: –Vin connected to COM.
Jumper X57 not inserted: –Vin floating (difference amplifier input).

The required signal type, such as unipolar or bipolar setpoints, is selected with parameter 31.

(2) **Use of the Vin inputs:**
When should jumper (X57) be removed?

- In the case of applications such as simple jockey roller positioning controls in which the rotational speed reference value is applied to the +Vin input and the jockey roller position-proportional voltage (jockey roller potentiometer) is applied to –Vin. The voltage at the –Vin input is then subtracted from the voltage level at +Vin. Ideally, the jockey roller potentiometer must be powered with a positive or negative voltage.
- In the case of interference problems on the setpoint leads. In applications in which the setpoint signal is supplied via long leads, laid in parallel to the inverter, this frequently results in a high noise component on the wanted signal. This common-mode interference can be eliminated by the difference amplifier (D1).

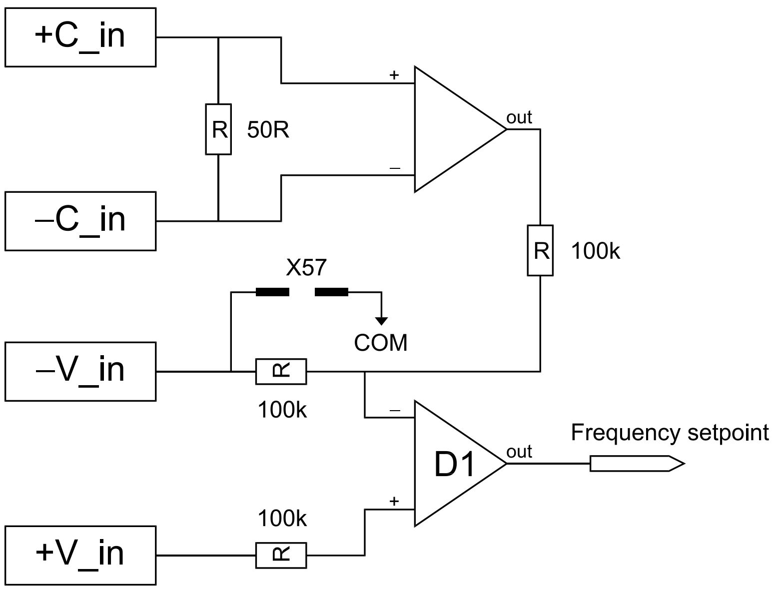


Figure 2.4

(3) **Use of the C_in inputs:**
This is a current input with a load of 50 Ohm. The input is not referred to COM potential. This means that several C_in inputs may be connected in series. At 20 mA, the voltage drop is 1 V. The number of inverters which can be connected in series depends on the maximum possible output voltage of the current detector. However, this voltage should not exceed 50 V.

ATTENTION!

If working with a current signal as the setpoint, inputs –Vin and +Vin must be jumpered. The setting of jumper X57 is of no significance in this case.

Jumper X57

The right-hand side panel of the inverter must be removed in order to set jumper X57. Please follow the steps below:

- Switch off the line voltage. Wait until lamp “BUS CHG” goes out or measure the DC link voltage. See also Chapter 1.2, Section 6 (Operation). Also ensure that there is no DC infeed (e.g. by a DC link coupling).
- Turn out the screw (right-hand thread) to loosen the terminal cover. Lift the bottom side of the cover and pull it downwards.
- Use a small screw driver to push the small plastic part at the bottom edge of the display cover out of the guideway.
- Push outwards the display cover at its bottom edge and lift it at the same time. Then push outwards the upper edge and pull the cover frontwards.
- Undo two resp. four cross-recessed-head screws on the right-hand side panel and pull the side panel out of its guide by tilting it and raising it.
- Adjust jumper X57 (see illustration).
- Insert the right side plate into the bottom guideway and tighten it with both cross-slotted screws.
- Put up the display cover and snap it into place.
- Insert the small plastic part into the bottom edge of the display cover (rounded-off edge up).
- Lift the terminal cover slightly and slip it into the groove of the display cover. Put up the cover and tighten it with plastic screw.

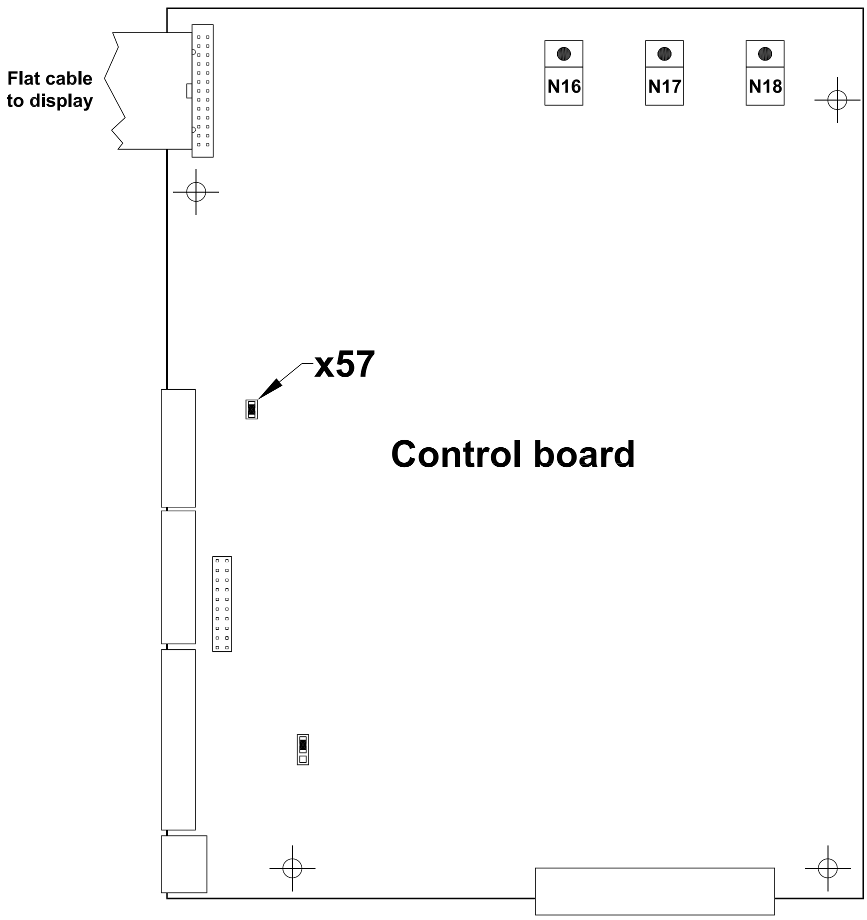
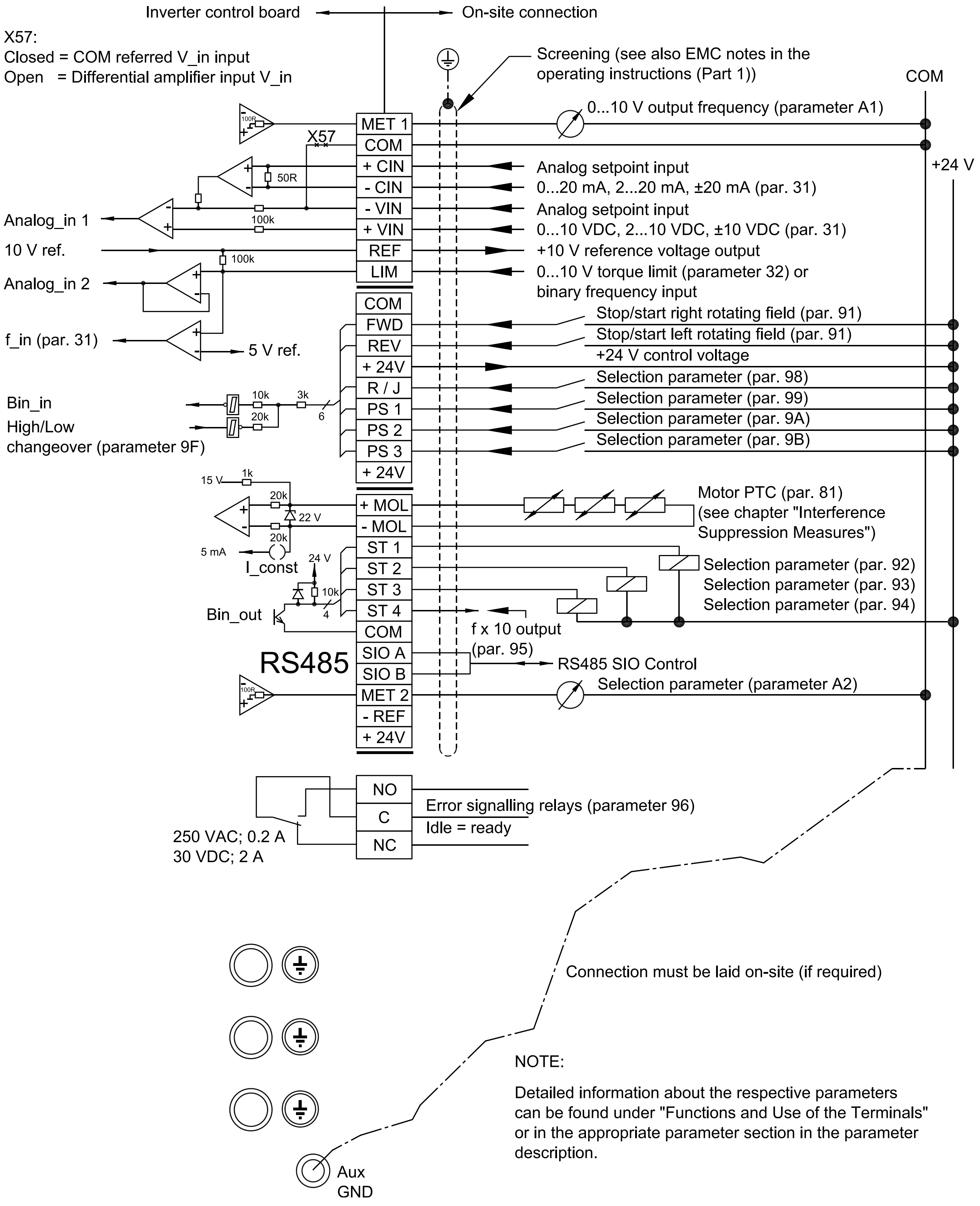


Figure 2.5

2.9 Typical Control Terminal Assignments



NOTE:

Detailed information about the respective parameters can be found under "Functions and Use of the Terminals" or in the appropriate parameter section in the parameter description.

Figure 2.6

3 Technical Data

3.1 Output Data

	UD 7000												
	7001-5	7002-2	7003-0	7004-0	7005-5	7007-5	7011-0	7015-0	7022-0	7030-0	7037-0	7045-0	7055-0
Connectable motor power (kW) [1]	1.5	2.2	3.0	4.0	5.5	7.5	11.0	15.0	22.0	30.0	37.0	45.0	55.0
Inverter power (kVA) [1]	2.5	3.5	4.6	6.2	7.9	10.6	15.2	20.0	29.0	39.0	46.5	57.0	70.0
Rate output current (A_{rms})	3.7	5.2	6.8	9.2	11.7	15.6	22.5	30.0	43.0	58.0	71.0	85.0	97.0
Continuous output current (A) [2]	110% of the rated output current												
Maximum output voltage	3 phase 98% of line voltage												
Output frequency (Hz)	programmable 0–875												
Maximum frequency resolution (Hz)	0.01 (see Chapter 3.3, “Resolution“)												
Overload factor at 45 °C ambient temperature	150% for 1 min. with 30 min. cycle time												
Maximum output current (A_{rms})	5.5	7.8	10.2	13.8	17.5	23.4	33.7	45.0	64.0	87.0	107.0	127.0	145.0
Power loss at a carrier frequency of 5 kHz (%)	2.6					2.1		1.9		1.7			
Power loss at a carrier frequency of 10 kHz (%)	3.2					2.6		2.6		2.3			

Table 3.1

3.2 Input Data

	UD 7000												
	7001-5	7002-2	7003-0	7004-0	7005-5	7007-5	7011-0	7015-0	7022-0	7030-0	7037-0	7045-0	7055-0
Input current for setting a PKZ (A) [3]	4.2	6.2	8.4	11.2	15.5	20.0	28.0	34.0	49.0	65.0	82.0	101.0	123.0
EMC filter	Installed by default (limit class A). The unit can also be supplied without a filter. [4]							Only externally as an accessory. [4]					
AC input voltage range (3-phase)	3 phase 380–460 VAC, ±15%. Conductor voltage asymmetry less than 2%.												
Maximum line voltage	529 VAC												
Line frequency	45–65 Hz												
DC infeed at the terminals +/–	350 VDC to 700 VDC. Please consult BERGES.												
Maximum DC voltage	745 VDC												

Table 3.2

NOTES:

1) At a set carrier frequency up to 5 kHz. At higher carrier frequencies, power staggering may be necessary depending on ambient conditions.

2) Information required for definition of the motor cable cross sections (1.25 × continuous current) on the basis of 400 V line voltage.

3) Information required for setting a PKZ switch (magnetic circuit breaker).

4) The maximum input voltage for EMC filters is 415 VAC +15%. Higher voltages on demand.

3.3 Control Data

Modulation method	Sinusoidal vector modulation, subharmonic method, trapezoidal control	
PWM frequency	2–9 kHz, in 0.01 kHz steps	
Setpoint input	**Setpoint source**	**Resolution**
	0–10 VDC, 2–10 VDC, ±10 VDC (100 kΩ), 0–20 mA, 4–20 mA, ±20 mA (50 Ω load)	10 bits (optionally 12 bits on request)
	Keypad: (in the 0 to 99.99 Hz frequency range) (in the 100.0 Hz to Fmax frequency range)	0.01 Hz 0.1 Hz
	Digital frequency input 0–100 kHz; Master setpoint phase-synchronous $f_{out} \times 6$ or $f_{out} \times 10$	0.01 Hz
	7 fixed frequencies can be selected in binary fashion	0.1 Hz
	Serial interface RS 485	0.01 Hz
V/Hz characteristic	Programmable characteristic with Autoboost or automatic definition	
Accel./Decel. times	Two sets, which can be switched over, 0.1–999.9 s	
Torque limiting	Selective in all 4 quadrants, selection from 0–150% T_{rated} possible	
Setting possibilities	Parameterisation by keypad and RS 485	
Field bus	Optional	

Table 3.3

3.4 Protective Function

Pilot indication of DC link voltage	Incandescent bulb within the range from 80 VDC to $V_{DC\ link\ max.}$
Earth fault	Motor connection terminals resistant to earth faults
Short circuit	Motor connection terminals resistant to short circuits
Thermal motor protection	$I^2 \times t$ monitoring, motor temperature sensor (optionally normally-closed contactor PTC)
Thermal protection of inverter	Heat sink temperature monitoring, integrated temperature monitoring in the IGBT module
RFI suppression in accordance with DIN VDE 0875, Part 11	Curve A without external filter. 1) Curve B with external filter
Voltage in the DC link	$V_{DC\ link\ min.}$ = 350 VDC to $V_{DC\ link\ max.}$ = 750 VDC
Torque limiting	Independently programmable in 4 quadrants
Activation lock	Protection against automatic starting on activation of the line voltage
Error message	Plain-text error display and error consequence
Error history	Storage of the last 5 errors, error display

Table 3.4

NOTE:

1) Applicable only to AC voltage connections L1, L2, L3 (in the 1.5–11.0 kW power range; external filters in excess of the value).

3.5 Brake Chopper Power Dissipation

	SIZE II					SIZE III		SIZE IV		SIZE V			SIZE VI
Inverter model number	7001-5	7002-2	7003-0	7004-0	7005-5	7007-5	7011-0	7015-0	7022-0	7030-0	7037-0	7045-0	7055-0
Inverter power (kW)	**1.5**	**2.2**	**3.0**	**4.0**	**5.5**	**7.5**	**11.0**	**15.0**	**22.0**	**30.0**	**37.0**	**45.0**	**55.0**
Maximum continuous transistor current (Amps)	10.0	10.0	10.0	12.5	12.5	15.0	15.0	50.0	50.0	75.0	75.0	75.0	75.0
Minimum resistance value (Ω)	70	70	70	70	70	50	50	16	16	10	10	10	10
Normal resistance (Ω)	75	75	75	75	75	75	75	20	20	20	20	20	20
Average power dissipation (Watts)	80	80	80	80	80	150	150	275	275	275	275	275	275
Maximum break time with nominal Inverter power (sec)	7.0	5.0	3.5	2.7	2.0	3.0	2.0	6.0	4.0	3.0	2.5	2.0	1.5
Duty cycle relative to the Inverter power (%)	5.0	3.7	2.7	2.0	1.5	2.0	1.4	2.0	1.25	1.0	0.75	0.6	0.5

Table 3.5

HINT!

When the motor is used as brake or torque application we recommend the following values (p. ex. for winders and so on):

	SIZE II					SIZE III		SIZE IV		SIZE V			SIZE VI
Inverter model number	7001-5	7002-2	7003-0	7004-0	7005-5	7007-5	7011-0	7015-0	7022-0	7030-0	7037-0	7045-0	7055-0
Inverter power (kW)	**1.5**	**2.2**	**3.0**	**4.0**	**5.5**	**7.5**	**11.0**	**15.0**	**22.0**	**30.0**	**37.0**	**45.0**	**55.0**
Power dissipation (average) (kW)	1.35	1.98	2.70	3.60	4.95	6.75	9.90	13.50	19.80	27.00	33.30	40.50	49.5
Brake chopper current (average) (A)	1.7	2.5	3.5	4.6	6.3	8.7	12.7	17.3	25.4	34.6	42.7	51.9	63.0
Minimum resistant (Ω)	120					60		30		15			

Table 3.6

3.6 Display and Operating Unit

Keypad	8 keys: FWD, REV, STOP, PROG, SHIFT, ENTER, ▲, ▼
Display	Alphanumeric 2-line super-twist LCD display with 16 characters in each line. Display languages: German or English
LED status displays	3 LED's integrated in the FWD, REV and STOP keys
Control possibilities	1. Keypad 2. Control terminals 3. Serial interface RS 485

Table 3.7

3.7 Parameter Groups

Parameter block 1	Motor data
Parameter block 2	Basic data
Parameter block 3	Setpoint selection (display: Setpoint-select)
Parameter block 4	Frequencies
Parameter block 5	Torque
Parameter block 6	V/Hz characteristic (display: V/f-char)
Parameter block 7	Inverter functions (display: Inverter funct.)
Parameter block 8	Protective functions (display: Security funct.)
Parameter block 9	Binary inputs/outputs (display: Binary In/Outpt)
Parameter block A	Analog outputs/SIO (display: Analog Out/SIO)
Parameter block B	Speed controller (display: Speed control)
Parameter block C	Stepper control (display: Step-control)
Parameter block D	Options
Parameter block E	Service data II
Parameter block F	Service data III (display: Service dataIII)
Parameter block 0	Service data I

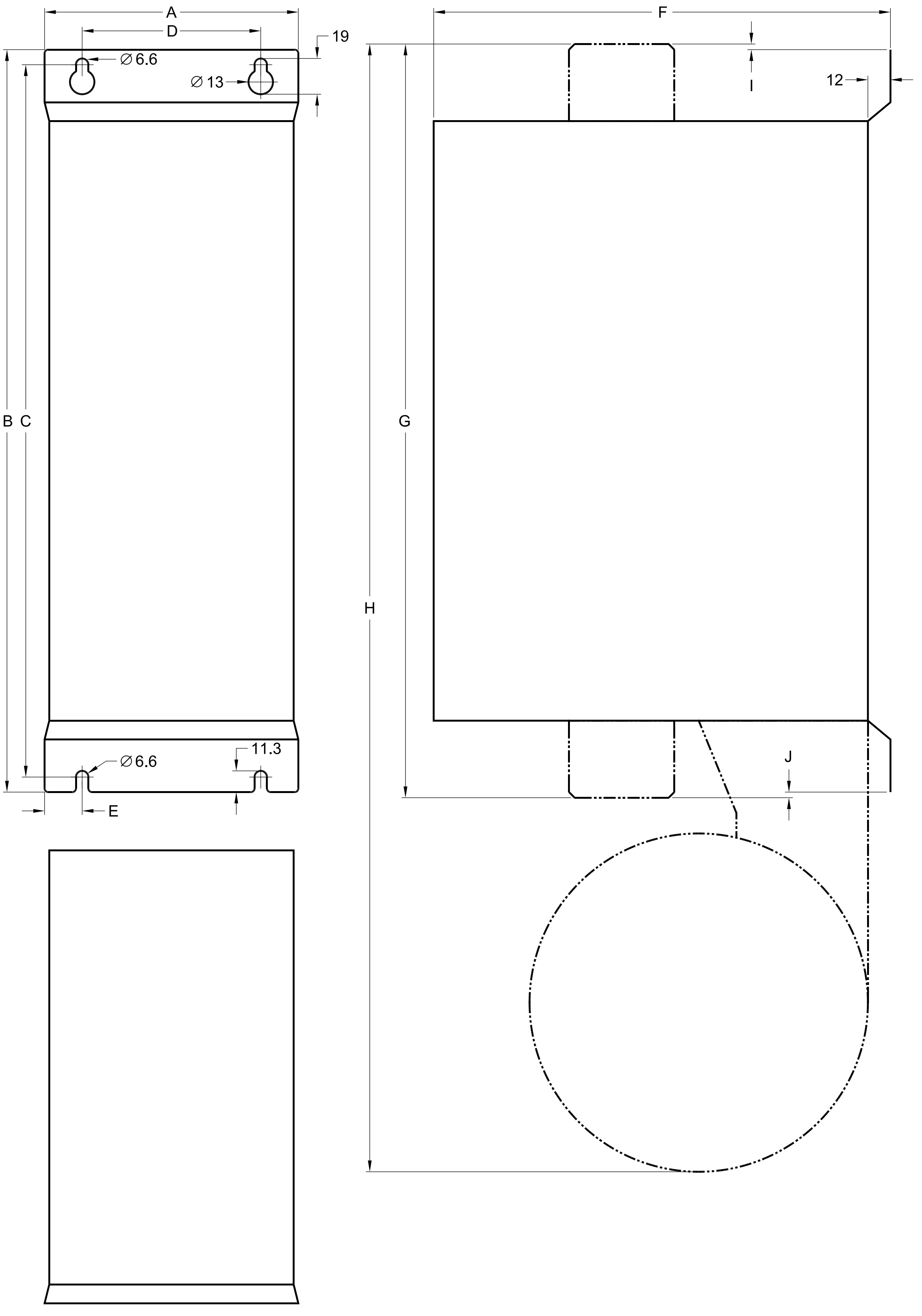
Table 3.8

3.8 Mechanical Design and Ambient Conditions

Housing design	Bookshelf
Degree of protection	IP 20
Installation	Installation in a separate housing protected against dust and corrosive vapours
Operating temperature	0 °C to 45 °C
Storage temperature range	–20 °C to +60 °C
Humidity	<90% relative humidity, no condensation
Vibration	Maximum 0.6 g
Altitude level	<1000 m without performance reduction

Table 3.9

3.9 Dimensions



Size II...VI

DIMENSIONS					
	Size II 1.5–5,5 kW	Size III 7.5–11 kW	Size IV 15–22 kW	Size V 30–45 kW	Size VI 55 kW
A	100	135	240	345	345
B	395	395	395	–	–
C	379	379	379	488	488
D	60	95	180	285	285
E	20	20	30	30	30
F	252	252	252	252	252
G	–	–	–	512	–
H	–	–	–	–	716
I	–	–	–	3	3
J	–	–	–	3	–

Dimensions in mm.

WEIGHT DATA				
Size II	Size III	Size IV	Size V	Size VI
5.7	8.2	15.4	26.5	31.0

Weight in kg.

4 Drive Variants

The UD 7000 Series of inverters are general-purpose controllers (static frequency converters) which can be used for low-loss open-loop or closed-loop control of the following motor variants:

1. Asynchronous motors with squirrel-cage rotor.
2. Asynchronous motors with squirrel-cage rotor and rotational speed feedback (encoder for feedback of the rotor speed of rotation).
3. Permanent-field synchronous servo-motors with feedback (resolver for feedback of the rotor position).

The UD Series of inverters features a high-performance, internal motor control system which controls the connected motor extremely effectively over the entire rotational speed range. A precise knowledge of the motor data is required so that the internal motor models used are able to supply as precise an image as possible of the connected motor. Since the user will generally be unfamiliar with this data apart from the information on the rating plate, the inverter features Autotest functions (also referred to as Autotuning) which determine this data automatically. This test must run at least once before placing the drive into operation. Please refer to the Parameter Description, parameter **2A – Test mode** (Page 2-45) for further information on this.

4.1 The Motor Drive Data and How it is Measured

Only the data of the motor rating plate is entered in the parameters of “Group 1 – Motor data” for optimum matching of the inverter to the connected motor. Detailed information on commissioning of the inverter as a function of the selected motor variant can be found in Chapter 6, “Commissioning” and in the section on parameter **2A – Test mode**.

On drives with feedback, certain other information on the feedback systems used must be entered in “Group B – Speed controller”. If all motor and feedback data has been programmed correctly, other motor feedback data absolutely necessary for optimum control of the selected motor variant is determined during the subsequent test run.

4.2 The Asynchronous Motor and Speed Control

The asynchronous motor has proven successful in the field of drive engineering owing to its rugged and low-cost design. When frequency converter technology became cheaper and cheaper and more reliable in the late 70s, it took the place of the closed-loop-controlled DC machine to an ever-increasing extent. Initially, the converter-controlled asynchronous motor was a low-cost alternative to the closed-loop-controlled DC motor only in the power range upwards of 3 kW. Today, it is a fully fledged alternative to the closed-loop-controlled DC motor even as of approx. 100 Watts in view of the fact that power electronic components are becoming cheaper and cheaper.

Constant-flux operation has become the most successful mode of controlling the asynchronous motor. This is because, not least, this variant ensures low-loss and optimum torque operation over the entire rotational speed range. This can be achieved by maintaining the magnetisation of the motor constant over the entire rotational speed range. In order to ensure this, the ratio of the applied motor voltage to the current motor frequency (V_{Mot}/f_{Mot}) must be maintained constantly. Theoretically, this should result in a linear relationship between voltage and frequency. However, as of the point at which the nominal frequency is reached, the motor is operated with rated voltage owing to the limited motor voltage. The constant power range starts as of this point. However, at low frequencies, the influence of the ohmic winding resistance (resistance of the stator winding) comes more and more to the fore so that it is necessary to compensate for this voltage drop which weakens the magnetisation. It is therefore necessary to boost the voltage slightly with respect to its ideal characteristic (I×R compensation).

Essentially, three methods are used for this magnetisation current control:

1. Characteristic control (V_{Mot}/f_{Mot}) with I×R compensation.
2. I_0 control (reactive power or reactive current control).
3. Field-orientated control with and without feedback (vector control).

These variants which are all integrated in the UD 7000 are discussed below.

4.2.1 V/f-Controlled Operation

The UD 7000 Series of inverters features a high-performance reactive current control system besides the pure V/f control. Selection is made with parameter **62 – V/Hz characteristic selection**.

In the case of pure V/f control (setting 2), the various interpolation points are permanently preset by the user in order to define the voltage at the related frequency. 5 V/f pairs are available (see the illustration below).

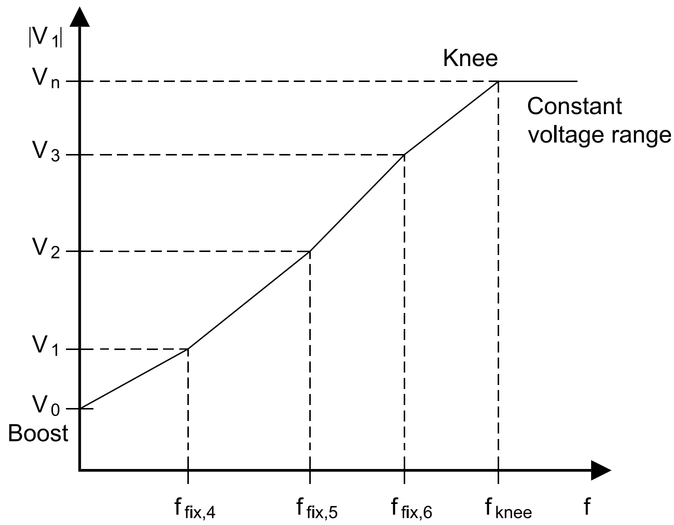


Figure 4.1
Controlled V/f characteristic

In general, presetting points V_0, V_1 and “Knee” will suffice for a standard asynchronous motor. In the case of special machines, such as reluctance motors for instance, it is frequently necessary to specify further intermediate values. The motor manufacturer must then be consulted for more precise data. Note that this preset characteristic is complied with firmly under all load conditions.

One other version of motor control is, as mentioned above, I_0 control in combination with slip compensation (parameter **76 – Slip compensation**). This type of V/f characteristic control can also be selected with parameter **62 – V/Hz characteristic selection** (settings 0, 3, 4, 5).

The inverter control system detects the instantaneous value of two motor currents. The third phase current can be computed from this. This allows the phase angle of the currents with respect to the applied voltage to be determined and the currents are then split into active component and reactive component via which it is then possible to conclude the current torque and machine flux. The simplified phasor diagram below clearly shows this situation.

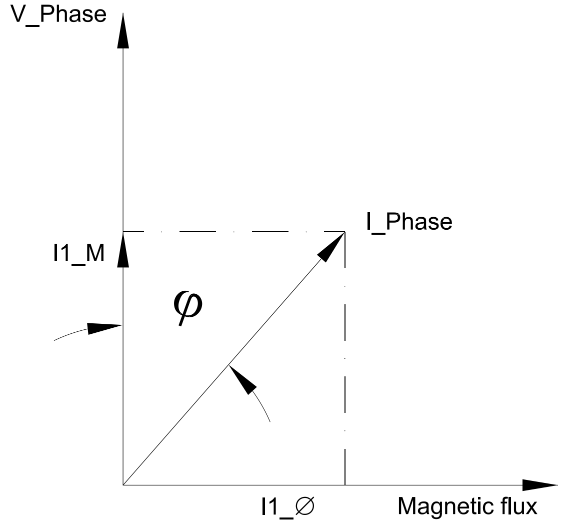


Figure 4.2
Simplified phasor diagram

It is must be noted that this method makes many simplifications for the complex machine model. Influences relating to the rotor are ignored completely for instance.

However, the method has major advantages over purely presetting the V/f ratio. Thus, for instance, the theoretical load dependence of the V/f ratio is corrected automatically which leads to a major improvement in the drive characteristics and a reduction in thermal motor loading in the part-load range. This is illustrated in the diagram below.

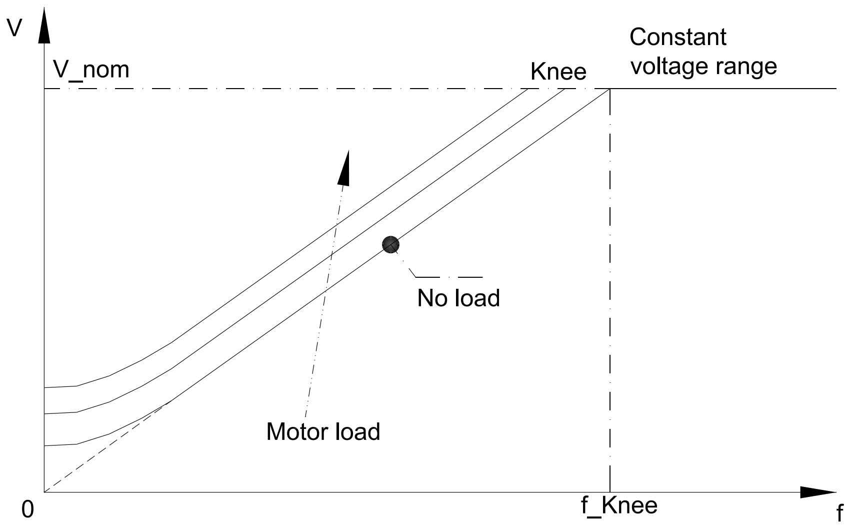


Figure 4.3
Controlled V/f characteristic

The diagram shows that the V/f characteristic is shifted in parallel upwards (starting from the no-load line) as the load increases. The increase in motor voltage in the lower area is performed automatically whereby the magnitude of the voltage to be added under no load depends on the motor data, i.e. correct specification of the motor data and conducting a test run are of major significance in this operating mode as well (see also Chapter 4.2, “The Asynchronous Motor and Speed Control”).

Besides automatic readjustment of the V/f ratio (in order to maintain the machine's flux constant), the inverter also features slip compensation. It can be connected as required, as mentioned above, and enhances rotational speed stability when subject to load variation. The mode of operation of slip compensation is illustrated in the diagram below:

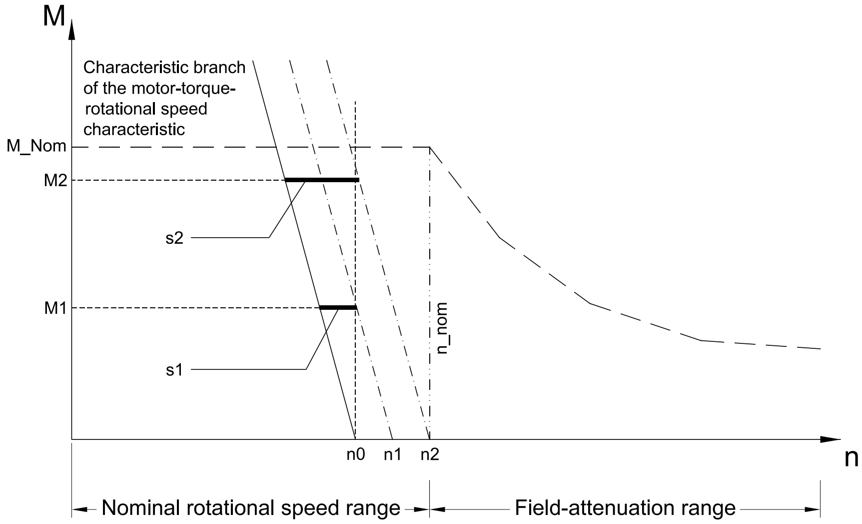


Figure 4.4
Slip compensation

Caption to illustration	
n0	Frequency setpoint
Field-attenuation range	Working range with decreasing maximum torque, resp. working range of constant power
Nominal rotational speed range	Working range with constant torque, resp. working range of increased power
n_nom	Nominal motor speed (speed of rotation at which the voltage limit was reached (f_Knee)
M	Torque M1<M2
s	Slip s1<s2 ({synchronous speed of rotation - rotor speed of rotation} / synchronous speed of rotation)

It is possible to draw conclusions as regards the load-dependent slip of the motor from the torque-generating current component I1_M. If we know the slip frequency (~fs1;fs2), this is added to the stator frequency (n1, n2). This greatly enhances rotational speed stability. The motor is provided with a so-called shunt behaviour. In generator operation, the slip frequency is, of course, subtracted from the stator frequency. Starting from the torque-rotational speed characteristic of the asynchronous motor in line operation, this corresponds to a parallel shift in this characteristic.

The essential disadvantage of these open-loop-controlled methods is the fact that these methods are all based on static models of the motor. In dynamic operating cases, the operating data determined differs greatly from the conditions actually obtaining in the motor. In order to optimise this, it is necessary to use dynamic motor models. In addition, the precise flux obtaining in the motor is computed in these models, i.e. the above-mentioned influences of the rotor on the stator variables are included in computation.

4.2.2 Field-Orientated-Controlled Mode (Vector Control)

Despite all control components, characteristic control does not suffice to achieve a similarly good control and load behaviour on the asynchronous motor as with a DC motor. The principle of field-orientated control is used for this purpose. In this case, the field and torque-generating current components are computed precisely and controlled highly dynamically. If this is possible, this provides a control structure which corresponds to that of a DC machine control. There as well, one has one controller for the excitation current and one controller for the armature current (torque controller). One talks of magnetisation current and torque-generating component on the asynchronous machine. A voltage-controlled asynchronous machine becomes a current-controlled asynchronous machine.

The fundamental mode of operation of the asynchronous motor which is able to develop a torque only if there is a rotational speed difference between stator field and rotor (slip), indicates a problem which cannot be easily solved. As the result of this slip, a current is induced in the motor winding and this current, together with the flux in the air gap (rotating field), results in a torque. The flux of the stator must now be linked in the air gap with the flux of the rotor in order to obtain the working flux.

The fundamental problem is to detect or compute the flux in the machine from easily measurable variables. Only then is it possible to control the torque decoupled from the flux.

The basic physics principle applies here as well:

$$M \sim I \times \phi \times \sin_{(\text{Angle between})} |I \times \phi|$$

Since the resultant flux in the machine is now determined not only by the stator-end average ampere conductors per unit of length but since the current also flows in the rotor owing to the motor's transformer-like design and this current also has a frequency which is not equal to the stator frequency and since this also generates a flux, the ratios become very complex. In addition, these rotor influences are also load-dependent. It can be now be easily imagined that the ratios at the rotor end can be computed exactly only if we know the precise rotor speed of rotation (rotational speed feedback). The conditions in the motor can now be grasped with the aid of complex mathematical motor models. The data obtained from this can now be transformed to the stator end so that one can construct a precise current-phasor diagram.

To summarise, the following measuring sensors are also required:

- Current transformer in the motor phases.
- Rotational speed feedback on the rotor.

The simplified phasor diagram in Figure 4.2 has now become a phasor diagram which allows for influences of the rotor end (I´2):

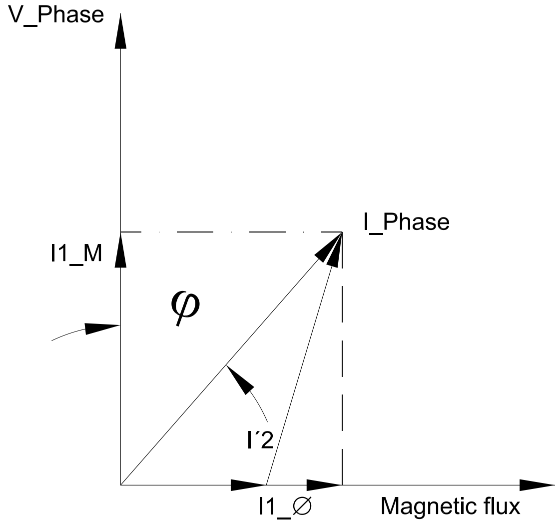


Figure 4.5
Extended phasor diagram

Here as well, it is of major significance that one obtains satisfactory drive characteristics only if the information provided in Chapter 4.1, “The Motor Drive Data and How it is Measured” is followed precisely.

What advantages are obtained from the field-orientated-controlled asynchronous machine?

- Maximum drive dynamics.
- Full torque at rotational speed 0. Closed-loop-controlled standstill.
- The torque can be controlled and limited precisely.
- Ramps can be deactivated. This means that the drive is ideally suited for applications in conjunction with superimposed positioning controls.
- Phase-synchronous Master-Slave operation (electronic transmission) is possible without external open-loop control systems. See also parameter **2C – Application**.
- Current-controlled operation means that the dead times and switching times of the output stages have no influence on the sinusoidal waveform of the motor current.
- More precise current limitation since the current in the motor is preset as a setpoint.

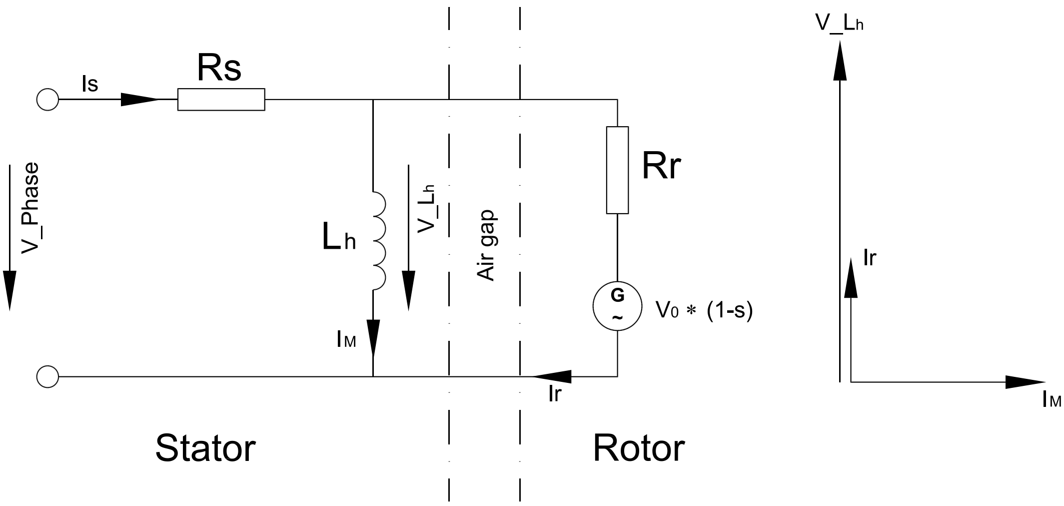
4.2.3 SLV (Sensorless Vector Control)

The field-orientated-controlled asynchronous machine represents an optimum control method for the asynchronous motor. The method has only one essential disadvantage that attachment of an encoder (rotational speed feedback) is necessary. The “sensorless field orientation” technology normally attempts to compute the position and amplitude of the motor field by suitable motor models from the motor voltages and currents. In recent years, certain methods have been developed, but none of them have yet reached the actual objective of full torque at zero rotational speed. Of these variants, it is the ***SLV***② method above all which has come to the fore owing to its rugged design. ***SLV***② stands for “**S**ensor**L**ess **V**ector”.

Unlike the above-mentioned, conventional methods, the ***SLV***② method does not compute the motor field but presets it in controlled manner. The method relies on the fact that the motor generates a correct magnetic field if it receives correct control signals. The underlying idea can be seen particularly well from the transformer model of the asynchronous motor.

APPROACH:

If the voltage (V_L_h) is maintained constant on the basis of the magnetising inductance, the magnetising current (I_M) is also constant. Rotor current (I_r) and magnetising current (I_M) are naturally perpendicular.



Where: $V\_L_h = I_M \times \omega \times L_h$.
V_L_h is proportional to ω

Figure 4.6
Transformer model of the asynchronous motor (leakage inductances ignored)

This provides all preconditions for optimum control of the motor. In the above equivalent circuit diagram, it can be seen that it is of tremendous importance to calculate with the correct motor data. Otherwise, the calculation of the field voltage V_L_h leads to incorrect values. The model data such as currents, voltages and rotor rotational speeds, are obtained from the ***SLV***② motor model.

The following block diagram illustrates how this data is obtained from the motor model.

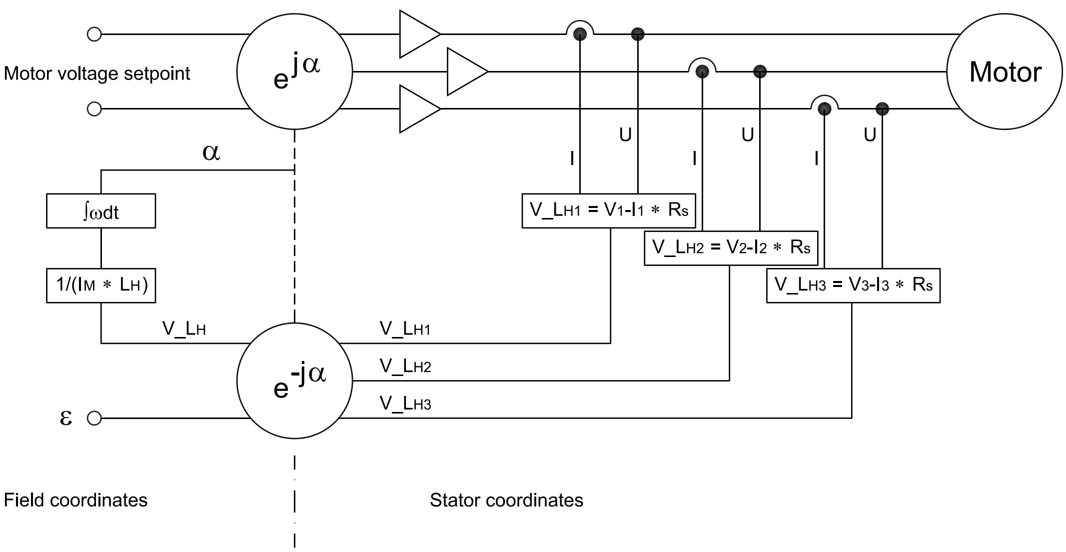


Figure 4.7
SLV② **implementation in the inverter**

Two vector rotators [1] play a central role, whereby the upper rotator transforms the motor voltage setpoints from the field coordinate system to the stator coordinate system and the lower rotator performs this transformation in reverse. It can be seen that the voltage V_L_h is calculated for each phase at the stator coordinate end. This provides the motor-internal actual variable of voltage as a function of magnetising inductance L_H. These rotating voltage vectors are transformed back at the field end where they become a DC voltage and are used to compute the angular velocity ω.

This is because:

$$\omega = \frac{V\_L_h}{(I_M \times L_H)}$$

and, by integration of the angular velocity ω, we obtain the angle of rotation a for controlling the vector rotators. We can see the basic principle of ***SLV***② for controlling the motor field:

The field current is preset as a setpoint! The field voltage is computed from this and is preset for the motor as a voltage setpoint.

This voltage is calculated back as an actual value from the variables measurable at the motor terminal and, on the basis of this, the angular velocity ω is computed, and this then controls the vector rotators after integration. The comparison between field voltage setpoint and actual field voltage value is therefore performed indirectly in the vector rotators. α is varied until $V_{LHact.} = V_{LHsetpoint}$. A field current controller is not necessary.

Slip computation:

In Figure 4.6 “Transformer model of the asynchronous motor (leakage inductances ignored)”, we can directly see that the rotor current I_R is proportional to the machine's slip s. If I_s and I_M are known and V_L_H is indirectly measurable as described above, it is possible to compute s.

We thus know all variables for implementing an optimum, field-orientated control with indirect rotational speed measurement.

SLV② in Practice

This mode of operation is particularly suitable for applications such as the following owing to its high dynamic response:

Application	Drive-engineering problem
• Agitators	Heavy starting
• Presses	Shock loads
• Winders	High torque in the lower frequency range
• Injection-moulding machines (screw conveyors)	High peak torques, heavy starting
• Inclined lifts	Starting torques
• Metering facilities	Constant rotational speed
• Washing machines	Constant rotational speed in the lower speed range. Acceleration at the torque limit
• Unwinders	Torque-control operation

(1) **Vector rotator:** a vector rotator is a mathematical method of, for instance, converting the rotating phasor of a periodic quantity to stationary vectors. It is easy to imagine a vector rotator by way of the following example: if we could represent the magnetic field of the motor optically by phasors or pointers and if we view what is happening from the outside, we can see quickly rotating phasors or pointers which cannot be easily described. If we now make it possible to position ourselves on a plate turning at the same speed as the field at its centre, we can see a stationary pointer or phasor which can only change its length. The vector rotator corresponds precisely to this rotating platform.

The Limits of *SLV*②

*SLV*② is not yet the optimum solution even at zero rotational speed as the inverter does not issue the voltages which it receives as the preset setpoint owing to switching times and dead times of the output stages. This contamination effect does, of course, occur to a particularly great extent at low voltages (lower frequency range). However, the cost-benefit ratio would be disproportionate as regards the improved drive behaviour were one to attempt to compensate for these errors by the use of expensive hardware. Higher-performance future microprocessors will be able to solve this disadvantage at less cost. Tests have established the following key performance aspects:

- Rotational speed accuracy: fabs <1% in the correcting range 1:7.
- Torque accuracy: fabs <1% in the correcting range 1:5.
- Torque at low rotational speeds: 150% at 0.5 Hz (at the motor with 50 Hz nominal frequency).

4.3 The EC Drive

The EC (electronically commutated) motor, as with the asynchronous motor at the stator end, has a three-phase winding. If a rotor with magnet poles is now fitted in the three-phase stator, this produces a synchronous motor.

Here as well – as is the case with asynchronous motors – the interlinked stator current should be as perpendicular (orthogonal) as possible on the rotor field in order to maximise the torque developed. A knowledge of the rotor position as an absolute magnitude is absolutely essential in order to guarantee this phase relationship between stator current and magnetic field position. In general, a resolver, mounted on the rotor, is used for this. This motor type as well features the drive-engineering advantages of the field-orientated-controlled asynchronous machine. It also features other advantages relating to motor physics, such as:

- Lower rotor moment of inertia. This predestines the motor for positioning tasks.
- Lower rotor losses. This results in enhanced efficiency and less rotor heating.
- Very low no-load currents.

The UD 7000 inverter allows operation of an EC motor of any manufacturer, whereby the counter-EMF of the motor should be sinusoidal. This variant achieves best possible true running characteristics. Trapezoidal operation is, admittedly, also possible but is not advisable owing to the aforesaid aspects.

When the motor is commissioned, the motor shaft must be able to turn freely since the mounting angle of the resolver is determined in a test run. This involves presetting a stationary voltage vector which pulls the rotor to its optimum position. If this is not followed, the motor is unable to develop its optimum torque and will demand a higher stator current at the same load.

5 Annex

5.1 Abbreviations Used

The following abbreviations are used in this parameter description:

OE Parameter can be edited on-line.

SC Parameter can be written in the SIO control mode through the serial interface (see description “UD 7000 – serial interface”).

SL Parameter is of significance in the version consisting of the standard inverter (Hz/V-controlled amplifier).

FO Parameter is significant in the version consisting of a field-oriented controller with feedback.

SLV Sensorless vector control ***SLV***②.

EC Parameter is significant in the version consisting of a brushless servo amplifier.

SIO Serial RS 485 interface.

5.2 Parameter Structure

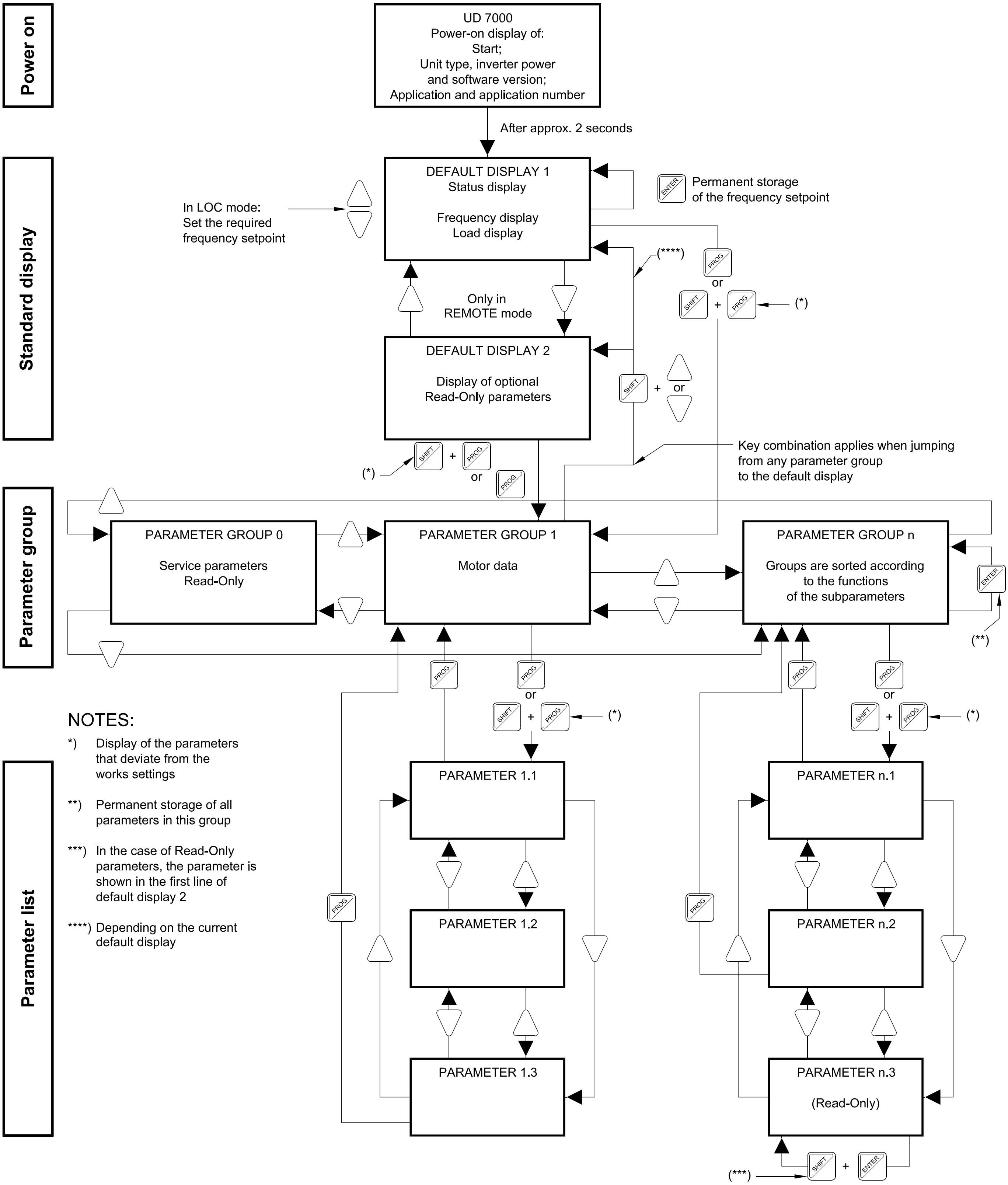


Figure 5.1

5.3 Parameter Overview

GROUP 1 – Motor data						
NO.	DISPLAY	DESCRIPTION	RESOLUTION	PAGE	DEFAULT	CUSTOMER
11	Nominal voltage	Rated voltage	[0.1 V]	2-40	400.0	
12	Nom. frequency	Rated frequency	[0.1 Hz]	2-40	50.0	
13	Power factor	Power factor	[0.01]	2-40		
14	Nominal speed	Rated speed	[min^{-1}]	2-41		
15	Nominal power	Rated power	[0.01 kW]	2-41		
16	Nominal current	Rated current	[0.1 A]	2-41		

GROUP 2 – Basic data						
NO.	DISPLAY	DESCRIPTION	RESOLUTION	PAGE	DEFAULT	CUSTOMER
21	V/Hz knee	Knee frequency	[0.1 Hz]	2-42	50.0	
22	Boost	Boost	[0.1%]	2-42	100.0	
23	Max. frequency	Maximum frequency	[0.1 Hz]	2-43	50.0	
24	Min. frequency	Minimum frequency	[0.1 Hz]	2-43	0.0	
25	Acceleration #1	Acceleration time 1	[0.1 s]	2-43	3.0	
26	Deceleration #1	Deceleration time 1	[0.1 s]	2-43	3.0	
27	Acceleration #2	Acceleration time 2	[0.1 s]	2-43	5.0	
28	Deceleration #2	Deceleration time 2	[0.1 s]	2-43	5.0	
29	Control mode	Control mode	[S-P]	2-43	13	
2A	Test mode	Test mode	[S-P]	2-45	101	
2B	Tuning mode	Adjustment mode	[S-P]	2-50	0	
2C	Application	Application	[S-P]	2-50	0	
2D	SW-Reset	Software reset	[S-P]	2-56	0	

GROUP 3 – Setpoint selection (display: Setpoint-select)						
NO.	DISPLAY	DESCRIPTION	RESOLUTION	PAGE	DEFAULT	CUSTOMER
31	Reference-selec	Setpoint selection (frequency setpoint)	[S-P]	2-57	0	
32	Selection LIM	Function of the LIM input	[S-P]	2-61	1	
33	Ratio frequency	Frequency factor	[0.01%]	2-62	100.00	
34	Fact.LIM analog	Scaling factor A_{LIM} for analogue LIM input	[0.1%]	2-63	10.0	
35	Calibr.LIM digi	Calibration digital LIM input with factor D_{LIM}	[0.1 Hz/kHz]	2-63	2.0	
36	Pulse numberLIM	Pulse number of LIM input	[1]	2-63	6	
37	Dir.master-ref.	Direction of rotation, master setpoint	[S-P]	2-65	0	
38	min Ratio freq.	Low frequency factor limit	[0.01%]	2-65	0.00	
39	max Ratio freq.	High frequency factor limit	[0.01%]	2-66	105.00	
3A	F-EXT1 (SIO)	External frequency setpoint 1	[0.01 Hz] (1)	2-66	0.00	
3B	F-EXT2 (SIO)	External frequency setpoint 2	[0.01 Hz] (1)	2-66	80.00	
3C	Time. VIN/CIN	Filtering time constant VIN/CIN input	[2^x ms]	2-66	4	
3D	Time. LIM	Filtering time constant LIM input	[2^x ms]	2-66	4	
3E	Pulse no. ST4	Pulse number ST4-output	[1]	2-66	10	
3F	Speed Reference	*Frequency setpoint on the basis of ramp*	*[0.1 Hz]*	2-67	r-o	

NOTES:

Various parameters are only available as a function of the current mode.

r-o Read-only parameters are printed in italics and the reference in the tables is abbreviated to “r-o”.

[S-P] Selection parameter (for adaptation of the inverter functions).

◊ Value range and default values.

(1) In the “high frequency” application profile: unit [0.1 Hz].

GROUP 4 – Frequencies						
NO.	DISPLAY	DESCRIPTION	RESOLUTION	PAGE	DEFAULT	CUSTOMER
41	Preset speed #1	Fixed frequency 1	[0.1 Hz]	2-67	5.0	
42	Preset speed #2	Fixed frequency 2	[0.1 Hz]	2-67	20.0	
43	Preset speed #3	Fixed frequency 3	[0.1 Hz]	2-67	40.0	
44	Preset speed #4	Fixed frequency 4	[0.1 Hz]	2-67	60.0	
45	Preset speed #5	Fixed frequency 5	[0.1 Hz]	2-67	0.0	
46	Preset speed #6	Fixed frequency 6	[0.1 Hz]	2-67	0.0	
47	Skip band	Hysteresis band for blocking frequencies	[0.1 Hz]	2-69	1.0	
48	Skip freq. #1	Blocking frequency 1	[0.1 Hz]	2-69	0.0	
49	Skip freq. #2	Blocking frequency 2	[0.1 Hz]	2-69	0.0	
4A	Skip freq. #3	Blocking frequency 3	[0.1 Hz]	2-69	0.0	
4B	Skip freq. #4	Blocking frequency 4	[0.1 Hz]	2-69	0.0	

GROUP 5 – Torque						
NO.	DISPLAY	DESCRIPTION	RESOLUTION	PAGE	DEFAULT	CUSTOMER
51	Select.TLim.MFo	Torque limit selection, right rotation, motor operation	[S-P]	2-69	0	
52	Select.TLim.MRe	Torque limit selection, left rotation, motor operation	[S-P]	2-69	0	
53	Select.TLim.GFo	Torque limit selection, right rotation, generator operation	[S-P]	2-69	0	
54	Select.TLim.GRe	Torque limit selection, left rotation, generator operation	[S-P]	2-69	0	
55	Torque-lim(LIM)	Torque factor LIM input	[0.1%]	2-70	100.0	
56	T-Offset-Acc.	Additional acceleration torque	[0.1%]	2-70	0.0	
57	T-Offset-Dec.	Additional deceleration torque	[0.1%]	2-70	0.0	
58	TLimit-Mot-FWD	Torque limit, right rotation, motor operation	[0.1%]	2-70	100.0	
59	TLimit-Mot-REV	Torque limit, left rotation, motor operation	[0.1%]	2-70	100.0	
5A	TLimit-Gen-FWD	Torque limit, right rotation, generator operation	[0.1%]	2-70	100.0	
5B	TLimit-Gen-REV	Torque limit, left rotation, generator operation	[0.1%]	2-70	100.0	
5C	SIO-Torq.limit	External torque limit	[0.1%]	2-70	100.0	
5D	Start torque	Starting torque	[0.1%]	2-71	130.0	
5E	Ref.torque(VIN)	Torque setpoint factor	[0.1%]	2-71	100.0	
5F	Gain TCtrl-ramp	Gain (V_{Rm}), acceleration control (ramp), torque	[0.1%]	2-71	200.0	

GROUP 6 – V/Hz characteristic (display: V/f-char)						
NO.	DISPLAY	DESCRIPTION	RESOLUTION	PAGE	DEFAULT	CUSTOMER
61	Autoboost	Autoboost	[S-P]	2-72	1	
62	V-Hz selector	V/Hz characteristic selection	[S-P]	2-73	3	
63	Curr. DC-brake	DC brake current	[0.1 A]	2-74		
64	DC-brake time	DC brake time	[0.1 s]	2-74	1.0	
65	Freq. DC On	DC brake switch-on frequency	[0.1 Hz]	2-74	0.5	
66	Setuptime field	Field build-up time	[0.1 s]	2-74	0.5	
67	V/f-Char. V0	V/Hz characteristic, voltage V0	[0.1 V]	2-75	0.0	
68	V/f-Char. V1	V/Hz characteristic, voltage V1	[0.1 V]	2-75	100.0	
69	V/f-Char. V2	V/Hz characteristic, voltage V2	[0.1 V]	2-75	150.0	
6A	V/f-Char. V3	V/Hz characteristic, voltage V3	[0.1 V]	2-75	200.0	
6B	Max. Voltage	Cut-in point of voltage limitation control	[0.1%]	2-76	98.0	
6C	Min.excitation	Minimum excitation	[0.1%]	2-76	33.0	
6D	Setup fld.activ	Field build-up time activation	[S-P]	2-76	1	
6E	Filt.Time.FWeak	Filter field weakening	[1 ms]	2-76	100	
6F	Increments	Increment	[1]	2-76	1	

GROUP 7 – Inverter functions (display: Inverter funct.)						
NO.	DISPLAY	DESCRIPTION	RESOLUTION	PAGE	DEFAULT	CUSTOMER
71	Start/Stop opt.	Start and Stop options	[S-P]	2-77	0	
72	Ramp selector	Ramp function selection	[S-P]	2-78	0	
73	Ramp. smooth	Drag time	[0.1 s]	2-79	0.1	
74	Sel. power fail	Power failure response	[S-P]	2-79	2	
75	Gain UDC-Ctrl.	DC link voltage control gain $V_{DC\ link}$	[0.1%]	2-80	500.0	
76	Slip compensat.	Slip compensation	[S-P]	2-80	0	
77	Gain slip-comp.	Slip compensation setting	[0.1%]	2-81	100.0	
78	Language	Language	[S-P]	2-81	0	
79	PWM frequency	PWM frequency	[0.01 kHz]	2-81	4.50	
7A	Power Chopp-R	Braking resistor power	[0.01 kW]	2-81	0.08	
7B	Sped motpot.Inc	Increment motor potentiometer speed	[0.1 s]	2-82	10.0	
7C	Sped motpot.Dec	Decrement motor potentiometer speed	[0.1 s]	2-82	10.0	
7D	heating time R	Permissible heating time of braking resistor	[1 s]	2-83	2	
7E	brake resistor	Connected braking resistor	[1 Ω]	2-83	20/75	
7F	PWM mode	Control method	[S-P]	2-83	1	

GROUP 8 – Protective functions (display: Security funct.)						
NO.	DISPLAY	DESCRIPTION	RESOLUTION	PAGE	DEFAULT	CUSTOMER
81	Selector MOL	MOL input function selection	[S-P]	2-83	2	
82	MOL-Input	*MOL input display*	*[1%]*	2-84	r-o	
83	Restart Select.	Restart after fault definition	[Binary]	2-84	0000	
84	Number Restart	Number of restarts	[1]	2-85	0	
85	Delay Restart	Restart delay	[0.1 s]	2-85	10.0	
87	Access code	Password	[1]	2-85	0	
88	Therm.timeconst	Thermal motor time constant	[1 min]	2-85	15	
89	I^2t-Limit(Warn)	I^2t warning threshold	[0.1%]	2-86	115.0	
8A	I^2t-Limit	I^2t error threshold	[0.1%]	2-86	120.0	
8B	Max.Ramp.Delay	Maximum permissible ramp extension in the event of stop	[1%]	2-86	200	
8C	T.Stop observer	*Current monitoring time t_{out} for stop ramp*	*[0.1 s]*	2-87		
8D	Refer. ST-Outp.	Reference value for load-dependent switching of control outputs	[0.1%]	2-88	0.0	
8E	Watch Speed	Selection speed control	[1]	2-88	0	

GROUP 9 – Binary inputs/outputs (display: Binary In/Outpt)						
NO.	DISPLAY	DESCRIPTION	RESOLUTION	PAGE	DEFAULT	CUSTOMER
91	Inputs FWD/REV	Function of inputs FWD and REV	[S-P]	2-89	1	
92	Aux. output #1	Output ST1 function selection	[S-P]	2-89	3	
93	Aux. output #2	Output ST2 function selection	[S-P]	2-89	102	
94	Aux. output #3	Output ST3 function selection	[S-P]	2-89	10	
95	Aux. output #4	Output ST4 function selection	[S-P]	2-89	115	
96	Auxiliary relay	Relay output function selection	[S-P]	2-89	101	
97	Outp.SIO-Contrl	Control of binary outputs through SIO	[Binary]	2-92	0	
98	Input Run/Jog	Run/Jog input function selection	[S-P]	2-92	0	
99	Input PS1	PS1 input function selection	[S-P]	2-93	4	
9A	Input PS2	PS2 input function selection	[S-P]	2-94	1	
9B	Input PS3	PS3 input function selection	[S-P]	2-96	6	
9C	Status Inputs	*Status of binary inputs*	*[Binary]*	2-99	r-o	
9D	Status Outputs	*Status of binary outputs*	*[Binary]*	2-100	r-o	
9F	Inpt.H/L-active	High/Low active binary input selection	[S-P]	2-100	1	

GROUP A – Analog outputs/SIO (display: Analog Out/SIO)						
NO.	DISPLAY	DESCRIPTION	RESOLUTION	PAGE	DEFAULT	CUSTOMER
A1	Meter output #1	Analog output MET1 selection	[S-P]	2-101	1	
A2	Meter output #2	Analog output MET2 selection	[S-P]	2-101	4	
A3	Factor Analog1	MET1 factor	[0.1%]	2-101	100.0	
A4	Factor Analog2	MET2 factor	[0.1%]	2-102	100.0	
A5	Offset Analog2	MET2 offset	[0.1%]	2-102	0.0	
A6	Reference MET	Reference value for the analog output	[1]	2-102	500	
A7	FilterTime Gr.0	Filtering time constant of displayed values in parameter group 0	[2^x ms]	2-103	6	
A8	SIO-Baudrate	Baud rate SIO selection	[S-P]	2-103	4	
A9	SIO-Address	Slave address of the inverter for SIO operation	[0–31]	2-103	0	
AA	SIO-Protocol	SIO protocol	[S-P]	2-104	1	
AB	SIO-Timeout	SIO operation time-out	[1 s]	2-104	0	
AC	SIO-Errors	*SIO operation error messages*	*[Binary]*	2-104	r-o	
AD	SIO-Commands	Inverter control commands in SIO mode	[Binary]	2-105	0	

GROUP B – Speed controller (display: Speed control)						
NO.	DISPLAY	DESCRIPTION	RESOLUTION	PAGE	DEFAULT	CUSTOMER
B1	P-gain	Speed controller gain	[1]	2-105	100	
B2	I-gain	Reset time of speed controller	[1 ms]	2-105	500	
B3	Gain boost	Speed controller gain boosting factor	[0.1]	2-106	1.1	
B4	Maxfreq.gain-b.	Speed controller gain boosting end frequency	[0.1 Hz]	2-106	0.0	
B5	Holding control	Holding control	[S-P]	2-107	0	
B7	Rel.drag.dist.	Specific holding controller following error	[0.001%]	2-107	0.100	
B8	TN pos.cntrl	Specific position control reset time	[2^x]	2-108	0	
BA	Pole pairs Rslv	Resolver pole pair number	[1]	2-108	1	
BB	Angle (mech.)	*Motor shaft angle*	*[0.1°]*	2-108	r-o	
BC	Off.angle senso	Angle sensor installation offset	[8000–$7FFF_H$]	2-108	0000	
BD	Dir.angle senso	Angle sensor direction of rotation	[S-P]	2-109	0	
BE	Lines Encoder	Number of encoder lines	[1]	2-109	1024	
BF	Angle (Sensor)	*Resolver measured angle*	*[0–$FFFF_H$]*	2-109	r-o	

GROUP C – Stepper control (display: Step-control)						
NO.	DISPLAY	DESCRIPTION	RESOLUTION	PAGE	DEFAULT	CUSTOMER
C2	Step-control	Enable step-by-step control application	[S-P]	2-110	0	
C3	Input step	Step number for parameter input	[1]	2-110	0	
C4	Condition Input	Input condition		2-110	0	
C5	Condition Outpt	Output condition		2-110	0	
C6	Parameter-no. 1	Parameter number 1	[1]	2-110	0	
C7	Param. value 1	Parameter value 1	[1]	2-110	0	
C8	Parameter-no. 2	Parameter number 2	[1]	2-110	0	
C9	Param. value 2	Parameter value 2	[1]	2-110	0	
CA	Parameter-no. 3	Parameter number 3	[1]	2-110	0	
CB	Param. value 3	Parameter value 3	[1]	2-110	0	
CC	Delay time	Waiting time	[0.001 s]	2-110	0	
CD	Actual step	Current step	[1]	2-110	0	
CE	Mask pin	Mask for terminal signals		2-110	0	
CF	Step-ctrl input	Input for terminal signals		2-110	0	

GROUP D – Options						
NR.	DISPLAY	DESCRIPTION	RESOLUTION	PAGE	DEFAULT	CUSTOMER
D1	Option	*Option number*	*[1]*	2-110	r-o	
D2	F-zero pulse	Zero pulse search frequency	[0.1 Hz]	2-110	0.5	
D3	Zero angle	Zero angle	[0.1°]	2-110	0.0	
D4	sigma	*Total stray factor σ*	*[0.01%]*	2-111	r-o	
D5	id/Id,nom	*Actual value of the field-generating current component i_d*	*[0.01%]*	2-111	r-o	
D6	iq/Iq,nom	*Actual value of the torque-generating current component i_q*	*[0.01%]*	2-111	r-o	
D7	iq,set/Iq,nom	*Setpoint of the torque-generating current component $i_{q,set}$*	*[0.01%]*	2-111	r-o	

GROUP E – Service data II						
NR.	DISPLAY	DESCRIPTION	RESOLUTION	PAGE	DEFAULT	CUSTOMER
E1	Real.Acc.time	*Realised acceleration time*	*[0.1 s]*	2-111	r-o	
E2	Real.Dec.time	*Realised deceleration time*	*[0.1 s]*	2-111	r-o	
E3	Ratio frequency	*Frequency factor*	*[0.01%]*	2-111	r-o	
E4	SoftwareVersion	*Software version*	*[0.01]*	2-112	r-o	
E5	Total op. time	*Lifetime*	*[1 h]*	2-112	r-o	
E6	Total run time	*On time*	*[1 h]*	2-112	r-o	
E7	Enable time	*Enabling time*	*[1 h]*	2-112	r-o	
E8	Status	*Inverter status*	*[Binary]*	2-112	r-o	
E9	Custom para.set	Customer parameter set	[S-P]	2-113	1	
EA	Reset Parameter	Application-dependent defaults	[S-P]	2-114	0	
EB	Status 2	*Inverter status 2*	*[Binary]*	2-115	r-o	
EC	Standarddisplay	Standard display	[S-P]	2-115	1	

GROUP F – Service data III (display: Service dataIII)						
NR.	DISPLAY	DESCRIPTION	RESOLUTION	PAGE	DEFAULT	CUSTOMER
F1	Nom.Power Inv	*Rated inverter power*	*[0.01 kW]*	2-115	r-o	
F2	Filt.power fail	Power failure filter	[0.001 s]	2-115	0.040	
F3	R1	Stator resistance R1	[0.01 Ω]	2-116		
F4	R2	Rotor resistance R2	[0.01 Ω]	2-116		
F5	Xsigma	Leakage reactance Xσ	[0.01 Ω]	2-116		
F6	Tr-Adaptation	Rotor time constant setting	[0.1%]	2-117	100.0	
F7	Main reactance	Main reactance X_h	[0.01 Ω]	2-117	30.00	
F8	Gain I-control	Current controller gain	[0.01 Ω]	2-118	1.00	
F9	TN/TA I-control	Specific current controller reset time	[1]	2-118	50	
FA	Dead-time comp.	Dead time compensation	[1]	2-118	1	
FB	PWM freq.chnge.	PWM frequency slaving	[1]	2-119	0	
FC	Ramp control	Ramp acceleration control (torque)	[S-P]	2-119	1	
FD	Torq.limitation	Torque limiting	[S-P]	2-119	1	
FE	Excitation	*Excitation*	*[0.1%]*	2-119	r-o	

GROUP 0 – Service data I						
NR.	DISPLAY	DESCRIPTION	RESOLUTION	PAGE	DEFAULT	CUSTOMER
01	Outpt frequency	*Output frequency*	*[0.1 Hz]*	2-120	r-o	
02	Output voltage	*Output voltage*	*[1%]*	2-120	r-o	
03	Output current	*Output current*	*[0.1 A]*	2-120	r-o	
04	Load torque	*Output torque*	*[0.1%]*	2-120	r-o	
05	Output power	*Output power*	*[0.1%]*	2-120	r-o	
06	Line voltage	*Line voltage*	*[1 V]*	2-120	r-o	
07	DC voltage	*DC link voltage*	*[1 V]*	2-120	r-o	
09	Actual freqncy.	*Actual frequency*	*[0.1 Hz]*	2-120	r-o	
0A	Inverter temp.	*Heat sink temperature*	*[1 °C]*	2-120	r-o	
0B	fault 1	*Error 1*		2-121	r-o	
0C	fault 2	*Error 2*		2-121	r-o	
0D	fault 3	*Error 3*		2-121	r-o	
0E	fault 4	*Error 4*		2-121	r-o	
0F	fault 5	*Error 5*		2-121	r-o	

5.4 Error States

HINT!

If the PROG, SHIFT or ENTER key is pressed, the message is reset on the ABE (display and operator-control unit). Acknowledgement of the error message does not cancel the cause of the error. Errors may be also still be pending after reset.

5.4.1 Normal Handling of Error States

In certain circumstances, the inverter may assume an error state. The occurrence of such a state can be reported through relay or transistor outputs (parameters 92–96, setting x01). The output is activated if an error occurs. When the cause of the error disappears, the error signalling output becomes inactive with deactivation of drive enabling; the drive is ready for operation.

5.4.2 Handling of Error States with the “Acknowledge Error State” Function

When a binary input R/J, PS1–PS3 is programmed with the “Acknowledge error state” function, an error state always continues to exist until the cause of the error has been remedied, drive enabling has been cancelled and the binary input “Acknowledge error state” is activated. Thus, in a system with several inverters, it is possible to cancel all drive enabling signals in the event of a malfunction occurring and to nevertheless locate the defective inverter through the relay or transistor output.

In the basic state, the binary input must be deactivated as otherwise the inverter cannot be started. In the event of an error, drive enabling must first be cancelled and only then the input activated. The binary input should not be cancelled until the error state is no longer indicated by the inverter.

FAULT NO.	MESSAGE	DESCRIPTION
0	Local stop	Keypad Stop button has been pushed in the remote mode
1	Min. net voltage	AC Line voltage to low
2	Overtemperature	Heat sink temperature to high
3	Overcurrent	Over current in the output stage
4	Error PWM	PWM Fault
5	MOL contact open	MOL contact open/Motor temperature to high
6	Overvoltage DC-L	DC Bus voltage to high
7	DC-Link failure	DC Bus voltage out of limit during power up
8	Speed observer	Speed above limit or control error too high (see parameter 8E)
9	Dyn.brake-overld	DB duty cycle above limit
10	UndervoltageDC-L	DC Bus voltage to low
11	Option	The option board is not plug in for the selected application
12	Auto-Stop	The auto stop control has been detect
13	SIO-Timeout	Series communication is disconnect
14	Position sensor	Motor feedback is disconnect
15	I^2t-Watch	The electronic motor protection has been exceeded
WARNING MESSAGES:		
16	Overtemperature	Warning: Heat sink temperature to high

FAULT NO.	MESSAGE	DESCRIPTION
17	MOL contact	Warning: Motor temperature exceeded
18	Dyn.brake 80%	Warning: DB resistor overload
19	Motor synchron.	Warning: Speed synchronization in an running motor doesn't work
21	I^2t	Warning: The electronic motor protection has been exceeded
22	R1-Measuring	Warning: R1 measuring out of limit
23	Overcurrent	Warning: Overcurrent limit would been reached
25	Cable cap.	The cable capacitor is to high
26	Xs-Measuring	Warning: Xσ-Measuring is out of limit
27	Set disconn	Warning: In case of setting the parameter 31 to 2 or 5 you get this message if the set-point is below 2 V/4 mA
28	Sensor off.	Warning: The measuring of the mounting offset is fail
29	Zero pulse	Warning: No zero pulse is found
30	CAN-Controller	No can controller found
31	Min. excitation	Warning: Minimum limit of excitation is reached
THE FOLLOWING INTERNAL FAULTS ARE DISPLAYED ONLY AFTER POWER UP:		
32	Watchdog reset	Watchdog-Fault
33	Ill.trap number	Unknown trap-number
34	Ill.Ext.Bus Acc.	Unknown external Bus-access
35	Ill.Instr.Access	Unknown instruction access
36	Ill.Word Op.Acc.	Unknown word access
37	Protection Fault	Protection fault
38	Undefined Opcode	Undefined op-code
39	Stack Underflow	Stack-underflow
40	Stack Overflow	Stack-overflow
41	Nonmaskable Int.	Nonmaskable interrupt

BERGES electronic GmbH
Industriestraße 13 • D–51709 Marienheide-Rodt
Postfach 1140 • D–51703 Marienheide
Tel. (0 22 64) 17-0 • Fax (0 22 64) 1 71 26
http://www.berges.de • e-mail: Info_BEL@berges.de