Design Guide
VLT® Micro Drive FC 51

Setup 1
1-23
50.0 Hz

Status   Quick   Main
Menu   Menu

Menu

Back   OK

On
Warn
Alarm

Hand On   Off   Auto

www.danfoss.com/drives

VLT® THE REAL DRIVE

Contents

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1 Introduction

1.1 Available Literature

NOTICE

This design guide contains the basic information necessary for installing and running the frequency converter.

Danfoss technical literature is available in print from local Danfoss Sales Offices or online at: *www.danfoss.com/ BusinessAreas/DrivesSolutions/Documentations*

- *VLT Micro Drive FC 51 Quick Guide, MG02B*

- *VLT Micro Drive FC 51 Programming Guide, MG02C*

- *FC 51 LCP Mounting Instruction, MI02A*

- *FC 51 De-coupling Plate Mounting Instruction, MI02B*

- *FC 51 Remote Mounting Kit Mounting Instruction, MI02C*

- *FC 51 DIN Rail Kit Mounting Instruction, MI02D*

- *FC 51 IP21 Kit Mounting Instruction, MI02E*

- *FC 51 Nema1 Kit Mounting Instruction, MI02F*

- *FC 51 Line Filter MCC 107 Installation Instruction, MI02U*

1.2 Document and Software Version

This manual is regularly reviewed and updated. All suggestions for improvement are welcome. *Table 1.1* shows the document version and the corresponding software version.

Edition	Remarks	Software Version
MG02K3XX	Replaces MG02K2XX	3.1X

Table 1.1 Document and Software Version

1.3 Abbreviations

°C	Degrees Celsius
A	Ampere/AMP
AC	Alternating current
AMT	Automatic Motor Tuning
AWG	American wire gauge
DC	Direct current
EMC	Electro Magnetic Compatibility
ETR	Electronic Thermal Relay
FC	Frequency Converter
$f_{M,N}$	Nominal motor frequency
g	Gram
Hz	Hertz
I_{INV}	Rated Inverter Output Current
I_{LIM}	Current limit
$I_{M,N}$	Nominal motor current
$I_{VLT,MAX}$	The maximum output current
$I_{VLT,N}$	The rated output current supplied by the frequency converter
kHz	Kilohertz
LCP	Local Control Panel
m	Meter
mA	Milliampere
MCT	Motion Control Tool
mH	Millihenry Inductance
min	Minute
ms	Millisecond
nF	Nanofarad
Nm	Newton Meters
n_s	Synchronous Motor Speed
$P_{M,N}$	Nominal motor power
PCB	Printed Circuit Board
PELV	Protective Extra Low Voltage
RPM	Revolutions Per Minute
Regen	Regenerative terminals
s	Second
T_{LIM}	Torque limit
$U_{M,N}$	Nominal motor voltage
V	Volts

Table 1.2 Abbreviations

1

1.4 Definitions

1.4.1 Frequency Converter

I$_{VLT,MAX}$
The maximum output current.

I$_{VLT,N}$
The rated output current supplied by the frequency converter.

U$_{VLT, MAX}$
The maximum output voltage.

1.4.2 Input

Control command
The connected motor can be started and stopped with LCP and the digital inputs.
Functions are divided into 2 groups.
Functions in group 1 have higher priority than functions in group 2.

Group 1	Reset, Coasting stop, Reset and Coasting stop, Quick-stop, DC braking, Stop and the [Off] key.
Group 2	Start, Pulse start, Reversing, Start reversing, Jog and Freeze output

Table 1.3 Function Groups

1.4.3 Motor

f$_{JOG}$
The motor frequency when the jog function is activated (via digital terminals).

f$_M$
The motor frequency.

f$_{MAX}$
The maximum motor frequency.

f$_{MIN}$
The minimum motor frequency.

f$_{M,N}$
The rated motor frequency (nameplate data).

I$_M$
The motor current.

I$_{M,N}$
The rated motor current (nameplate data).

n$_{M,N}$
The rated motor speed (nameplate data).

P$_{M,N}$
The rated motor power (nameplate data).

U$_M$
The instantaneous motor voltage.

U$_{M,N}$
The rated motor voltage (nameplate data).

Break-away torque
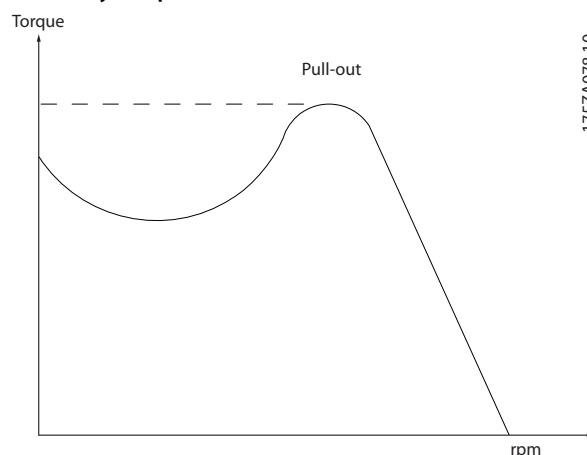
Illustration 1.1 Break-away Torque

η$_{VLT}$
The efficiency of the frequency converter is defined as the ratio between the power output and the power input.

Start-disable command
A stop command belonging to the group 1 control commands, see *Table 1.3*.

Stop command
See Control commands.

1.4.4 References

Analog Reference
A signal transmitted to the analog inputs 53 or 54, can be voltage or current.

Bus Reference
A signal transmitted to the serial communication port (FC port).

Preset Reference
A defined preset reference to be set from -100% to +100% of the reference range. Selection of 8 preset references via the digital terminals.

Ref$_{MAX}$
Determines the relationship between the reference input at 100% full scale value (typically 10 V, 20 mA) and the resulting reference. The maximum reference value set in *3-03 Maximum Reference*.

Ref$_{MIN}$
Determines the relationship between the reference input at 0% value (typically 0 V, 0 mA, 4 mA) and the resulting reference. The minimum reference value set in *3-02 Minimum Reference*

1.4.5 Miscellaneous

Analog Inputs
The analog inputs are used for controlling various functions of the frequency converter.
There are 2 types of analog inputs:

- Current input, 0-20 mA and 4-20 mA

- Voltage input, 0-10 V DC.

Analog Outputs
The analog outputs can supply a signal of 0-20 mA, 4-20 mA, or a digital signal.

Automatic Motor Tuning, AMT
AMT algorithm determines the electrical parameters for the connected motor at standstill.

Brake Resistor
The brake resistor is a module capable of absorbing the brake power generated in regenerative braking. This regenerative braking power increases the intermediate circuit voltage and a brake chopper ensures that the power is transmitted to the brake resistor.

CT Characteristics
Constant torque characteristics used for all applications such as conveyor belts, displacement pumps and cranes.

Digital Inputs
The digital inputs can be used for controlling various functions of the frequency converter.

Relay Outputs
The frequency converter features two programmable Relay Outputs.

ETR
Electronic Thermal Relay is a thermal load calculation based on present load and time. Its purpose is to estimate the motor temperature.

Initialising
If initialising is carried out (*14-22 Operation Mode*), the programmable parameters of the frequency converter return to their default settings.
Initialising *14-22 Operation Mode* does not initialise communication parameters.

Intermittent Duty Cycle
An intermittent duty rating refers to a sequence of duty cycles. Each cycle consists of an on-load and an off-load period. The operation can be either periodic duty or none-periodic duty.

LCP
The Local Control Panel makes up a complete interface for control and programming of the frequency converter. The control panel is detachable and can be installed up to 3 m from the frequency converter, that is, in a front panel with the installation kit option.

lsb
Least significant bit.

MCM
Short for Mille Circular Mil, an American measuring unit for cable cross-section. 1 MCM ≡ 0.5067 mm^2.

msb
Most significant bit.

On-line/Off-line Parameters
Changes to on-line parameters are activated immediately after the data value is changed. Changes to off-line parameters are not activated until pressing [OK].

PI Controller
The PI controller maintains the desired speed, pressure, temperature, etc. by adjusting the output frequency to match the varying load.

RCD
Residual Current Device.

Set-up
Save parameter settings in 2 set-ups. Change between the 2 parameter set-ups and edit one set-up, while another set-up is active.

Slip Compensation
The frequency converter compensates for the motor slip by giving the frequency a supplement that follows the measured motor load keeping the motor speed almost constant.

Smart Logic Control (SLC)
The SLC is a sequence of user-defined actions executed when the associated user-defined events are evaluated as true by the SLC.

Thermistor
A temperature-dependent resistor placed where the temperature is to be monitored (frequency converter or motor).

STW
Status Word.

FC Standard Bus
Includes RS 485 bus with FC protocol. See *8-30 Protocol*.

Trip
A state entered in fault situations, e.g. if the frequency converter is subject to an over-temperature or when the frequency converter is protecting the motor, process or mechanism. Restart is prevented until the cause of the fault has disappeared and the trip state is canceled by activating reset or, in some cases, by being programmed to reset automatically. Trip may not be used for personal safety.

1

Trip Locked

A state entered in fault situations when the frequency converter is protecting itself and requiring physical intervention, for example, if the frequency converter is subject to a short circuit on the output. A locked trip can only be canceled by cutting off mains, removing the cause of the fault, and reconnecting the frequency converter. Restart is prevented until the trip state is canceled by activating reset or, in some cases, by being programmed to reset automatically. Trip locked may not be used for personal safety.

VT Characteristics

Variable torque characteristics used for pumps and fans.

VVC^plus

If compared with standard voltage/frequency ratio control, Voltage Vector Control (VVC^plus) improves the dynamics and the stability, both when the speed reference is changed and in relation to the load torque.

1.5 Power Factor

The power factor is the relation between I_1 and I_{RMS}.

$$Power\ factor = \frac{\sqrt{3} \times U \times I_1 \times COS\varphi}{\sqrt{3} \times U \times I_{RMS}}$$

The power factor for 3-phase control:

$$= \frac{I_1 \times cos\varphi 1}{I_{RMS}} = \frac{I_1}{I_{RMS}}\ since\ cos\varphi 1 = 1$$

The power factor indicates to which extent the frequency converter imposes a load on the mains supply.

The lower the power factor, the higher the I_{RMS} for the same kW performance.

$$I_{RMS} = \sqrt{I_1^2 + I_5^2 + I_7^2 + \ldots + I_n^2}$$

In addition, a high-power factor indicates that the different harmonic currents are low.

2 Safety and Conformity

2.1 Safety

The following symbols are used in this document:

⚠WARNING

Indicates a potentially hazardous situation which could result in death or serious injury.

⚠CAUTION

Indicates a potentially hazardous situation which could result in minor or moderate injury. It may also be used to alert against unsafe practices.

NOTICE

Indicates important information, including situations that may result in damage to equipment or property.

2.1.1 Safety Precautions

⚠WARNING

HIGH VOLTAGE

Frequency converters contain high voltage when connected to AC mains input power. Failure to perform installation, start-up, and maintenance by qualified personnel could result in death or serious injury.

- Installation, start-up, and maintenance must be performed by qualified personnel only.

⚠WARNING

UNINTENDED START

When the frequency converter is connected to AC mains, the motor may start at any time, causing risk of death, serious injury, equipment, or property damage. The motor can start by means of an external switch, a serial bus command, an input reference signal from the LCP or LOP, via remote operation using MCT 10 software, or after a cleared fault condition.

- Disconnect the frequency converter from mains whenever personal safety considerations make it necessary to avoid unintended motor start.

- Press [Off/Reset] on the LCP, before programming parameters.

- The frequency converter, motor, and any driven equipment must be in operational readiness when the frequency converter is connected to AC mains.

⚠WARNING

DISCHARGE TIME

The frequency converter contains DC-link capacitors, which can remain charged even when the frequency converter is not powered. Failure to wait the specified time after power has been removed before performing service or repair work, could result in death or serious injury.

1. Stop motor.

2. Disconnect AC mains, permanent magnet type motors, and remote DC-link power supplies, including battery back-ups, UPS, and DC-link connections to other frequency converters.

3. Wait for the capacitors to discharge fully, before performing any service or repair work. The duration of waiting time is specified in *Table 2.1*.

Size	Minimum waiting time (min)
M1, M2 and M3	4
M4 and M5	15

Table 2.1 Discharge Time

⚠WARNING

LEAKAGE CURRENT HAZARD

Leakage currents exceed 3.5 mA. Failure to ground the frequency converter properly could result in death or serious injury.

- Ensure correct grounding of the equipment by a certified electrical installer.

⚠WARNING

EQUIPMENT HAZARD

Contact with rotating shafts and electrical equipment can result in death or serious injury.

- Ensure that only trained and qualified personnel perform installation, start up, and maintenance.

- Ensure that electrical work conforms to national and local electrical codes.

- Follow the procedures in this manual.

2

⚠CAUTION

WINDMILLING
Unintended rotation of permanent magnet motors causes risk of personal injury and equipment damage.

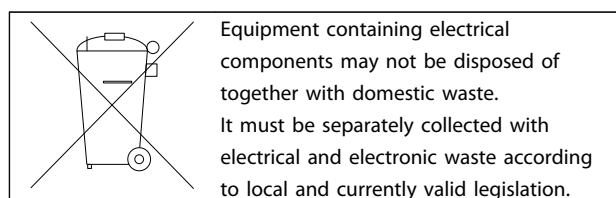- **Ensure that permanent magnet motors are blocked to prevent unintended rotation.**

⚠CAUTION

POTENTIAL HAZARD IN THE EVENT OF INTERNAL FAILURE
Risk of personal injury when the frequency converter is not properly closed.

- **Before applying power, ensure all safety covers are in place and securely fastened.**

2.2 Disposal Instruction

Equipment containing electrical components may not be disposed of together with domestic waste.
It must be separately collected with electrical and electronic waste according to local and currently valid legislation.
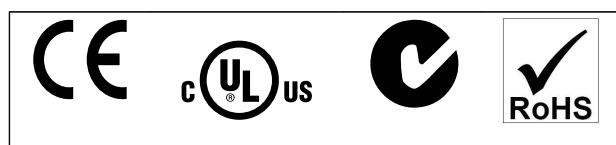
2.3 Approvals

Table 2.2 Approvals

The frequency converter complies with UL508C thermal memory retention requirements. For more information refer to *chapter 3.5.1 Motor Thermal Protection*.

2.4 CE Labeling

2.4.1 CE Conformity and Labeling

What is CE Conformity and Labeling?
The purpose of CE labeling is to avoid technical trade obstacles within EFTA and the EU. The EU has introduced the CE label as a simple way of showing whether a product complies with the relevant EU directives. The CE label says nothing about the specifications or quality of the product. Frequency converters are regulated by 3 EU directives:

The machinery directive (98/37/EEC)
All machines with critical moving parts are covered by the machinery directive of January 1, 1995. Since a frequency converter is largely electrical, it does not fall under the machinery directive. However, if a frequency converter is supplied for use in a machine, Danfoss provides

information on safety aspects relating to the frequency converter. Danfoss do this by means of a manufacturer's declaration.

The low-voltage directive (73/23/EEC)
Frequency converters must be CE labeled in accordance with the low-voltage directive of January 1, 1997. The directive applies to all electrical equipment and appliances used in the 50-1000 V AC and the 75-1500 V DC voltage ranges. Danfoss CE-labels in accordance with the directive and issues a declaration of conformity upon request.

The EMC directive (89/336/EEC)
EMC is short for electromagnetic compatibility. The presence of electromagnetic compatibility means that the mutual interference between different components/appliances does not affect the way the appliances work. The EMC directive came into effect January 1, 1996. Danfoss CE-labels in accordance with the directive and issues a declaration of conformity upon request. To carry out EMC-correct installation, see the instructions in this Design Guide. In addition, Danfoss specifies which standards our products comply with. Danfoss offers the filters presented in the specifications and provide other types of assistance to ensure the optimum EMC result.

The frequency converter is most often used by professionals of the trade as a complex component forming part of a larger appliance, system or installation. Not that the responsibility for the final EMC properties of the appliance, system or installation rests with the installer.

2.4.2 What is Covered

The EU "*Guidelines on the Application of Council Directive 89/336/EEC*" outline three typical situations of using a frequency converter. See *chapter 2.4.3 Danfoss Frequency Converter and CE Labeling* for EMC coverage and CE labeling.

1. The frequency converter is sold directly to the end-consumer. The frequency converter is for example sold to a DIY market. The end-consumer is a layman. He installs the frequency converter himself for use with a hobby machine, a kitchen appliance, etc. For such applications, the frequency converter must be CE labeled in accordance with the EMC directive.

2. The frequency converter is sold for installation in a plant. The plant is built up by professionals of the trade. It could be a production plant or a heating/ventilation plant designed and installed by professionals of the trade. Neither the frequency converter nor the finished plant has to be CE labeled under the EMC directive. However, the unit must comply with the basic EMC requirements of the directive. This is ensured by

using components, appliances, and systems that are CE labeled under the EMC directive.

3.   The frequency converter is sold as part of a complete system. The system is being marketed as complete and could for example, be an air-conditioning system. The complete system must be CE labeled in accordance with the EMC directive. The manufacturer can ensure CE labeling under the EMC directive either by using CE labeled components or by testing the EMC of the system. If only CE labeled components are chosen, the entire system does not have to be tested.

2.4.3 Danfoss Frequency Converter and CE Labeling

CE labeling is a positive feature when used for its original purpose, that is, to facilitate trade within the EU and EFTA.

However, CE labeling may cover many different specifications. Check what a given CE label specifically covers.

The covered specifications can be very different and a CE label may therefore give the installer a false feeling of security when using a frequency converter as a component in a system or an appliance.

Danfoss CE labels the frequency converters in accordance with the low-voltage directive. This means that if the frequency converter is installed correctly, Danfoss guarantees compliance with the low-voltage directive. Danfoss issues a declaration of conformity that confirms our CE labeling in accordance with the low-voltage directive.

The CE label also applies to the EMC directive provided that the instructions for EMC-correct installation and filtering are followed. On this basis, a declaration of conformity in accordance with the EMC directive is issued.

The Design Guide offers detailed instructions for installation to ensure EMC-correct installation. Furthermore, Danfoss specifies which our different products comply with.

Danfoss provides other types of assistance that can help to obtain the best EMC result.

2.4.4 Compliance with EMC Directive 89/336/EEC

As mentioned, the frequency converter is mostly used by professionals of the trade as a complex component forming part of a larger appliance, system, or installation. Not that the responsibility for the final EMC properties of the appliance, system or installation rests with the installer. As an aid to the installer, Danfoss has prepared EMC installation guidelines for the Power Drive system. The standards and test levels stated for Power Drive systems are complied with, if the EMC-correct instructions for installation are followed.

The frequency converter has been designed to meet the IEC/EN 60068-2-3 standard, EN 50178 9.4.2.2 at 50 °C.

2.5 Aggressive Environments

A frequency converter contains many mechanical and electronic components. All are to some extent vulnerable to environmental effects.

⚠ CAUTION

The frequency converter should not be installed in environments with airborne liquids, particles, or gases capable of affecting and damaging the electronic components. Failure to take the necessary protective measures increases the risk of stoppages, thus reducing the life of the frequency converter.

Liquids can be carried through the air and condense in the frequency converter and may cause corrosion of components and metal parts. Steam, oil, and salt water may cause corrosion of components and metal parts. In such environments, use equipment with enclosure rating IP54. As an extra protection, coated printed circuit boards can be ordered as an option. (Standard on some power sizes.)

Airborne particles such as dust may cause mechanical, electrical, or thermal failure in the frequency converter. A typical indicator of excessive levels of airborne particles is dust particles around the frequency converter fan. In dusty environments, use equipment with enclosure rating IP54 or a cabinet for IP20/TYPE 1 equipment.

In environments with high temperatures and humidity, corrosive gases such as sulphur, nitrogen, and chlorine compounds causes chemical processes on the frequency converter components.

Such chemical reactions rapidly affects and damages the electronic components. In such environments, mount the equipment in a cabinet with fresh air ventilation, keeping aggressive gases away from the frequency converter.

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An extra protection in such areas is a coating of the printed circuit boards, which can be ordered as an option.

NOTICE

Mounting frequency converters in aggressive environments increases the risk of stoppages and considerably reduces the life of the frequency converter.

Before installing the frequency converter, check the ambient air for liquids, particles, and gases. This is done by observing existing installations in this environment. Typical indicators of harmful airborne liquids are water or oil on metal parts, or corrosion of metal parts.

Excessive dust particle levels are often found on installation cabinets and existing electrical installations. One indicator of aggressive airborne gases is blackening of copper rails and cable ends on existing installations.

2.6 Vibration and Shock

The frequency converter has been tested according to the procedure based on the shown standards, *Table 2.3* Vibration and shock

The frequency converter complies with requirements that exist for units mounted on the walls and floors of production premises, as well as in panels bolted to walls or floors.

| IEC/EN 60068-2-6 | Vibration (sinusoidal) - 1970 |
| IEC/EN 60068-2-64 | Vibration, broad-band random |

Table 2.3 Standards

2.7 Advantages

2.7.1 Why use a Frequency Converter for Controlling Fans and Pumps?

A frequency converter takes advantage of the fact that centrifugal fans and pumps follow the laws of proportionality for such fans and pumps. For further information see *chapter 2.7.3 Example of Energy Savings*.

2.7.2 The Clear Advantage - Energy Savings

The clear advantage of using a frequency converter for controlling the speed of fans or pumps lies in the electricity savings.
When comparing with alternative control systems and technologies, a frequency converter is the optimum energy control system for controlling fan and pump systems.
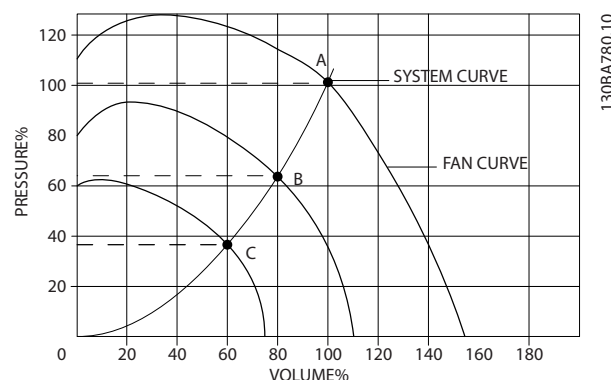

Illustration 2.1 Fan Curves (A, B, and C) for Reduced Fan Volumes
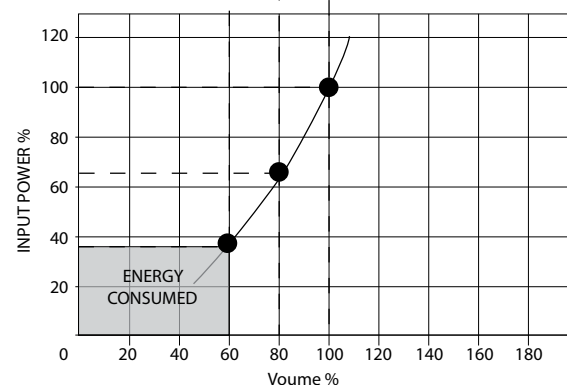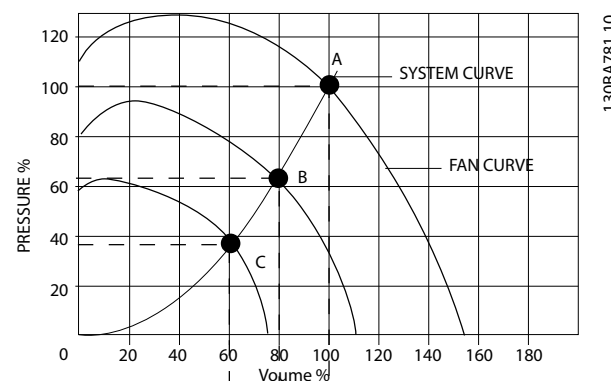
Illustration 2.2 When using a frequency converter to reduce fan capacity to 60% - more than 50% energy savings may be obtained in typical applications.

2.7.3 Example of Energy Savings

As shown in *Illustration 2.3*, the flow is controlled by changing the RPM. By reducing the speed only 20% from the rated speed, the flow is also reduced by 20%. This is because the flow is directly proportional to the RPM. The consumption of electricity, however, is reduced by 50%.
If the system in question only needs to be able to supply a flow that corresponds to 100% a few days in a year, while the average is below 80% of the rated flow for the remainder of the year, the amount of energy saved is even more than 50%.

Illustration 2.3 describes the dependence of flow, pressure and power consumption on RPM.
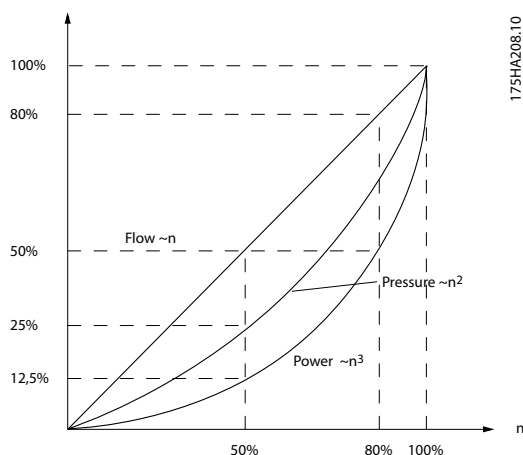
Illustration 2.3 Laws of Proportionally

$Flow: \dfrac{Q1}{Q2} = \dfrac{n1}{n2}$

$Pressure: \dfrac{H1}{H2} = \left(\dfrac{n1}{n2}\right)^2$

$Power: \dfrac{P1}{P2} = \left(\dfrac{n1}{n2}\right)^3$

Q=Flow	P=Power
Q_1=Rated flow	P_1=Rated power
Q_2=Reduced flow	P_2=Reduced power
H=Pressure	n=Speed regulation
H_1=Rated pressure	n_1=Rated speed
H_2=Reduced pressure	n_2=Reduced speed

Table 2.4 The Laws of Proportionality

2.7.4 Comparison of Energy Savings

The Danfoss frequency converter solution offers major savings compared with traditional energy saving solutions. This is because the frequency converter is able to control fan speed according to thermal load on the system and the fact that the frequency converter has a built-in facility that enables the frequency converter to function as a Building Management System, BMS.

Illustration 2.5 shows typical energy savings obtainable with 3 well-known solutions when fan volume is reduced to i.e. 60%.
As the graph shows, more than 50% energy savings can be achieved in typical applications.
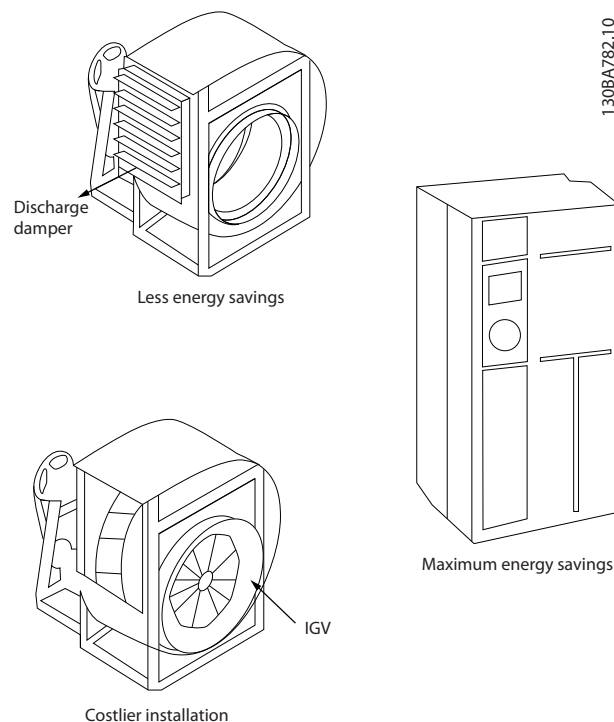
Illustration 2.4 The 3 Common Energy Saving Systems
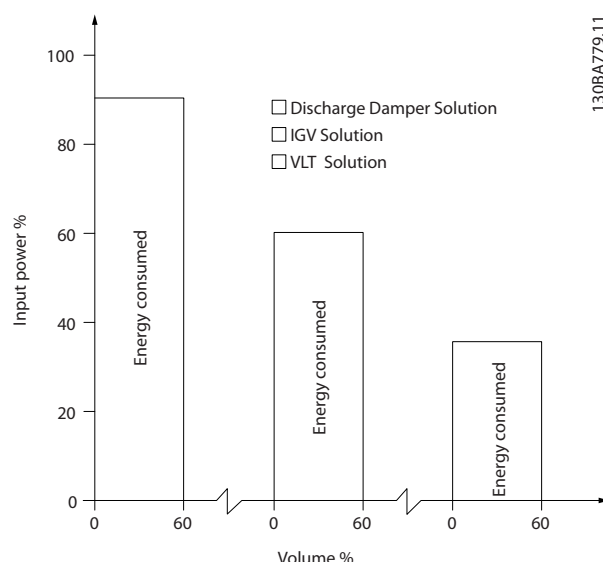
Illustration 2.5 Energy Savings

Discharge dampers reduce power consumption. Inlet Guide Vans offer a 40% reduction, but are expensive to install. The Danfoss frequency converter solution reduces energy consumption with more than 50% and is easy to install.

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2.7.5 Example with Varying Flow over 1 Year

This example is calculated based on pump characteristics obtained from a pump datasheet.
The result obtained shows energy savings in excess of 50% at the given flow distribution over a year. The pay back period depends on the price per kWh and price of frequency converter. In this example it is less than a year when compared with valves and constant speed.

Energy savings

$P_{shaft} = P_{shaft\ output}$
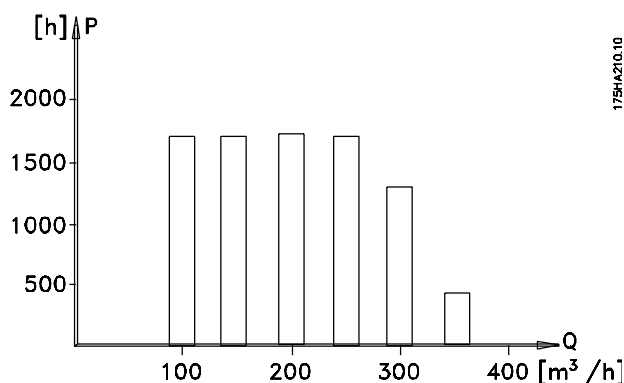
Illustration 2.6 Flow Distribution over 1 Year
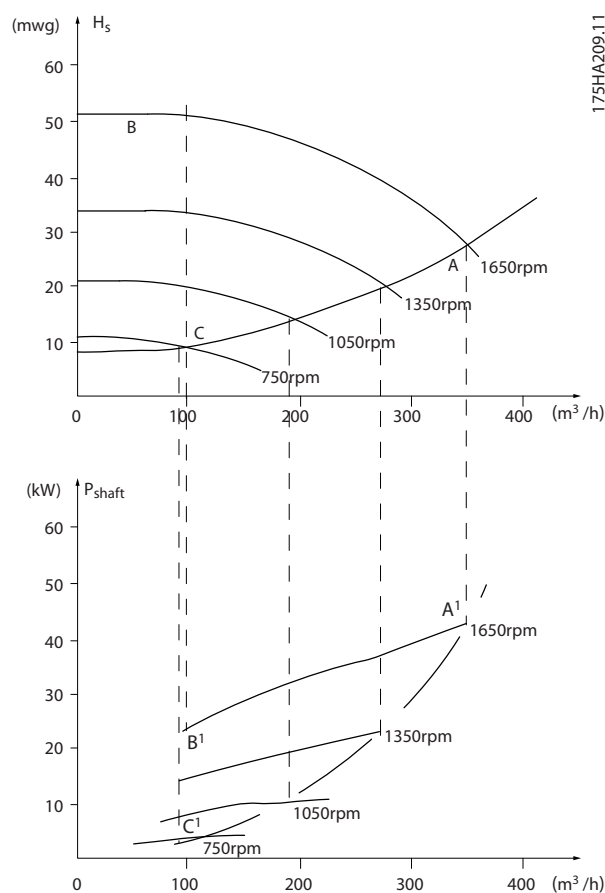
Illustration 2.7 Energy

m³/h	Distri-bution		Valve regulation		Frequency converter control	
	%	Hours	Power	Consump-tion	Power	Consump-tion
			A₁ - B₁	kWh	A₁ - C₁	kWh
350	5	438	42.5	18.615	42.5	18.615
300	15	1314	38.5	50.589	29.0	38.106
250	20	1752	35.0	61.320	18.5	32.412
200	20	1752	31.5	55.188	11.5	20.148
150	20	1752	28.0	49.056	6.5	11.388
100	20	1752	23.0	40.296	3.5	6.132
Σ	100	8760		275.064		26.801

Table 2.5 Result

2.7.6 Better Control

If a frequency converter is used for controlling the flow or pressure of a system, improved control is obtained.
A frequency converter can vary the speed of the fan or pump, obtaining variable control of flow and pressure. Furthermore, a frequency converter can quickly adapt the speed of the fan or pump to new flow or pressure conditions in the system.
Simple control of process (Flow, Level or Pressure) utilising the built-in PI control.

2.7.7 Star/Delta Starter or Soft-starter not Required

When larger motors are started, it is necessary in many countries to use equipment that limits the start-up current. In more traditional systems, a star/delta starter or soft-starter is widely used. Such motor starters are not required if a frequency converter is used.

As illustrated in *Illustration 2.8*, a frequency converter does not consume more than rated current.
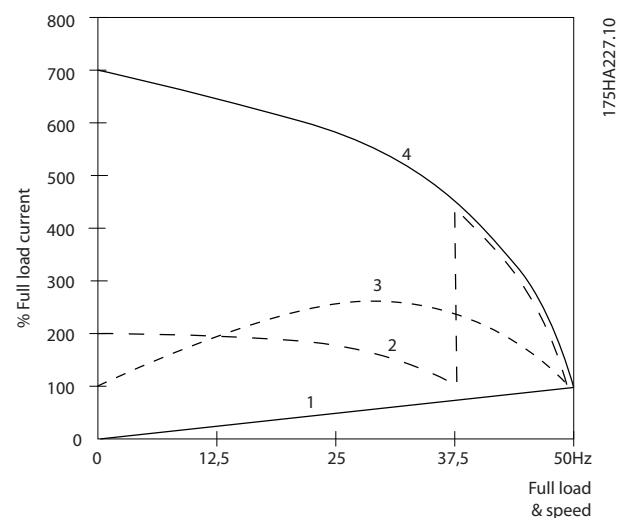
1	VLT® Micro Drive
2	Star/delta starter
3	Soft-starter
4	Start directly on mains

Illustration 2.8 Current

2.7.8 Using a Frequency Converter Saves Money

Example *chapter 2.7.9 Without a Frequency Converter* shows that a lot of equipment is not required when a frequency converter is used. It is possible to calculate the cost of installing the 2 different systems. In the example, the 2 systems can be established at roughly the same price.

2.7.9 Without a Frequency Converter
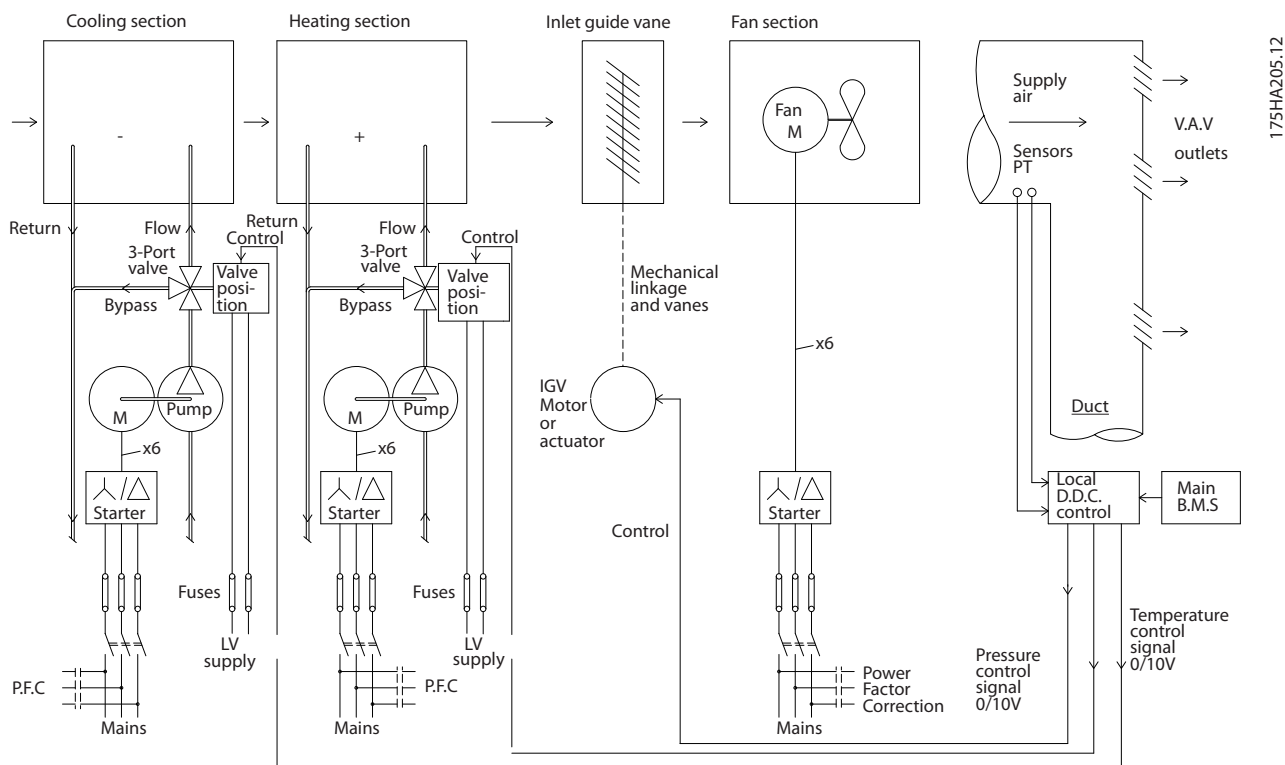
D.D.C.	Direct Digital Control
E.M.S.	Energy Management system
V.A.V.	Variable Air Volume
Sensor P	Pressure
Sensor T	Temperature

Table 2.6 Abbreviations used in *Illustration 2.9*

Illustration 2.9 Traditional Fan System

2.7.10 With a Frequency Converter
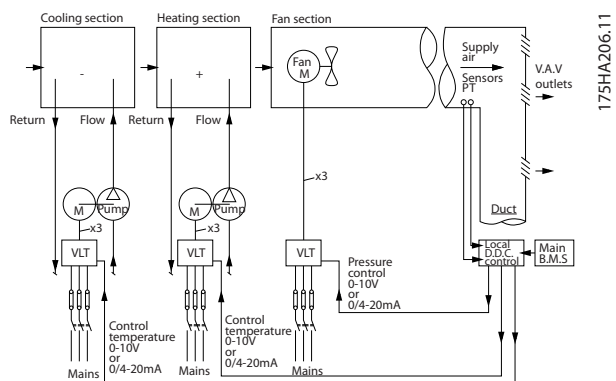
D.D.C.	Direct Digital Control
E.M.S.	Energy Management system
V.A.V.	Variable Air Volume
Sensor P	Pressure
Sensor T	Temperature

Table 2.7 Abbreviations used in *Illustration 2.10*

Illustration 2.10 Fan System Controlled by Frequency Converters

3 Product Overview

3.1 Control Structures

Select open loop or closed loop in *1-00 Configuration Mode*.

3.1.1 Control Structure Open Loop
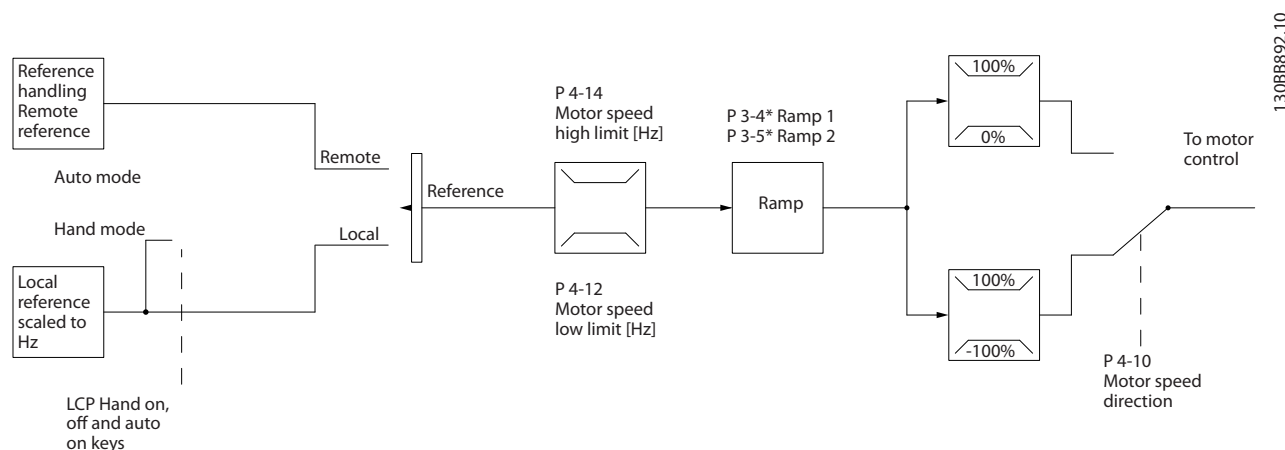
Illustration 3.1 Open Loop Structure

In the configuration shown in *Illustration 3.1*, *1-00 Configuration Mode* is set to *[0] Open loop*. The resulting reference from the reference handling system or the local reference is received and fed through the ramp limitation and speed limitation before being sent to the motor control. The output from the motor control is then limited by the maximum frequency limit.

3.1.2 Local (Hand On) and Remote (Auto On) Control

The frequency converter can be operated manually via the local control panel (LCP) or remotely via analog/digital inputs or serial bus. If allowed in *0-40 [Hand on] Key on LCP*, *0-44 [Off/Reset] Key on LCP*, and *0-42 [Auto on] Key on LCP*, it is possible to start and stop the frequency converter by LCP pressing the [Hand On] and [Off/Reset] keys. Alarms can be reset via the [Off/Reset] key. After pressing the [Hand On] key, the frequency converter goes into hand mode and follows (as default) the local reference set by using the LCP potentiometer (LCP 12) or [▲]/[▼] (LCP 11). The potentiometer can be disabled by parameter *6-80 LCP Potmeter Enable*. If the potentiometer is disabled, use the navigation keys for adjusting reference.

After pressing the [Auto On] key, the frequency converter goes into auto mode and follows (as default) the remote reference. In this mode, it is possible to control the frequency converter via the digital inputs and RS-485. See more about starting, stopping, changing ramps and parameter set-ups etc. in parameter group *5-1* Digital Inputs* or parameter group *8-5* Serial Communication*.

Illustration 3.2 LCP Control Keys

Local reference forces the configuration mode to open loop, independent on the setting of *1-00 Configuration Mode*.

Local reference is restored at power-down.

3.1.3 Control Structure Closed Loop

The internal controller allows the frequency converter to become an integral part of the controlled system. The frequency converter receives a feedback signal from a sensor in the system. It then compares this feedback to a set-point reference value and determines the error, if any, between these 2 signals. It then adjusts the speed of the motor to correct this error.

For example, consider a pump application where the speed of a pump is to be controlled so that the static pressure in a pipe is constant. The desired static pressure value is supplied to the frequency converter as the set-point reference. A static pressure sensor measures the actual static pressure in the pipe and supplies this to the frequency converter as a feedback signal. If the feedback signal is greater than the set-point reference, the frequency converter slows down to reduce the pressure. In a similar way, if the pipe pressure is lower than the set-point reference, the frequency converter automatically speed up to increase the pressure provided by the pump.
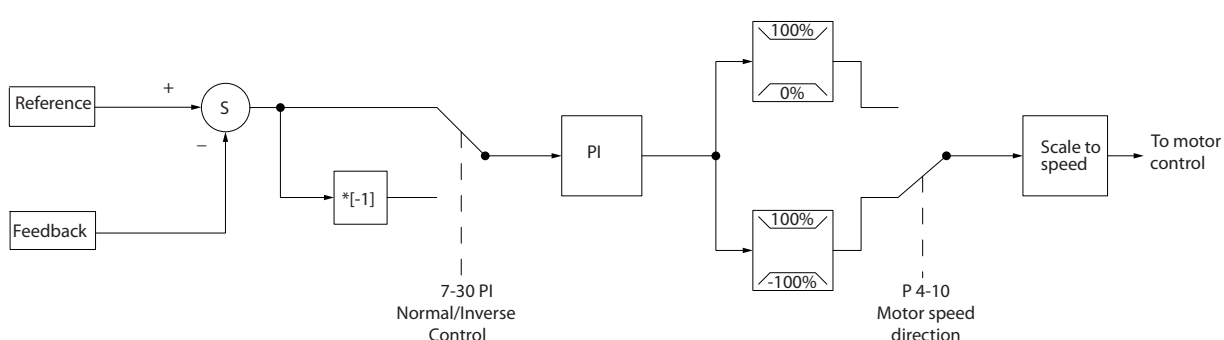
Illustration 3.3 Control Structure Closed Loop

While the default values for the frequency converter's closed loop controller often provides satisfactory performance, the control of the system can often be optimised by adjusting some of the closed loop controller's parameters.

3.1.4 Reference Handling

Details for open loop and closed loop operation.
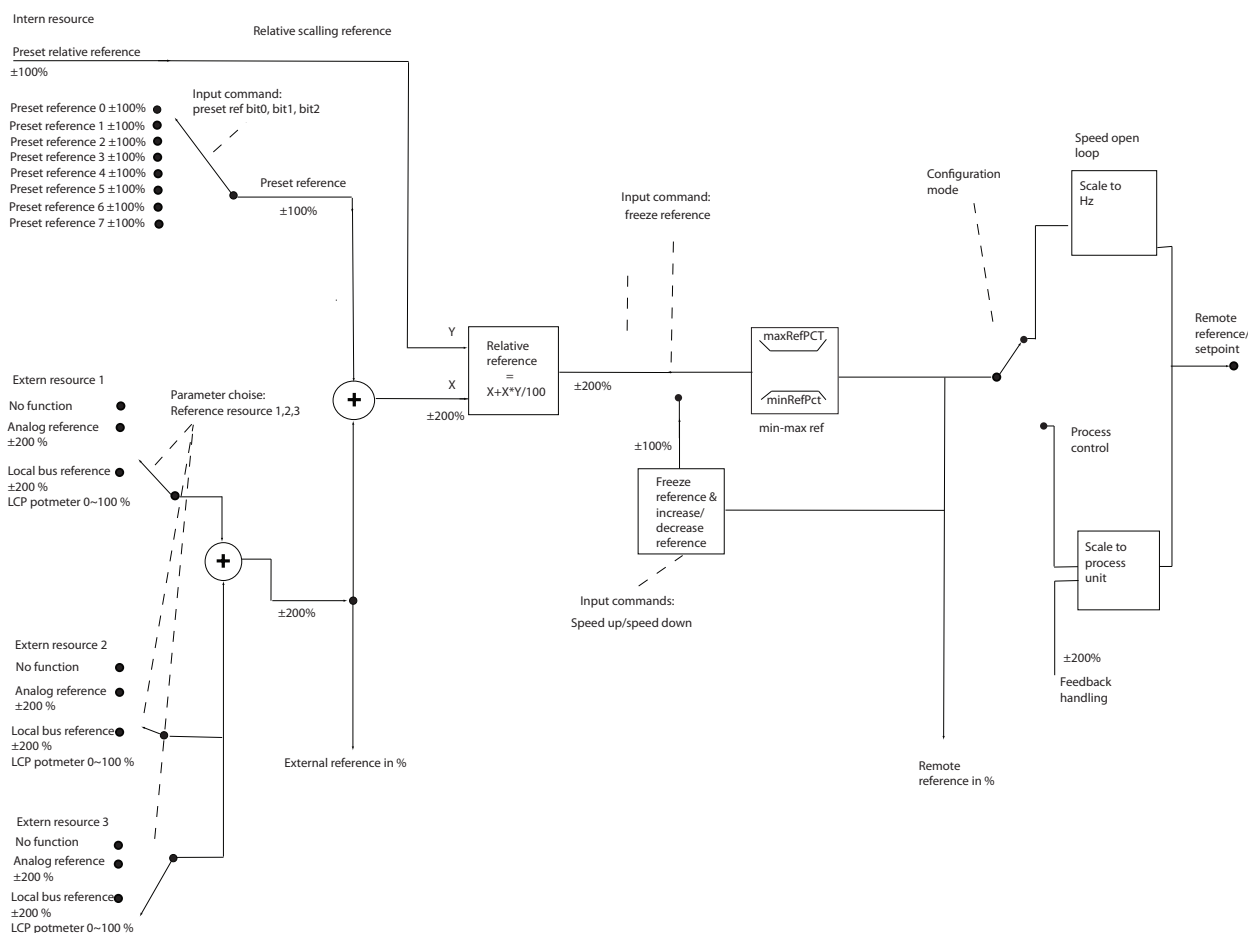
Illustration 3.4 Block Diagram Showing Remote Reference

The remote reference is comprised of:

- Preset references

- External references (analog inputs and serial communication bus references)

- The preset relative reference

- Feedback controlled setpoint

Up to 8 preset references can be programmed in the frequency converter. The active preset reference can be selected using digital inputs or the serial communications bus. The reference can also be supplied externally, most commonly from an analog input. This external source is selected by one of the 3 Reference Source parameters (*3-15 Reference 1 Source*, *3-16 Reference 2 Source* and *3-17 Reference 3 Source*). All reference resources and the bus reference are added to produce the total external reference. The external reference, the preset reference or the sum of the 2 can be selected to be the active reference. Finally, this reference can by be scaled using *3-14 Preset Relative Reference*.

The scaled reference is calculated as follows:

$$Reference = X + X \times \left(\frac{Y}{100}\right)$$

Where X is the external reference, the preset reference or the sum of these and Y is *3-14 Preset Relative Reference* in [%].

If Y, *3-14 Preset Relative Reference*, is set to 0%, the reference is not affected by the scaling.

3.2 General Aspects of EMC

Electrical interference is usually conducted at frequencies in the range 150 kHz to 30 MHz. Airborne interference from the frequency converter system in the range 30 MHz to 1 GHz is generated from the inverter, motor cable, and the motor. As shown in *Illustration 3.5*, capacitance in the motor cable coupled with a high dU/dt from the motor voltage generate leakage currents.

The use of a screened motor cable increases the leakage current (see *Illustration 3.5*) because screened cables have higher capacitance to ground than unscreened cables. If the leakage current is not filtered, it causes greater interference on the mains in the radio frequency range below approximately 5 MHz. Since the leakage current (I_1) is carried back to the unit through the screen (I_3), there is in principle only a small electro-magnetic field (I_4) from the screened motor cable according to *Illustration 3.5*.

The screen reduces the radiated interference, but increases the low-frequency interference on the mains. Connect the motor cable screen to the frequency converter enclosure as well as on the motor enclosure. This is best done by using integrated screen clamps so as to avoid twisted screen ends (pigtails). Pigtails increase the screen impedance at higher frequencies, which reduces the screen effect and increases the leakage current (I_4).

If a screened cable is used for relay, control cable, signal interface and brake, mount the screen on the enclosure at both ends. In some situations, however, it is necessary to break the screen to avoid current loops.
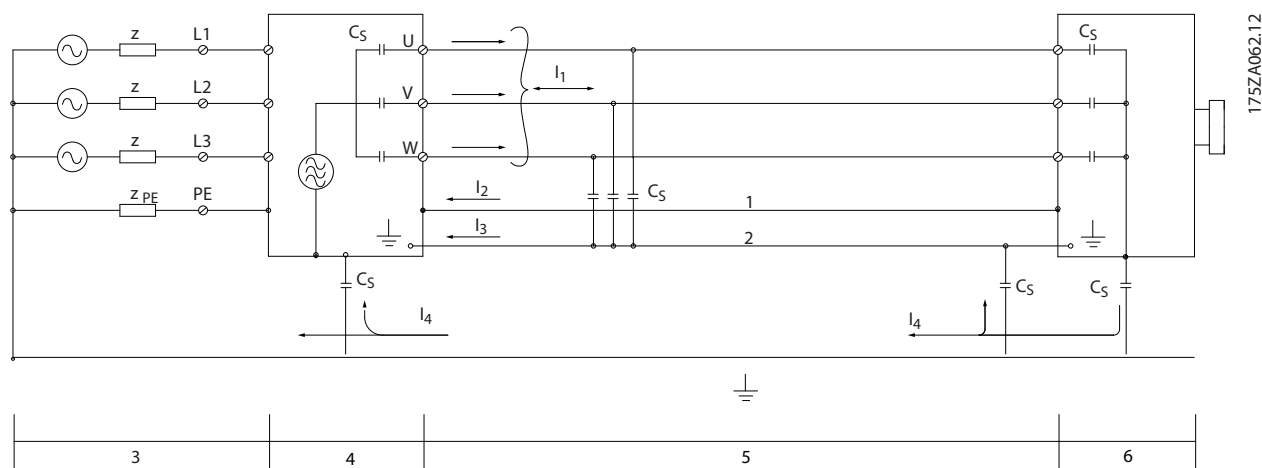
1	Ground wire	4	Frequency converter
2	Screen	5	Screened motor cable
3	AC mains supply	6	Motor

Illustration 3.5 Situation that Generates Leakage Currents

If the screen is to be placed on a mounting plate for the frequency converter, the mounting plate must be made of metal, to convey the screen currents back to the unit. Moreover, ensure good electrical contact from the mounting plate through the mounting screws to the frequency converter chassis.

When unscreened cables are used, some emission requirements are not complied with, although most immunity requirements are observed.

To reduce the interference level from the entire system (unit+installation), make motor and brake cables as short as possible. Avoid placing cables with a sensitive signal level alongside motor and brake cables. Radio interference higher than 50 MHz (airborne) is especially generated by the control electronics.

3.2.1 Emission Requirements

The EMC product standard for frequency converters defines 4 categories (C1, C2, C3 and C4) with specified requirements for emission and immunity. *Table 3.1* states the definition of the 4 categories and the equivalent classification from EN 55011.

Category	Definition	Equivalent emission class in EN 55011
C1	Frequency converters installed in the first environment (home and office) with a supply voltage less than 1000 V.	Class B
C2	Frequency converters installed in the first environment (home and office) with a supply voltage less than 1000 V, which are neither plug-in nor movable and are intended to be installed and commissioned by a professional.	Class A Group 1
C3	Frequency converters installed in the second environment (industrial) with a supply voltage lower than 1000 V.	Class A Group 2
C4	Frequency converters installed in the second environment with a supply voltage equal to or above 1000 V or rated current equal to or above 400 A or intended for use in complex systems.	No limit line. An EMC plan should be made.

Table 3.1 Correlation between IEC 61800-3 and EN 55011

When the generic (conducted) emission standards are used, the frequency converters are required to comply with the limits in *Table 3.2*.

Environment	Generic emission standard	Equivalent emission class in EN 55011
First environment (home and office)	EN/IEC 61000-6-3 Emission standard for residential, commercial and light industrial environments.	Class B
Second environment (industrial environment)	EN/IEC 61000-6-4 Emission standard for industrial environments.	Class A Group 1

Table 3.2 Correlation between Generic Emission Standards and EN 55011

3.2.2 EMC Test Results (Emission)

Drive type	Conducted emission. Maximum shielded cable length [m]						Radiated emission			
	Industrial environment				Housing, trades and light industries		Industrial environment			
	EN 55011 Class A2		EN 55011 Class A1		EN 55011 Class B		EN 55011 Class A2		EN 55011 Class A1	
	Without external filter	With external filter	Without external filter	With external filter	Without external filter	With external filter	Without external filter	With external filter	Without external filter	With external filter
≤2.2 kW. Single phase, 230 V	25	-	15	50	5	15	Yes	-	No	Yes
≤7.5 kW. Up to 500 V AC, 3 phase	25	-	15	50	-	15	Yes	-	No	Yes
11 kW to 22 kW. Up to 500 V AC, 3 phase	25	-	15	50	-	15	Yes	-	No	Yes

Table 3.3 EMC Test Result

3.2.3 Harmonics Emission Requirements

Equipment connected to the public supply network

⚠WARNING

Cannot comply, only with power option

Options	Definition
1	IEC/EN 61000-3-2 Class A for 3-phase balanced equipment (for professional equipment only up to 1 kW total power).
2	IEC/EN 61000-3-12 Equipment 16 A-75 A and professional equipment as from 1 kW up to 16 A phase current.

Table 3.4 Harmonics Emission Requirements

3.2.4 Immunity Requirements

The immunity requirements for frequency converters depend on the environment where they are installed. The requirements for the industrial environment are higher than the requirements for the home and office environment. All Danfoss frequency converters comply with the requirements for the industrial environment and consequently comply also with the lower requirements for home and office environment with a large safety margin.

3.3 Galvanic Isolation (PELV)

3.3.1 PELV - Protective Extra Low Voltage

PELV offers protection by way of extra low voltage. Protection against electric shock is ensured when the electrical supply is of the PELV type and the installation is made as described in local/national regulations on PELV supplies.

All control terminals and relay terminals 01-03/04-06 comply with PELV (Protective Extra Low Voltage) (Does not apply to grounded Delta leg above 440 V).

Galvanic (ensured) isolation is obtained by fulfilling requirements for higher isolation and by providing the relevant creapage/clearance distances. These requirements are described in the EN 61800-5-1 standard.

The components that make up the electrical isolation, as described, also comply with the requirements for higher isolation and the relevant test as described in EN 61800-5-1.
The PELV galvanic isolation can be shown in *Illustration 3.7*.

To maintain PELV all connections made to the control terminals must be PELV, e.g. thermistor must be reinforced/double insulated.

0.25-22 kW
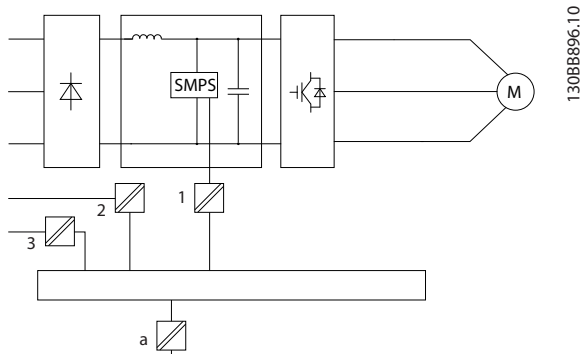
1	Power supply (SMPS)
2	Optocouplers, communication between AOC and BOC
3	Custom relays
a	Control card terminals

Illustration 3.6 Galvanic Isolation

30-90 kW
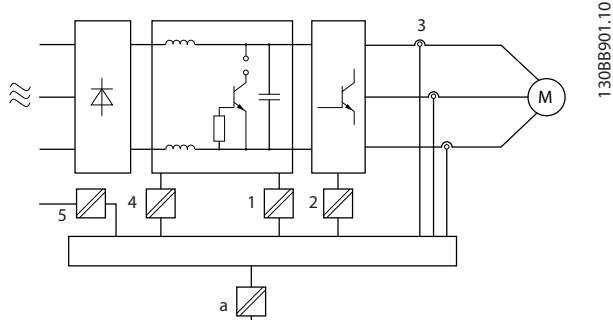
1	Power supply (SMPS) incl. signal isolation of UDC, indicating the intermediate current voltage
2	Gate drive that runs the IGBTs (trigger transformers/opto-couplers)
3	Current transducers
4	Internal soft-charge, RFI and temperature measurement circuits
5	Custom relays
a	Control card terminals

Illustration 3.7 Galvanic Isolation

The functional galvanic isolation (see *Illustration 3.6*) is for the RS-485 standard bus interface.

⚠**CAUTION**

Installation at high altitude:
At altitudes above 2,000 m, contact Danfoss regarding PELV.

3.4 Earth Leakage Current

⚠**WARNING**

DISCHARGE TIME
Touching the electrical parts could be fatal - even after the equipment has been disconnected from mains.
Also make sure that other voltage inputs have been disconnected, such as load sharing (linkage of DC intermediate circuit), as well as the motor connection for kinetic back-up.
Before touching any electrical parts, wait at least the amount of time indicated in *Table 2.1*.
Shorter time is allowed only if indicated on the nameplate for the specific unit.

NOTICE

Leakage Current
The earth leakage current from the frequency converter exceeds 3.5 mA. To ensure that the ground cable has a good mechanical connection to the ground connection, the cable cross section must be at least 10 mm² Cu or 16 mm² Al or 2 rated earth wires terminated separately.
Residual Current Device protection RCD
This product can cause a DC current in the protective conductor. Where a residual current device (RCD) is used for protection in case of direct or indirect contact, only an RCD of Type B is allowed on the supply side of this product. Otherwise, another protective measure shall be applied, such as separation from the environment by double or reinforced insulation, or isolation from the supply system by a transformer. See also Application Note *Protection against Electrical Hazards, MN90G*.
Protective earthing of the frequency converter and the use of RCDs must always follow national and local regulations.

3.5 Extreme Running Conditions

Short circuit (motor phase – phase)
Current measurement in each of the 3 motor phases or in the DC-link, protects the frequency converter against short circuts. A short circuit between 2 output phases causes an overcurrent in the inverter. The inverter is turned off individually when the short circuit current exceeds the permitted value (Alarm 16 Trip Lock).
For information about protecting the frequency converter against a short circuit at the load sharing and brake outputs, see the design guidelines.

Switching on the output
Switching on the output between the motor and the frequency converter is fully permitted. The frequency converter is not damaged in any way by switching on the output. However, fault messages may appear.

3

Motor-generated over-voltage

The voltage in the intermediate circuit is increased when the motor acts as a generator. This occurs in following cases:

- The load drives the motor (at constant output frequency from the frequency converter), that is the load generates energy.

- During deceleration ("ramp-down") if the moment of inertia is high, the friction is low and the ramp-down time is too short for the energy to be dissipated as a loss in the frequency converter, the motor and the installation.

- Incorrect slip compensation setting (*1-62 Slip Compensation*) may cause higher DC link voltage.

The control unit may attempt to correct the ramp if possible (*2-17 Over-voltage Control*.)
The inverter turns off to protect the transistors and the intermediate circuit capacitors when a certain voltage level is reached.

Mains drop-out

During a mains drop-out, the frequency converter keeps running until the intermediate circuit voltage drops below the minimum stop level, which is typically 15% below the frequency converter's lowest rated supply voltage. The mains voltage before the drop-out and the motor load determines how long it takes for the frequency converter to coast.

3.5.1 Motor Thermal Protection

Motor thermal protection can be provided in 2 ways.

One method uses a motor thermistor, via one of the following

- Thermistor input on a standard AI

- Sensor input MCB 114

- PTC Thermistor input MCB 112

The frequency converter monitors motor temperature as the speed and load vary to detect overheating conditions.

The other method calculates motor temperature by measuring current, frequency, and operating time. The converter displays the thermal load on the motor in percentage and can issue a warning at a programmable overload setpoint. Programmable options at the overload allow the frequency converter to stop the motor, reduce output, or ignore the condition. Even at low speeds, the frequency converter meets I2t Class 20 electronic motor overload standards.
This method is called Electronic Thermal Relay (ETR).
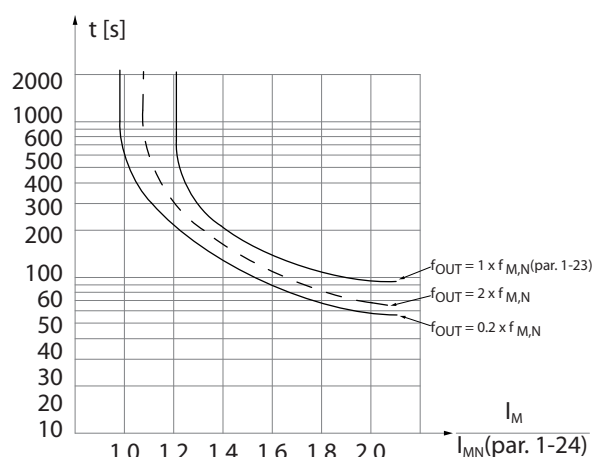
Illustration 3.8 ETR Characteristics

The X-axis shows the ratio between I_{motor} and I_{motor} nominal. The Y- axis shows the time in seconds before the ETR cut of and trips the frequency converter. The curves show the characteristic nominal speed, at twice the nominal speed and at 0,2 x the nominal speed.
At lower speed, the ETR cuts off at lower heat due to less cooling of the motor. In that way, the motor is protected from being over heated even at low speed. The ETR feature is calculating the motor temperature based on actual current and speed. The calculated temperature is visible as a read out parameter in *16-18 Motor Thermal* in the product specific *Programming Guide*.
A special version of the ETR is also available for EX-e motors in ATEX areas. This function makes it possible to enter a specific curve to protect the Ex-e motor. The *Programming Guide* takes the user through the set-up.

4 Selection

4.1 Options and Accessories

4.1.1 Local Control Panel (LCP)

For detailed information on programming, see *VLT® Micro Drive FC 51Programming Guide*.

NOTICE

The frequency converter can also be programmed from a PC via RS-485 com-port by installing the MCT 10 Set-up Software.
This software can either be ordered using code number 130B1000 or downloaded from the DanfossWeb site:
www.danfoss.com/BusinessAreas/DrivesSolutions/software-download
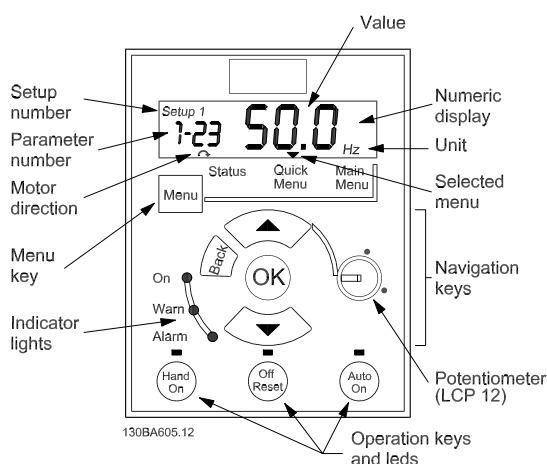
Illustration 4.1 Description of LCP Keys and Display

Press [Menu] to select one of the following menus:

Status:
For readouts only.

Quick Menu:
For access to Quick Menus 1 and 2.

Main Menu:
For access to all parameters.

Navigation Keys:
[Back]: For moving to the previous step or layer in the navigation structure.
[▲] [▼]: For maneuvering between parameter groups, parameters and within parameters.
[OK]: For selecting a parameter and for accepting changes to parameter settings.

Operation Keys:
A yellow light above the operation keys indicates the active key.
[Hand On]: Starts the motor and enables control of the frequency converter via the LCP.
[Off/Reset]: Stops the motor (off). If in alarm mode the alarm is reset.
[Auto On]: The frequency converter is controlled either via control terminals or serial communication.
[Potentiometer] (LCP 12): The potentiometer works in 2 ways depending on the mode in which the frequency converter is running.
In *Auto Mode* the potentiometer acts as an extra programmable analog input.
In *Hand on Mode* the potentiometer controls local reference.

4.1.2 Remote Mounting Kit for LCP

The LCP can be moved to the front of a cabinet by using the remote built-in kit. The enclosure is IP55.

Enclosure	IP55 front
Max. cable length between LCP and unit:	3 m
Communication std:	RS-485
Ordering no.	132B0102

Table 4.1 Technical Data

4.1.3 FC 51 LCP Mounting Instruction

Step 1

Place the bottom of the LCP in the frequency converter.
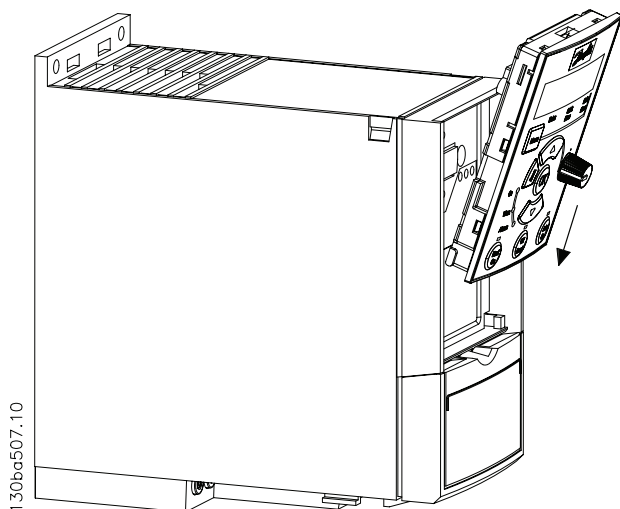
Illustration 4.2 Place the LCP in the Frequency Converter

Step 2

Push the top of the LCP into the frequency converter.
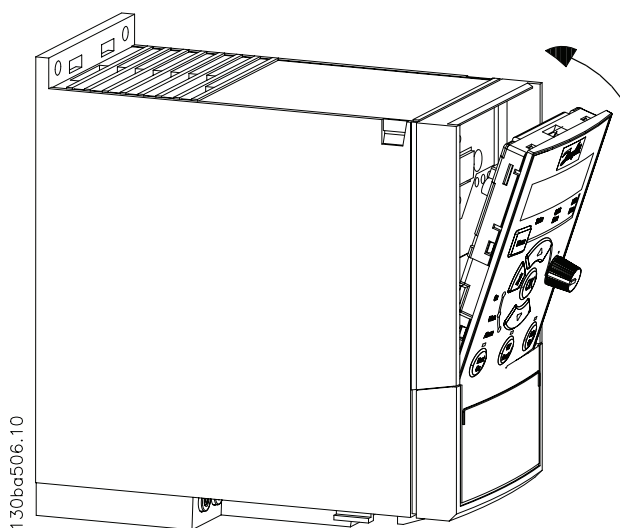
Illustration 4.3 Push the Top of the LCP into Place

4.1.4 FC 51 Remote Mounting Kit Mounting Instruction

Step 1

Fit gasket on LCP in the frequency converter.
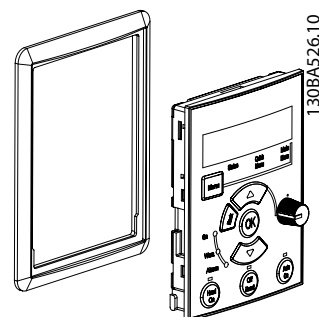
Illustration 4.4 Fit Gasket on LCP

Step 2

Place LCP on panel - see dimensions of hole on drawing.
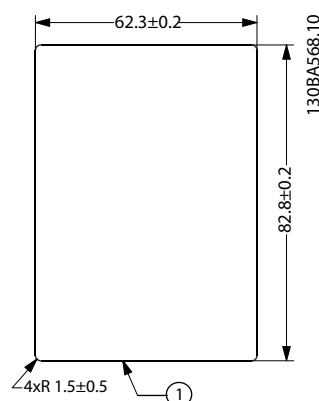
Illustration 4.5 Dimensions of Hole
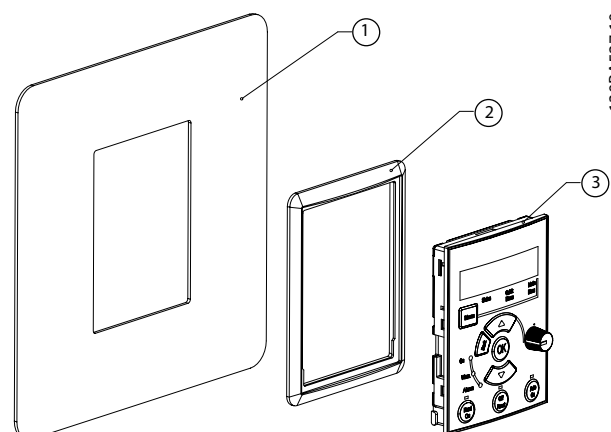
Illustration 4.6 Panel, Gasket and LCP

Step 3

Place the bracket on the back of the LCP, then slide down. Tighten screws and connect the cable to the LCP.

NOTICE

Use the provided thread cutting screws to fasten the connector to the LCP. Tightening torque: 1.3 Nm.

Illustration 4.7 Place the Bracket on LCP
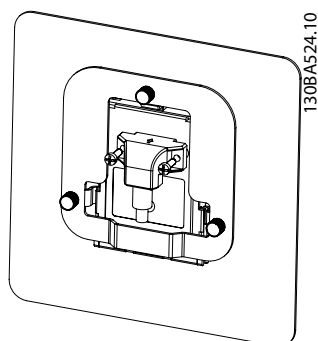
Illustration 4.8 Tighten Screws and Connect Cable to LCP

Step 4

Connect the cable to the frequency converter.

NOTICE

Use the provided thread cutting screws to fasten connector to the frequency converter. Tightening torque: 1.3 Nm.
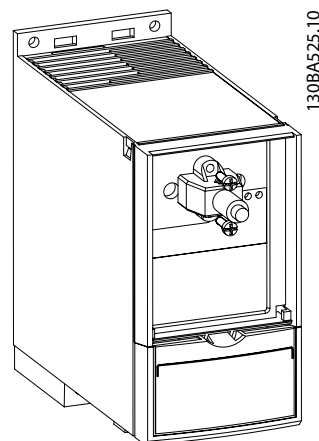
Illustration 4.9 Connect Cable to the Frequency Converter

4.1.5 IP21/TYPE 1 Enclosure Kit

Frame	IP class	Power [kW]			Height [mm]	Width [mm]	Depth [mm]	Ordering no.
		1x200-240 V	3x200-240 V	3x380-480 V	A	B	C	
M1	IP21	0.18-0.75	0.25-0.75	0.37-0.75	219.3	73	155.9	132B0108
M2	IP21	1.5	1.5	1.5-2.2	245.6	78	175.4	132B0109
M3	IP21	2.2	2.2-3.7	3.0-7.5	297.5	95	201.4	132B0110
M4	IP21	-	-	11-15	-	-	-	-
M5	IP21	-	-	18.5-22	-	-	-	-

Table 4.2 IP21/TYPE 1 Enclosure Kit

4.1.6 Type 1 (NEMA)

Frame	IP class	Power [kW]			Height [mm]	Width [mm]	Depth [mm]	Ordering no.
		1x200-240 V	3x200-240 V	3x380-480 V	A	B	C	
M1	IP20	0.18-0.75	0.25-0.75	0.37-0.75	194.3	70.0	155.9	132B0103
M2	IP20	1.5	1.5	1.5-2.2	220.6	75.0	175.4	132B0104
M3	IP20	2.2	2.2-3.7	3.0-7.5	282.5	90.0	201.3	132B0105
M4	IP20	-	-	11-15	345.6	125.0	248.5	132B0120
M5	IP20	-	-	18.5-22	385.5	165.0	248.2	132B0121

Table 4.3 Type 1 (NEMA)

4.1.7 De-Coupling

Frame	IP class	Power [kW]			Height [mm]	Width [mm]	Depth [mm]	Ordering no.
		1x200-240 V	3x200-240 V	3x380-480 V	A	B	C	
M1	IP20	0.18-0.75	0.25-0.75	0.37-0.75	204.2	70.0	155.9	132B0106
M2	IP20	1.5	1.5	1.5-2.2	230.0	75.0	175.4	132B0106
M3	IP20	2.2	2.2-3.7	3.0-7.5	218.5	90.0	201.3	132B0107
M4	IP20	-	-	11-15	347.5	125.0	248.5	132B0122
M5	IP20	-	-	18.5-22	387.5	165.0	248.2	132B0122

Table 4.4 De-Coupling

4

4.1.8 FC 51 Type 1 Kit Mounting Instruction for M1, M2 and M3

Step 1

Mount metal plate on frequency converter and tighten the screws. Tightening torque: 2 Nm.

M1	4 x ½"
M2	5 x ½ "
M3	2 x ½"
	3 x 3/4"

Table 4.5 Conduit Sizes
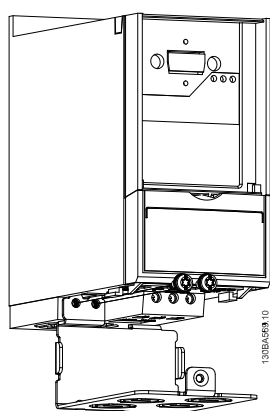
Illustration 4.10 Mount Metal Plate on Frequency Converter

Step 2

Fit bottom cover on frequency converter and tighten screw.

Illustration 4.11 Fit Bottom Cover on Frequency Converter

4.1.9 FC 51 Type 1 Kit Mounting Instruction for M4 and M5

Step 1

Mount metal plate on frequency converter and tighten the screws. Tightening torque: 2 Nm.

M4	3x½"
M5	3x1"

Table 4.6 Conduit Sizes

Illustration 4.12 Mount Metal Plate on Frequency Converter

Step 2

Fit bottom cover on frequency converter and tighten screw.
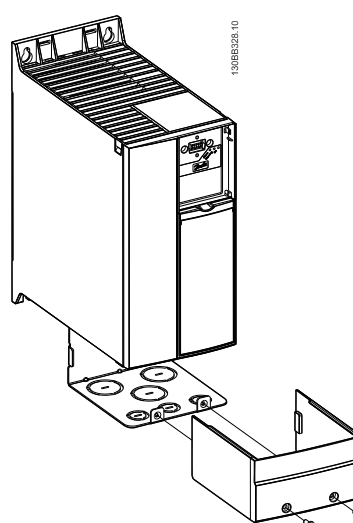
Illustration 4.13 Fit Bottom Cover on Frequency Converter

4.1.10 FC 51 IP21 Kit Mounting Instruction

Step 1

Fit top cover on frequency converter.
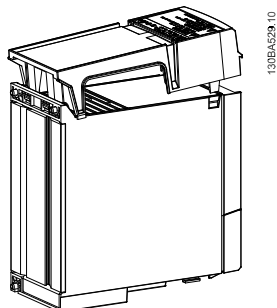
Illustration 4.14 Fit Top Cover on Frequency Converter

Step 2

Remove knock-outs on metal plate and fit rubber grommets.
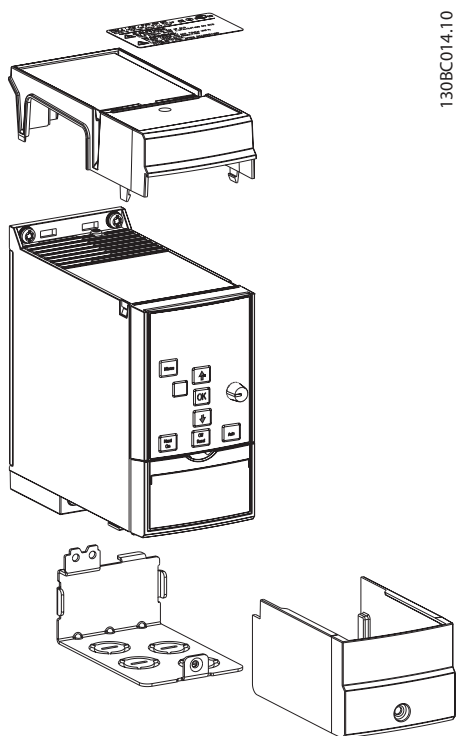
Illustration 4.15 Remove Knock-outs and Fit Rubber Grommets

Step 3

Mount metal plate on frequency converter and tighten screws. Tightening torque: 2 Nm.
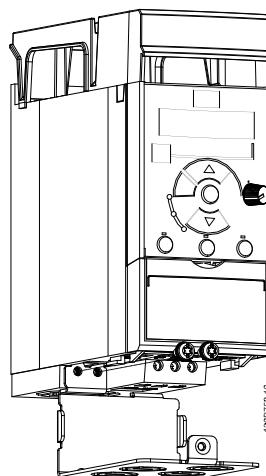
Illustration 4.16 Mount Metal Plate on Frequency Converter

Step 4

Fit bottom cover on frequency converter and tighten screw.

NOTICE

IP21 is only achieved with LCP 11 or LCP 12 mounted.
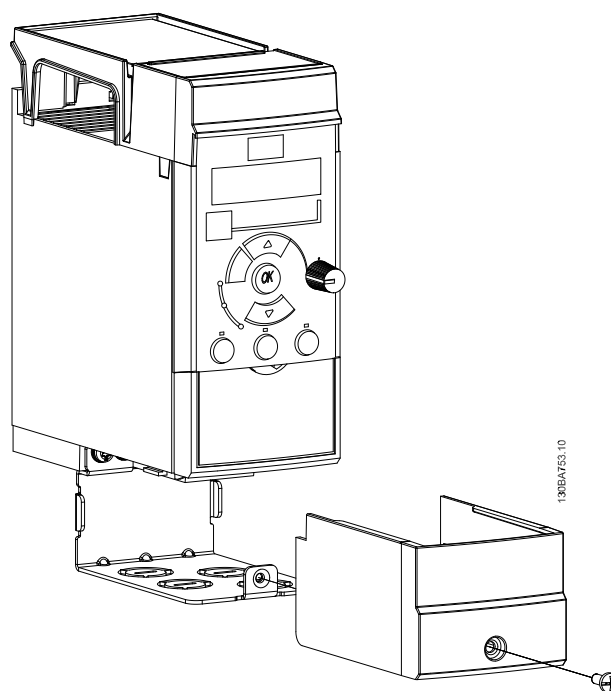
Illustration 4.17 Fit Bottom Cover on Frequency Converter

4.1.11 FC 51 De-coupling Plate Mounting Instruction for M1 and M2

Step 1

Mount metal plate on frequency converter and fasten with two screws. Tightening torque: 2 Nm.
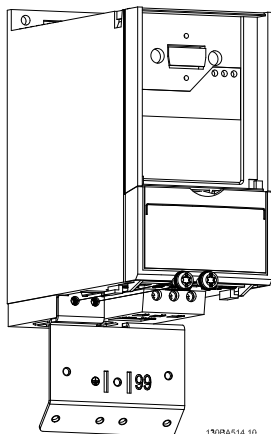
Illustration 4.18 Mount Metal Plate

Step 2

Mount bracket on de-coupling plate.
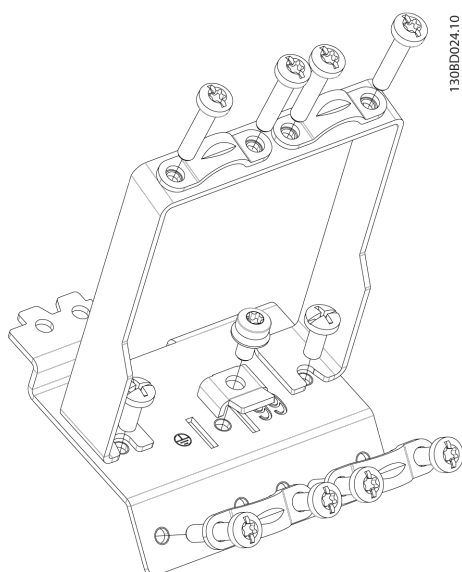
Illustration 4.19 Mount Bracket

Step 3

De-coupling plate mounted.
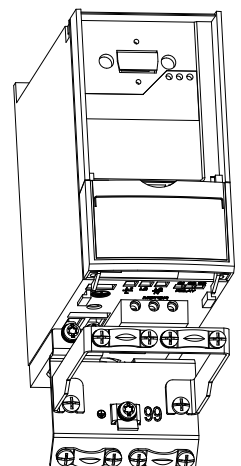
Illustration 4.20 De-coupling Plate Mounted

4.1.12 FC 51 De-coupling Plate Mounting Instruction for M3

Step 1

Mount de-coupling plate on frequency converter and fasten with 2 screws. Tightening torque: 2 Nm.

Illustration 4.21 Mount De-coupling Plate
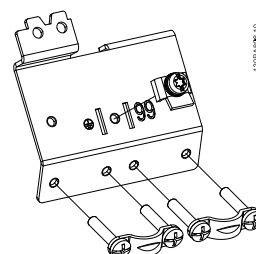
Illustration 4.22 Fasten with Screws

Step 2

De-coupling plate mounted.
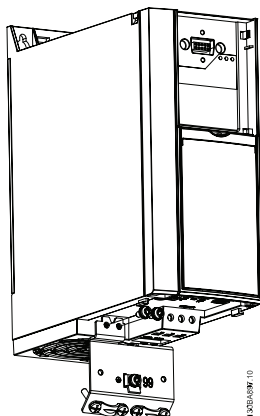
Illustration 4.23 De-coupling Plate Mounted

4.1.13 FC 51 De-coupling Plate Mounting Instruction for M4 and M5

Step 1

Mount metal plate on frequency converter and fasten with 2 screws. Tightening torque: 2 Nm.
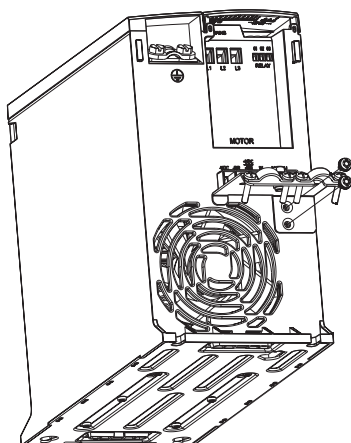
Illustration 4.24 Mount Metal Plate

Step 2

De-coupling plate mounted.
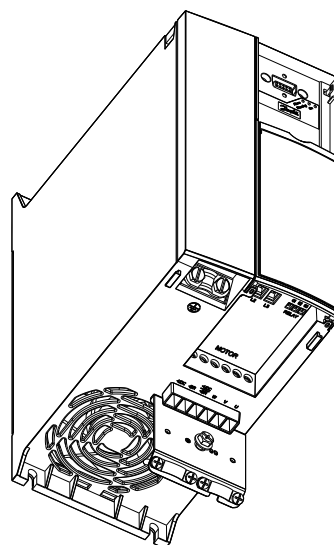
Illustration 4.25 De-coupling Plate Mounted

Step 3

Mount bracket on de-coupling plate.
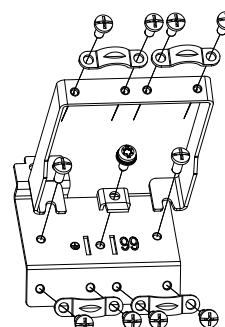
Illustration 4.26 Mount Bracket

4.1.14 FC 51 DIN Rail Kit Mounting Instruction

Step 1

Mount plastic part on frequency converter.
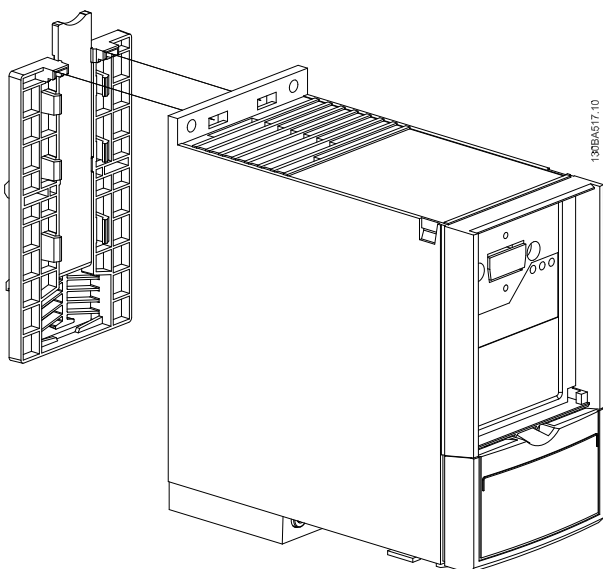
Illustration 4.27 Mount Plastic Part

Step 2

Fit frequency converter on DIN rail (Din Rail kit is only for M1 and M2).
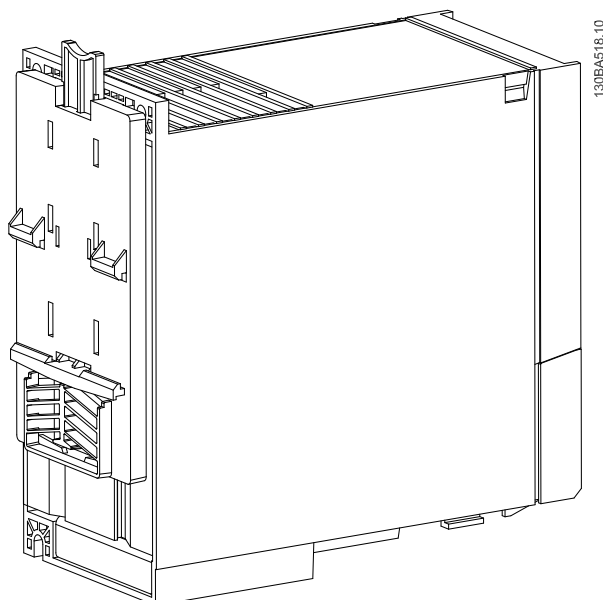
Illustration 4.28 Fit Frequency Converter on DIN Rail

4.1.15 Line Filter MCC 107 Installation Instructions

Line filters of the type MCC 107 combine a harmonic filter and an EMC filter. The line filters improve performance of the line current to the frequency converter. The 3 different line filter frame sizes correspond to the VLT® Micro Drive enclosure types M1, M2 and M3.
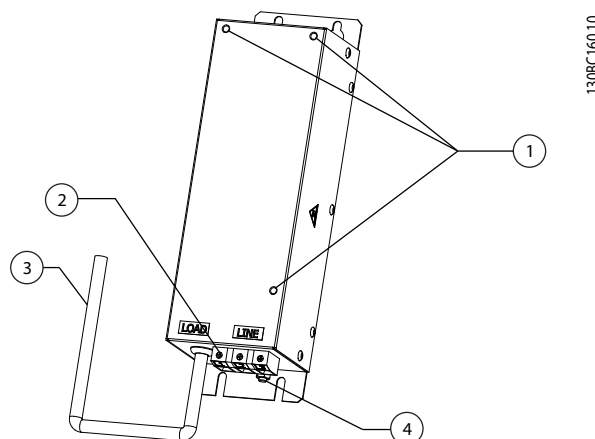
1	Mounting holes for frequency converter
2	Input terminal
3	Output line
4	Protective earth (PE)

Illustration 4.29 Line Filter MCC 107 with Micro Drive FC 51

⚠CAUTION

Hot surfaces

Risk of high surface temperatures.

- **Do NOT touch the line filter during operation or wear protective gloves**

⚠WARNING

High voltage

Risk of electric shock.

- **Never carry out maintenance work on the line filter during operation. Wait at least 4 minutes after the equipment has been disconnected from the frequency converter before touching any potentially live parts.**

NOTICE

- **Never repair a defective filter**

4.1.16 Mounting

There are 2 options for mounting the line filter correctly:

1. Front mounting

- Mount the filter in a vertical position with the terminals at the bottom.

- Mount the frequency converter on the front of the line filter using 3 M4 bolts.
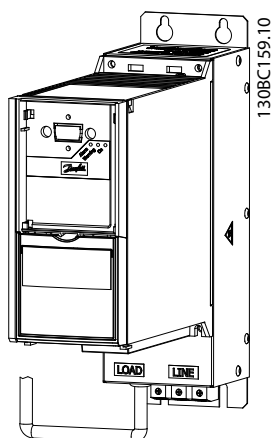
Illustration 4.30 Line Filter with Frequency Converter

- Ensure metal-to-metal contact between filter and frequency converter.

NOTICE

Metal-to-metal contact improves EMC performance and enables the baseplate of the frequency converter to function as heat sink for the line filter

2. Side mounting

- Mount the filter side-by-side with the frequency converter.
  There is no requirement for spacing between filter and frequency converter.

- Mount the back of the line filter to a cooling surface, such as a metal wall. Alternatively, derate the line filter by one size: For example use a 0.75 kW line filter with a 0.37 kW Micro Drive.

⚠CAUTION

High temperatures
Risk of fire or device damage

- **Do not mount the line filter in close proximity to other heating elements or heat-sensitive material (such as wood).**

4.1.17 Wiring

⚠WARNING

Risk of electrical shock due to high leakage currents

- **Do not power up the line filter before it is connected to protective earth (PE)**

1. Connect line filter to protective earth (PE). Use a cabinet mounting panel or similar to achieve optimum earthing conditions.

2. Connect input terminal to mains power (cable not supplied)

3. Connect output cable to the input terminals of the frequency converter

4. Ensure solid electrical contact between line filter and frequency converter (high frequency earthing)
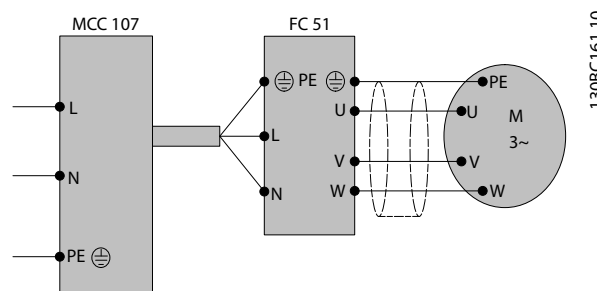
Illustration 4.31 Line 1
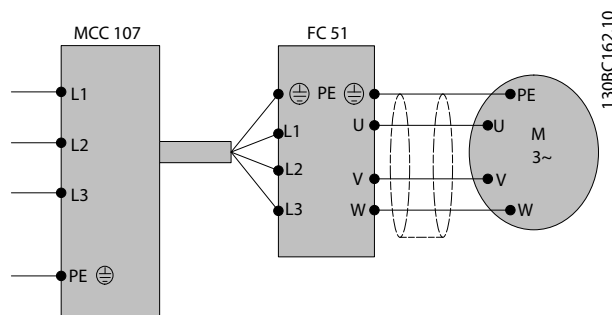
Illustration 4.32 Line 2

NOTICE

- Reduce common mode interferences by establishing a low impedance current path to the frequency converter.

- To ensure optimum EMC performance, use a De-Coupling plate kit (ordering numbers 132B0106 or 132B0107)

For voltage rating, wire size and fuse selection, see the *VLT® Micro Drive Quick Guide*.

4.1.18 Dimensions
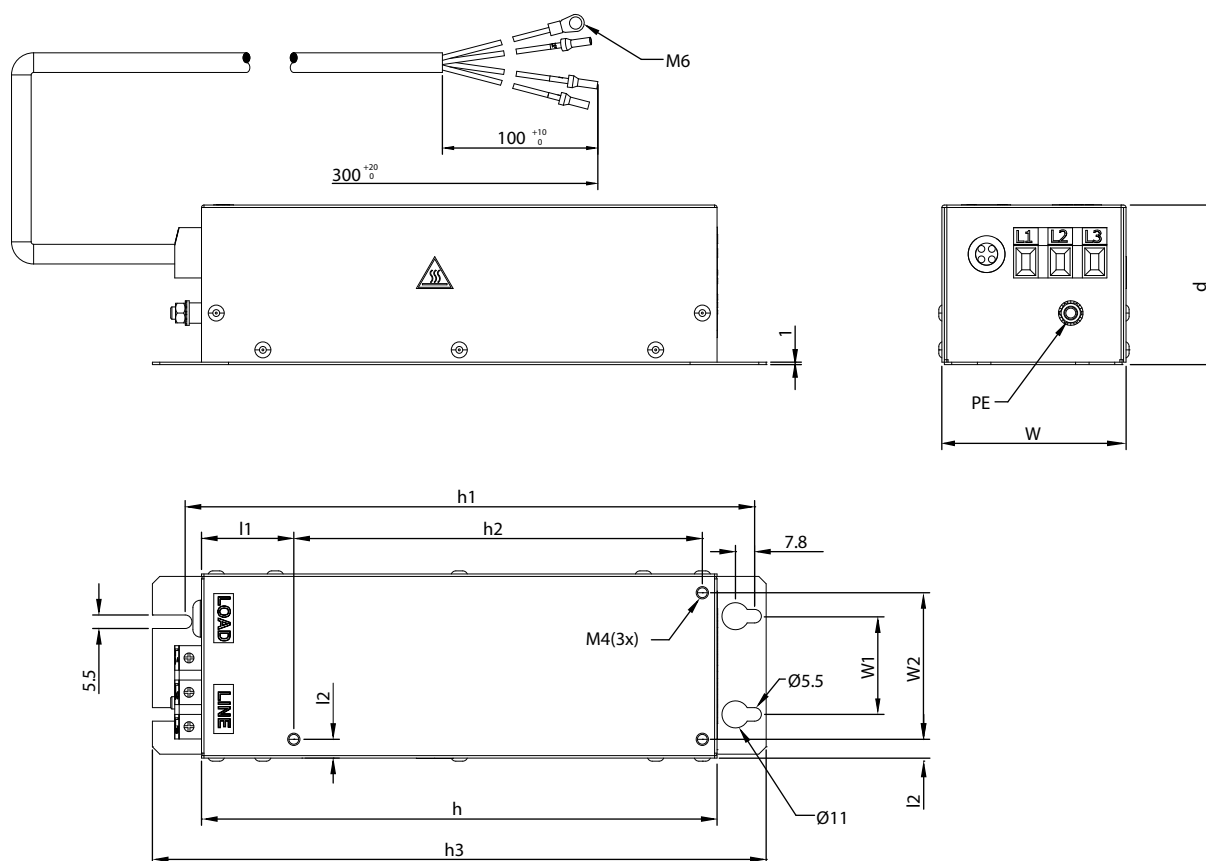
Frame	M1	M2	M3
w [mm]	70	75	90
d [mm]	55	65	69
h [mm]	190	210	300
h3 [mm]	230	250	340
w1 [mm]	40	40	55.6
h1 [mm]	213	233	323
w2 [mm]	55	59	69
h2 [mm]	140	166.5	226
l1 [mm]	45	38.5	68
l2 [mm]	7.6	8	9.3
PE (metric)	M6	M6	M6
Weight [kg]	2	3	5

Table 4.7 Dimension Data

Illustration 4.33 Dimensions

4.2 Special Conditions

4.2.1 Purpose of Derating

Take the purpose of derating into account when using the frequency converter at low air pressure (heights), at low speeds, with long motor cables, cables with a large cross section or at high ambient temperature. The required action is described in this section.

4.2.2 Derating for Ambient Temperature

Derating for ambient temperature and IGBT Switching.

The ambient temperature measured over 24 hours should be at least 5 °C lower than the max. ambient temperature. If the frequency converter is operated at high ambient temperature, the continuous output current should be decreased. The frequency converter has been designed for operation at max. 50 °C ambient temperature with one motor size smaller than nominal. Continuous operation at full load at 50 °C ambient temperature reduces the lifetime of the frequency converter.
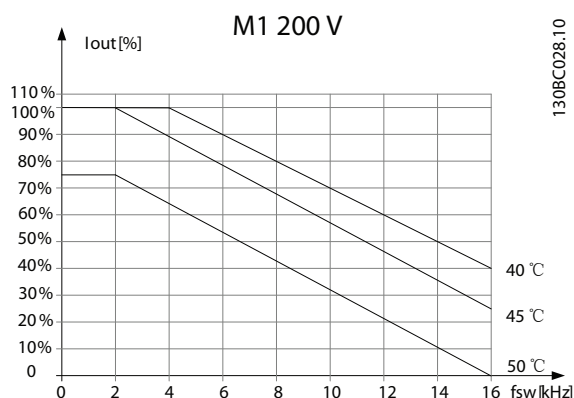
Illustration 4.34 M1 200 V
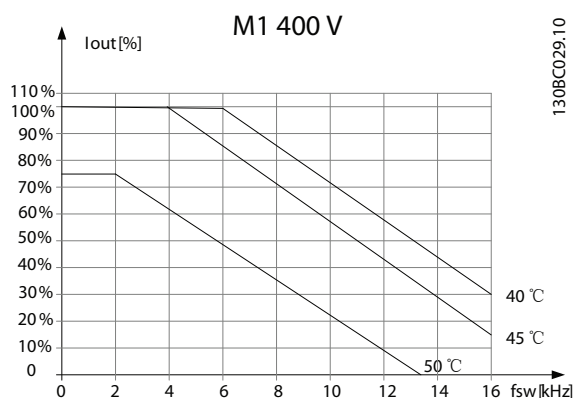
Illustration 4.35 M1 400 V
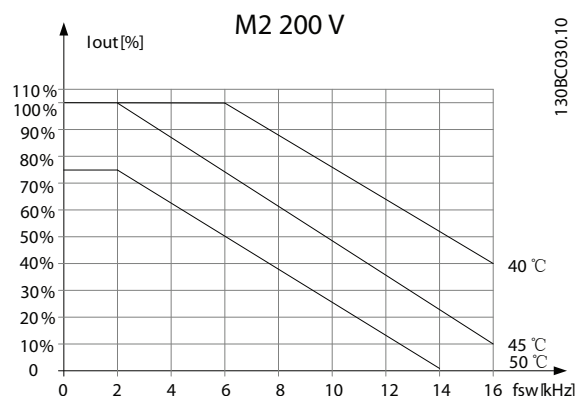
Illustration 4.36 M2 200 V
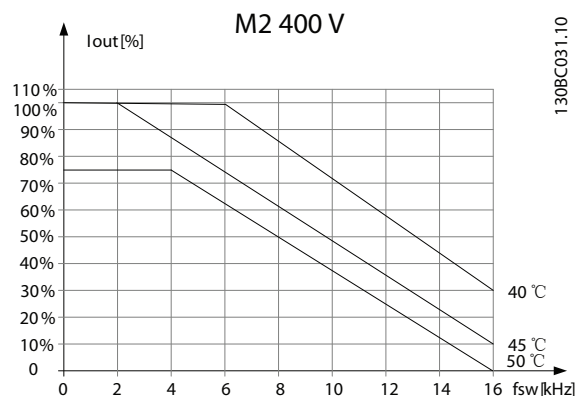
Illustration 4.37 M2 400 V
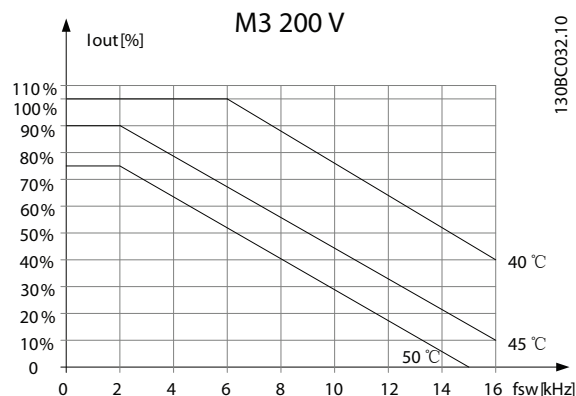
Illustration 4.38 M3 200 V

4
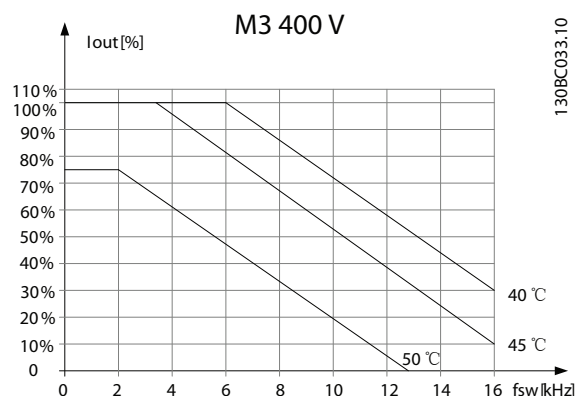
Illustration 4.39 M3 400 V
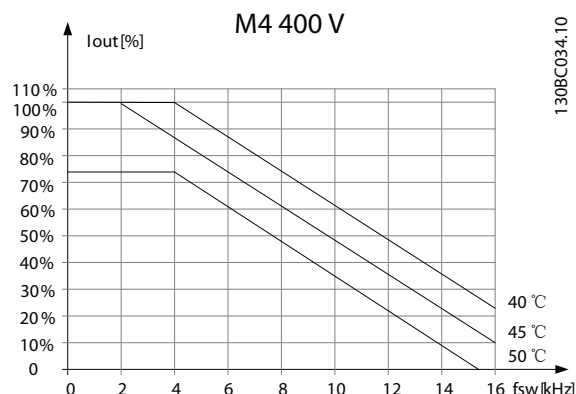
Illustration 4.40 M4 200 V
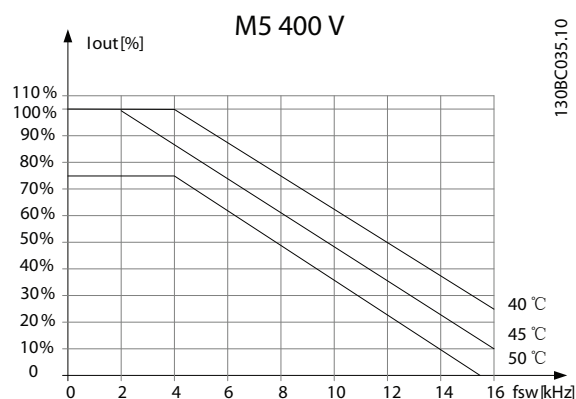
Illustration 4.41 M4 400 V

4.2.3 Derating for Low Air Pressure

The cooling capability of air is decreased at low air pressure.

For altitudes above 2,000 m, contact Danfoss regarding PELV.

Below 1,000 m altitude no de-rating is necessary, but above 1.000 m the ambient temperature or the maximum output current should be decreased.
Decrease the output by 1% per 100 m altitude above 1,000 m or reduce the max. ambient temperature by 1 ° C per 200 m.

4.2.4 Automatic Adaptations to Ensure Performance

The frequency converter constantly checks for critical levels of internal temperature, load current, high voltage on the intermediate circuit and low motor speeds. As a response to a critical level, the frequency converter can adjust the switching frequency and/or change the switching pattern to ensure the performance of the frequency converter. The capability for automatic output current reduction extends the acceptable operating conditions even further.

4.2.5 Derating for Running at Low Speed

When a motor is connected to a frequency converter, it is necessary to check that the cooling of the motor is adequate. The level of heating depends on the load on the motor, as well as the operating speed and time.

Constant torque applications (CT mode)
A problem may occur at low RPM values in constant torque applications. In a constant torque application a motor may over-heat at low speeds due to less cooling air from the motor integral fan.

Therefore, if the motor is to be run continuously at an RPM value lower than half of the rated value, the motor must be supplied with additional air-cooling (or a motor designed for this type of operation may be used).

An alternative is to reduce the load level of the motor by choosing a larger motor. However, the design of the frequency converter puts a limit to the motor size.

5 How to Order

5.1 Drive Configurator

It is possible to design a frequency converter according to the application requirements by using the ordering number system.

Frequency converters can be ordered as standard or with internal options by using a type code string, that is,

FC051PXXXXXXXXHXXXXXXXSXXX

Use the Internet-based Drive Configurator to configure the right frequency converter for the right application and generate the type code string. The Drive Configurator automatically generates an 8-digit sales number (either for one product or a project list with several products) to be delivered to your local sales office.

The Drive Configurator can be found on: *www.danfoss.com/drives*.

5.2 FC Identification

The nameplate sticker is located on the top of each frequency converter and shows the ratings, serial number, warnings catalog number, and other relevant data for each unit. See *Table 5.2* for details, how to read the type code string.
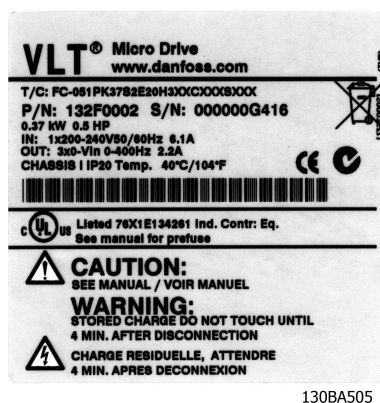
130BA505

Illustration 5.1 Nameplate Sticker

5.3 Type Code

```
      1  2  3  4   5  6  7   8  9  10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
     FC-0 5 1 P                      H           X X X S X X X
                                                              130BA589.10
```

Table 5.1 Type Code

Description	Pos	Possible choice
Product group	1-3	Adjustable Frequency Converters
Series and product type	4-6	Micro Drive
Power size	7-10	0.18-22 kW
Mains voltage	11-12	S2: Single phase 200-240 V AC
		T 2: Three phase 200-240 V AC
		T 4: Three phase 380-480 V AC
Enclosure	13-15	IP20/Chassis
RFI filter	16-17	H3: RFI filter A1/B (reduced cable length*)
Brake	18	B: Brake chopper included (from 1.5 kW and up)
		X: No brake chopper included
Display	19	X: No Local Control Panel
		N: Numerical Local Control Panel (LCP)
		P: Numerical Local Control Panel (LCP) with potentiometer
Coating PCB	20	C: Coated PCB
		X: No coated PCB
Mains option	21	X: No mains option
Adaptation A	22	X: No adaptation
Adaptation B	23	X: No adaptation
Software release	24-27	SXXX: Latest release - std. software

Table 5.2 Type Code Description

5.4 Ordering Numbers

| Power [kW] | 200-240 V | | | 380-480 V | |
	Current [I_{nom}]	1 ph.	3 ph.	Current [I_{nom}]	3 ph.
0.18	1.2	132F 0001			
0.25	1.5		132F 0008		
0.37	2.2	132F 0002	132F 0009	1.2	132F 0017
0.75	4.2	132F 0003	132F 0010	2.2	132F 0018
1.5	6.8	132F 0005	132F 0012	3.7	132F 0020
2.2	9.6	132F 0007	132F 0014	5.3	132F 0022
3.0				7.2	132F 0024
3.7	15.2		132F 0016		
4.0				9.0	132F 0026
5.5				12.0	132F 0028
7.5				15.5	132F 0030
11.0		Micro drives from 1.5 kW and up have built in brake chopper		23.0	132F 0058
15.0				31.0	132F 0059
18.5				37.0	132F 0060
22.0				43.0	132F 0061

Table 5.3 Ordering Numbers

5.5 Options

Ordering No	Description
132B0100	VLT Control Panel LCP 11 w/o potentiometer
132B0101	VLT Control Panel LCP 12 w/o potentiometer
132B0102	Remote Mounting Kit for LCP incl. 3 m cable IP55 with LCP 11, IP21 with LCP 12
132B0103	Nema Type 1 kit for M1 frame
132B0104	Type 1 kit for M2 frame
132B0105	Type 1 kit for M3 frame
132B0106	De-coupling plate kit for M1 and M2 frames
132B0107	De-coupling plate kit for M3 frame
132B0108	IP21 for M1 frame
132B0109	IP21 for M2 frame
132B0110	IP21 for M3 frame
132B0111	DIN rail mounting kit for M1 and M2 frame
132B0120	Type 1 kit for M4 frame
132B0121	Type 1 kit for M5 frame
132B0122	De-coupling plate kit for M4 and M5 frames
130B2522	Line Filter MCC 107 for 132F0001
130B2522	Line Filter MCC 107 for 132F0002
130B2533	Line Filter MCC 107 for 132F0003
130B2525	Line Filter MCC 107 for 132F0005
130B2530	Line Filter MCC 107 for 132F0007
130B2523	Line Filter MCC 107 for 132F0008
130B2523	Line Filter MCC 107 for 132F0009
130B2523	Line Filter MCC 107 for 132F0010
130B2526	Line Filter MCC 107 for 132F0012
130B2531	Line Filter MCC 107 for 132F0014
130B2527	Line Filter MCC 107 for 132F0016
130B2523	Line Filter MCC 107 for 132F0017
130B2523	Line Filter MCC 107 for 132F0018
130B2524	Line Filter MCC 107 for 132F0020

Ordering No	Description
130B2526	Line Filter MCC 107 for 132F0022
130B2529	Line Filter MCC 107 for 132F0024
130B2531	Line Filter MCC 107 for 132F0026
130B2528	Line Filter MCC 107 for 132F0028
130B2527	Line Filter MCC 107 for 132F0030

Table 5.4 Options for VLT Micro Drive

NOTICE

Danfoss line filters and brake resistors are available upon request.

6 How to Install

6.1 Before Starting

6.1.1 Checklist

When unpacking the frequency converter, make sure that the unit is undamaged and complete. Check that the packaging contains the following:

- VLT® Micro Drive FC 51
- Quick Guide

Optional: LCP and/or de-coupling plate.
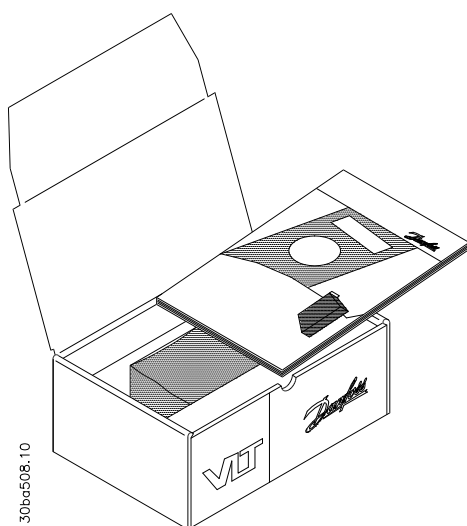
Illustration 6.1 Content of Box

6.2 Side-by-Side Installation

The frequency converter can be mounted side-by-side for IP 20 rating units and requires 100 mm clearance above and below for cooling. Regarding surroundings in general, see *chapter 9 Specifications*.
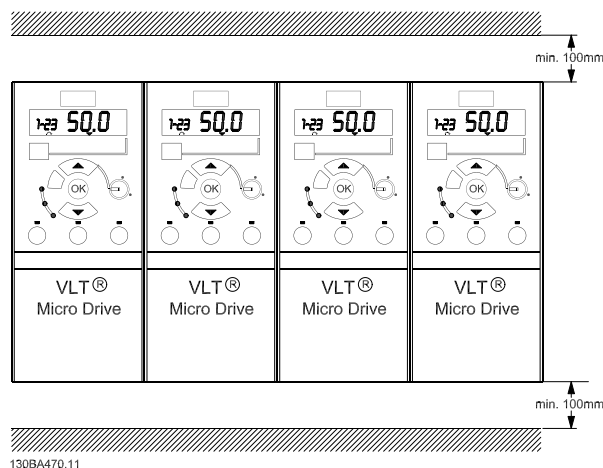
Illustration 6.2 Side-by-side Installation

6.3 Before Commencing Repair Work

1. Disconnect the FC 51 from mains (and external DC supply, if present.)

2. Wait for 4 min (M1, M2 and M3) and 15 min (M4 and M5) for discharge of the DC-link. See *Table 2.1*.

3. Disconnect DC bus terminals and brake terminals (if present).

4. Remove motor cable.

6.4 Mechanical Dimensions

A template for drilling can be found on the flap of the packaging.

Illustration 6.3 Mechanical Dimensions
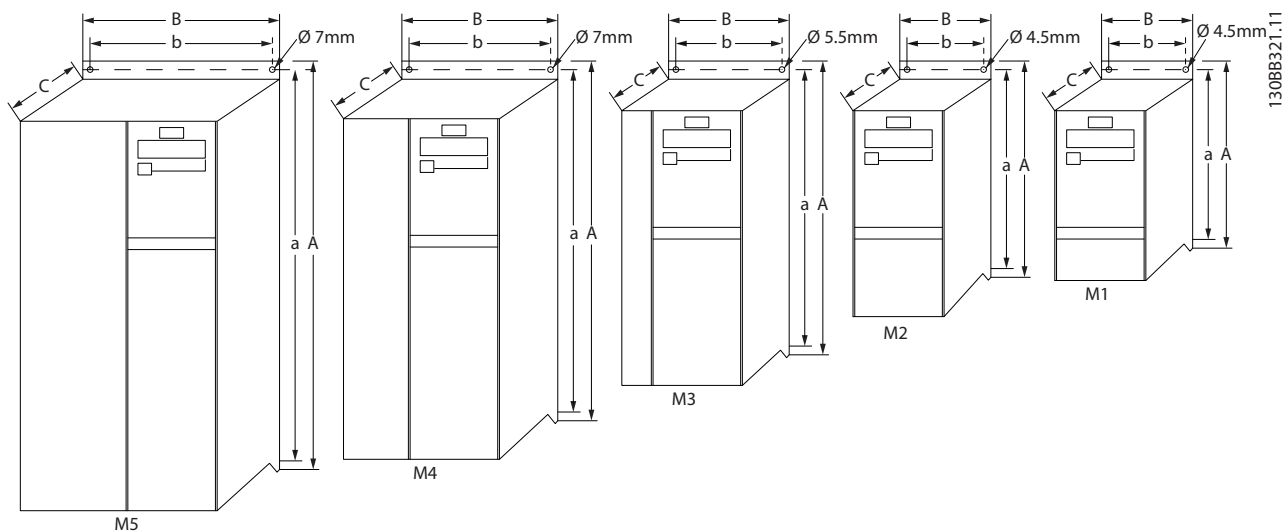
	Power [kW]			Height [mm]		Width [mm]		Depth[1] [mm]	Max. Weight
Frame	1X200-240 V	3X200-240 V	3X380-480 V	A	A (incl. decoupling plate)	a	B	b	C	[kg]
M1	0.18-0.75	0.25-0.75	0.37-0.75	150	205	140.4	70	55	148	1.1
M2	1.5	1.5	1.5-2.2	176	230	166.4	75	59	168	1.6
M3	2.2	2.2-3.7	3.0-7.5	239	294	226	90	69	194	3.0
M4			11.0-15.0	292	347.5	272.4	125	97	241	6.0
M5			18.5-22.0	335	387.5	315	165	140	248	9.5
[1] For LCP with potentiometer, add 7.6 mm.										

6.5 Electrical Installation in General

NOTICE

All cabling must comply with national and local regulations on cable cross-sections and ambient temperature. Copper conductors required, (60-75 °C) recommended.

	Power [kW]			Torque [Nm]					
Enclosure	1x200-240 V	3x200-240 V	3x380-480 V	Line	Motor	DC connection/Brake	Control Terminals	Earth	Relay
M1	0.18-0.75	0.25-0.75	0.37-0.75	1.4	0.7	Spade[1]	0.15	3	0.5
M2	1.5	1.5	1.5-2.2	1.4	0.7	Spade[1]	0.15	3	0.5
M3	2.2	2.2-3.7	3.0-7.5	1.4	0.7	Spade[1]	0.15	3	0.5
M4			11.0-15.0	1.3	1.3	1.3	0.15	3	0.5
M5			18.5-22.0	1.3	1.3	1.3	0.15	3	0.5
[1] Spade connectors (6.3 mm Faston plugs)									

Table 6.1 Tightening of Terminals

6.6 Fuses

Branch circuit protection

To protect the installation against electrical and fire hazard, all branch circuits in an installation, switch gear, machines etc., must be short-circuited and overcurrent protected according to national/international regulations.

Short circuit protection

Danfoss recommends using the fuses mentioned in the following tables to protect service personnel or other equipment in case of an internal failure in the unit or short-circuit on DC-link. The frequency converter provides full short circuit protection in case of a short-circuit on the motor or brake output.

Overcurrent protection

Provide overload protection to avoid overheating of the cables in the installation. Overcurrent protection must always be carried out according to national regulations. Fuses must be designed for protection in a circuit capable of supplying a maximum of 100,000 A_{rms} (symmetrical), 480 V maximum.

Non UL compliance

If UL/cUL is not to be complied with, Danfoss recommends using the fuses mentioned in *Table 6.2*, which ensures compliance with EN50178/IEC61800-5-1:
In case of malfunction, not following the fuse recommendation may result in damage to the frequency converter and the installation.

FC 51	Max. Fuses UL						Max. fuses non UL
	Bussmann	**Bussmann**	**Bussmann**	**Littel fuse**	**Ferraz-Shawmut**	**Ferraz-Shawmut**	
1X200-240 V							
kW	Type RK1	Type J	Type T	Type RK1	Type CC	Type RK1	Type gG
0K18-0K37	KTN-R15	JKS-15	JJN-15	KLN-R15	ATM-R15	A2K-15R	16A
0K75	KTN-R25	JKS-25	JJN-25	KLN-R25	ATM-R25	A2K-25R	25A
1K5	KTN-R35	JKS-35	JJN-35	KLN-R35	-	A2K-35R	35A
2K2	KTN-R50	JKS-50	JJN-50	KLN-R50	-	A2K-50R	50A
3x200-240 V							
0K25	KTN-R10	JKS-10	JJN-10	KLN-R10	ATM-R10	A2K-10R	10A
0K37	KTN-R15	JKS-15	JJN-15	KLN-R15	ATM-R15	A2K-15R	16A
0K75	KTN-R20	JKS-20	JJN-20	KLN-R20	ATM-R20	A2K-20R	20A
1K5	KTN-R25	JKS-25	JJN-25	KLN-R25	ATM-R25	A2K-25R	25A
2K2	KTN-R40	JKS-40	JJN-40	KLN-R40	ATM-R40	A2K-40R	40A
3K7	KTN-R40	JKS-40	JJN-40	KLN-R40	-	A2K-40R	40A
3x380-480 V							
0K37-0K75	KTS-R10	JKS-10	JJS-10	KLS-R10	ATM-R10	A6K-10R	10A
1K5	KTS-R15	JKS-15	JJS-15	KLS-R15	ATM-R15	A2K-15R	16A
2K2	KTS-R20	JKS-20	JJS-20	KLS-R20	ATM-R20	A6K-20R	20A
3K0	KTS-R40	JKS-40	JJS-40	KLS-R40	ATM-R40	A6K-40R	40A
4K0	KTS-R40	JKS-40	JJS-40	KLS-R40	ATM-R40	A6K-40R	40A
5K5	KTS-R40	JKS-40	JJS-40	KLS-R40	-	A6K-40R	40A
7K5	KTS-R40	JKS-40	JJS-40	KLS-R40	-	A6K-40R	40A
11K0	KTS-R60	JKS-60	JJS-60	KLS-R60	-	A6K-60R	63A
15K0	KTS-R60	JKS-60	JJS-60	KLS-R60	-	A6K-60R	63A
18K5	KTS-R60	JKS-60	JJS-60	KLS-R60	-	A6K-60R	80A
22K0	KTS-R60	JKS-60	JJS-60	KLS-R60	-	A6K-60R	80A

Table 6.2 Fuses

6

6.7 Mains Connection

Step 1: Mount ground cable.

Step 2: Mount wires in terminals L1/L, L2 and L3/N and tighten.
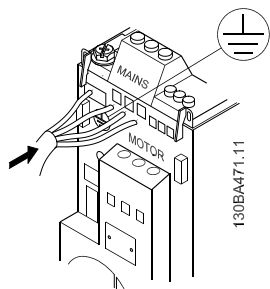
Illustration 6.4 Mounting of Ground Cable and Mains Wires

For 3-phase connection, connect wires to all three terminals.
For single-phase connection, connect wires to terminals L1/L and L3/N.
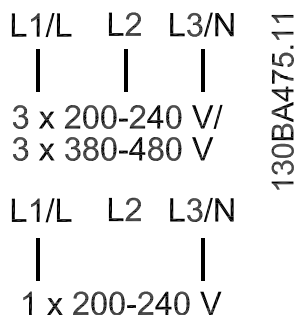
Illustration 6.5 3-phase and Single-phase Wire Connections

6.8 Motor Connection

6.8.1 How to Connect the Motor

See *chapter 9 Specifications* for correct dimensioning of motor cable cross-section and length.

- Use a shielded/armored motor cable to comply with EMC emission specifications, and connect this cable to both the decoupling plate and the motor metal.

- Keep motor cable as short as possible to reduce the noise level and leakage currents.

For further details on mounting of the decoupling plate, see *VLT® Micro Drive FC 51 De-coupling Plate Mounting Instruction for M1 and M2*.

All types of 3-phased asynchronous standard motors can be connected to the frequency converter. Normally, small motors are star-connected (230/400 V, Δ/Y). Large motors are delta-connected (400/690 V, Δ/Y). Refer to motor nameplate for correct connection and voltage.
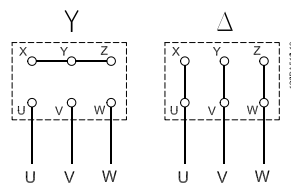
Illustration 6.6 Star and Delta Connections

Step 1: Mount the ground cable.

Step 2: Connect wires to terminals either in star or delta-connection. See motor nameplate for further information.
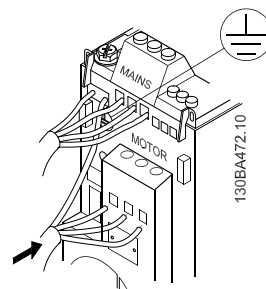
Illustration 6.7 Mounting of Earth Cable and Motor Wires

For EMC correct installation, use optional de-coupling plate, see *chapter 5.5 Options*.
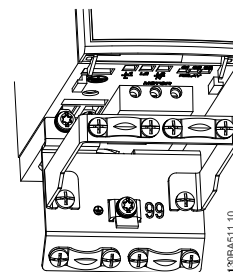
Illustration 6.8 Frequency Converter with De-coupling Plate

6.8.2 Motor Cables

See *chapter 9 Specifications* for maximum dimensioning of motor cable cross-section and length.

- Use a screened/armoured motor cable to comply with EMC emission specifications.

- Keep the motor cable as short as possible to reduce the noise level and leakage currents.

- Connect the motor cable screen to both the de-coupling plate of the frequency converter and to the metal cabinet of the motor.

- Make the screen connections with the largest possible surface area (cable clamp). This is done by using the supplied installation devices in the frequency converter.

- Avoid mounting with twisted screen ends (pigtails), which spoils high frequency screening effects.

- If it is necessary to split the screen to install a motor isolator or motor relay, the screen must be continued with the lowest possible HF impedance.

6.8.3 Electrical Installation of Motor Cables

Screening of cables
Avoid installation with twisted screen ends (pigtails). They spoil the screening effect at higher frequencies.
If it is necessary to break the screen to install a motor isolator or motor contactor, the screen must be continued at the lowest possible HF impedance.

Cable length and cross-section
The frequency converter has been tested with a given length of cable and a given cross-section of that cable. If the cross-section is increased, the cable capacitance - and thus the leakage current - may increase, and the cable length must be reduced correspondingly.

Switching frequency
When frequency converters are used together with Sine-wave filters to reduce the acoustic noise from a motor, the switching frequency must be set according to the Sine-wave filter instruction in *14-01 Switching Frequency*.

Aluminium conductors
Aluminium conductors are not recommended. Terminals can accept aluminium conductors but the conductor surface has to be clean and the oxidation must be removed and sealed by neutral acid free Vaseline grease before the conductor is connected.
Furthermore, the terminal screw must be retightened after 2 days due to the softness of the aluminium. It is crucial to keep the connection a gas tight joint, otherwise the aluminium surface oxidises again.

6.8.4 EMC-Correct Electrical Installation

General points to be observed to ensure EMC-correct electrical installation.

- Use only screened/armoured motor cables and screened/armoured control cables.

- Connect the screen to earth at both ends.

- Avoid installation with twisted screen ends (pigtails), since this ruins the screening effect at high frequencies. Use the cable clamps provided instead.

- It is important to ensure good electrical contact from the installation plate through the installation screws to the metal cabinet of the frequency converter.

- Use starwashers and galvanically conductive installation plates.

- Do not use unscreened/unarmoured motor cables in the installation cabinets.

6

PLC etc.

Panel

PLC

Output con-
tactor etc.

Earthing rail

Cable insula-
tion stripped

Min. 16 mm²
Equalizing cable

Control cables

All cable entries in
one side of panel

Motor cable

Min. 200mm
between control
cable, mains cable
and between mains
motor cable

Mains-supply

L1
L2
L3
PE

Reinforced protective earth

Motor, 3 phases and
Protective earth
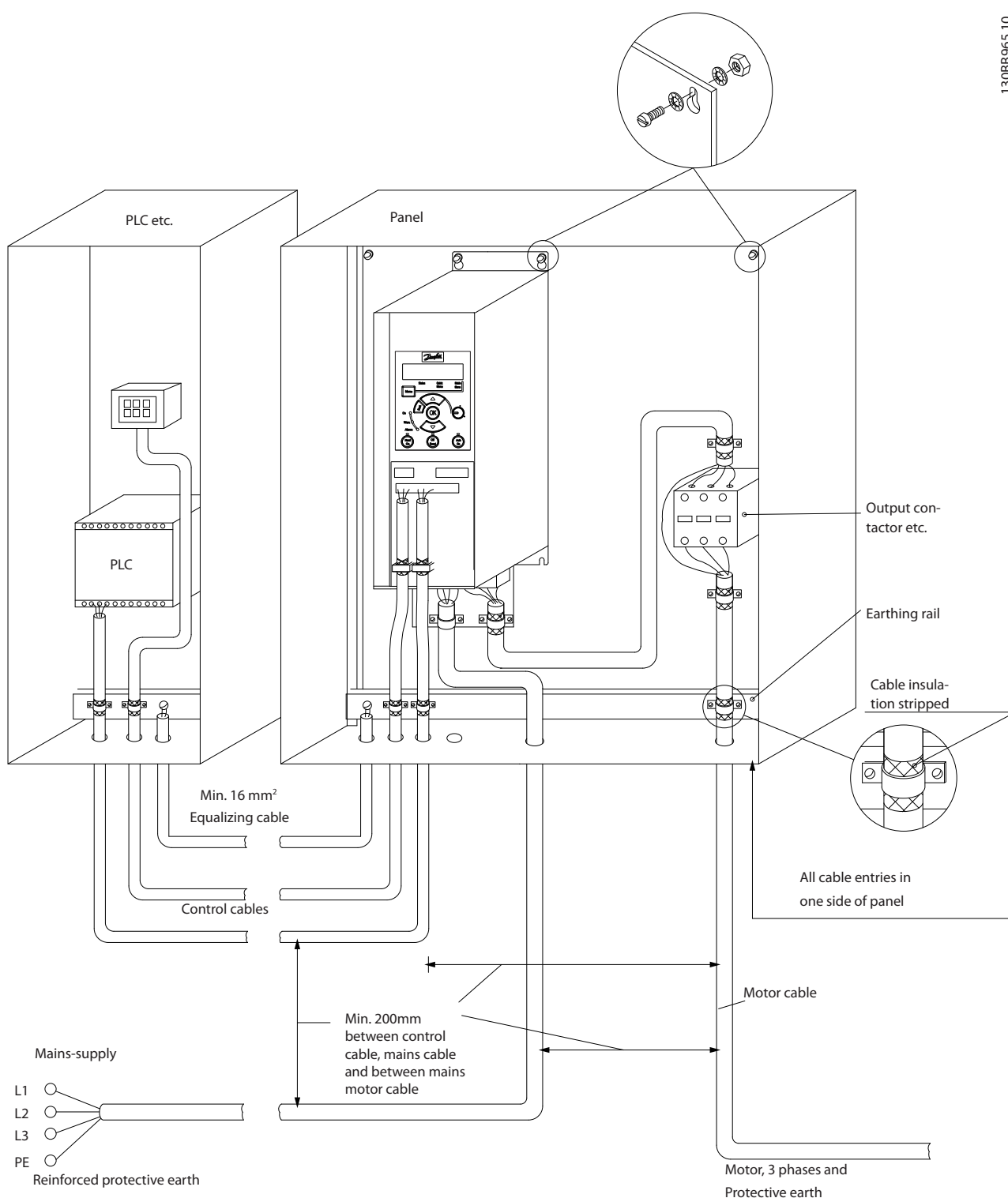
Illustration 6.9 EMC-correct Electrical Installation

NOTICE

For North America use metal conduits instead of shielded cables.

6.9 Use of EMC-Correct Cables

Danfoss recommends braided screened/armoured cables to optimise EMC immunity of the control cables and the EMC emission from the motor cables.

The ability of a cable to reduce the in- and outgoing radiation of electric noise depends on the transfer impedance (Z_T). The screen of a cable is normally designed to reduce the transfer of electric noise; however, a screen with a lower transfer impedance (Z_T) value is more effective than a screen with a higher transfer impedance (Z_T).

Transfer impedance (Z_T) is rarely stated by cable manufacturers but it is often possible to estimate transfer impedance (Z_T) by assessing the physical design of the cable.

Transfer impedance (Z_T) can be assessed on the basis of the following factors:

- The conductibility of the screen material.

- The contact resistance between the individual screen conductors.

- The screen coverage, that is, the physical area of the cable covered by the screen - often stated as a percentage value.

- Screen type, that is, braided or twisted pattern.

a. Aluminium-clad with copper wire.

b. Twisted copper wire or armoured steel wire cable.

c. Single-layer braided copper wire with varying percentage screen coverage.
    This is the typical Danfoss reference cable.

d. Double-layer braided copper wire.

e. Twin layer of braided copper wire with a magnetic, screened/armoured intermediate layer.

f. Cable that runs in copper tube or steel tube.

g. Lead cable with 1.1 mm wall thickness.
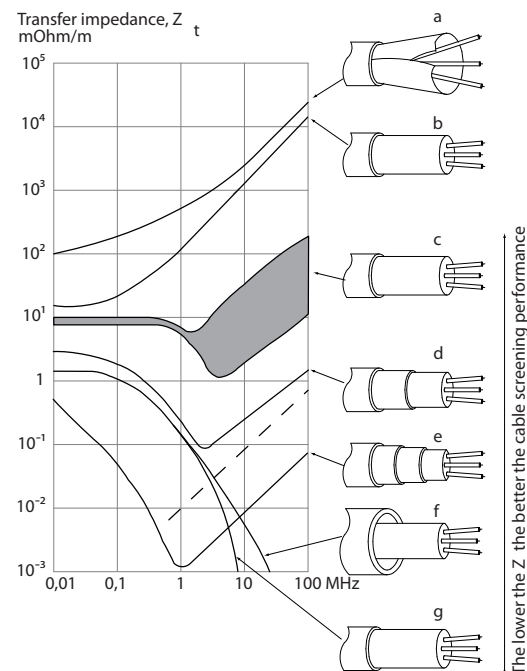
Illustration 6.10 Transfer Impedance of Different Wires

6.10 Earthing of Screened/Armoured Control Cables

Control cables should be braided, screened/armoured, and the screen must be connected with a cable clamp at both ends to the metal cabinet of the unit. *Illustration 6.11* shows correct earthing examples.
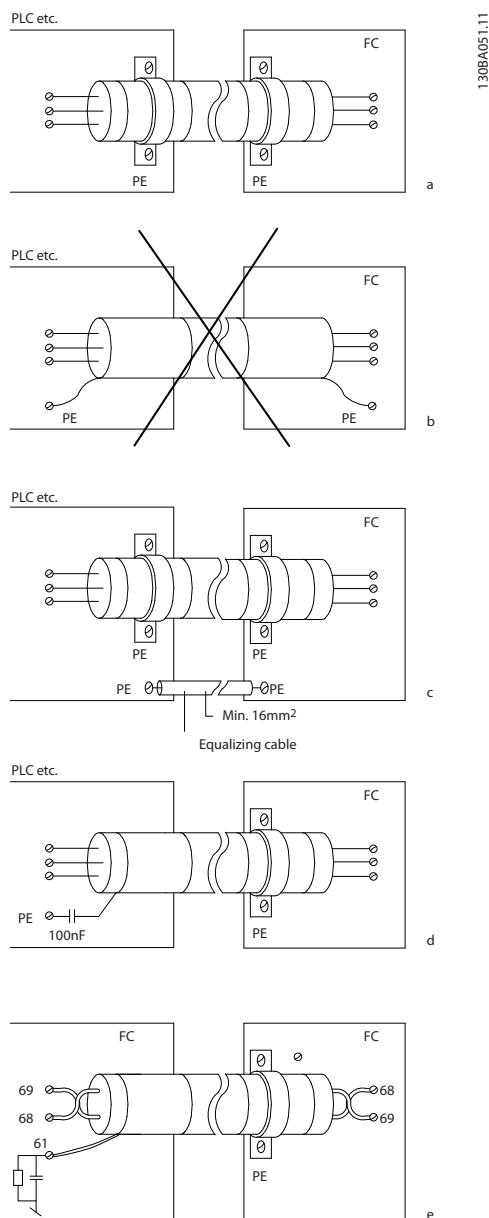
a. **Correct grounding**
    Control cables and cables for serial communication are fitted with cable clamps at both ends to ensure the best possible electrical contact.

b. **Incorrect grounding**
    Do not use twisted cable ends (pigtails). They increase the screen impedance at high frequencies.

c. **Protection from potential between PLC and frequency converter**
    If the earth potential between the frequency converter and the PLC (etc.) is different, electric noise that disturbs the entire system is possible. Fit an equalizing cable, next to the control cable. Minimum cable cross-section: 16 mm^2.

d. **For 50/60 Hz earth loops**
    Using long control cables sometimes causes 50/60 Hz ground loops. Connect one end of the screen to earth via a 100 nF capacitor (keeping leads short).

e. **Cables for serial communication**
    Eliminate low-frequency noise currents between 2 frequency converters by connecting one end of the screen to terminal 61. This terminal is connected to ground via an internal RC link. Use twisted-pair cables to reduce the differential mode interference between the conductors.

6.11 Residual Current Device

Use RCD relays, multiple protective earthing or earthing as extra protection, if local safety regulations are complied with.
If an earth fault appears, a DC content may develop in the faulty current.
If RCD relays are used, local regulations must be observed. Relays must be suitable for protection of 3-phase equipment with a bridge rectifier and for a brief discharge on power-up see *chapter 3.4 Earth Leakage Current* for further information.

a	Correct earthing
b	Incorrect earthing
c	Protection from potential between PLC and frequency converter
d	50/60 Hz earth loops
e	Cables for Serial Communication

Illustration 6.11 Earthing Examples

6.12 Electrical Overview

6.12.1 Power Circuit - Overview
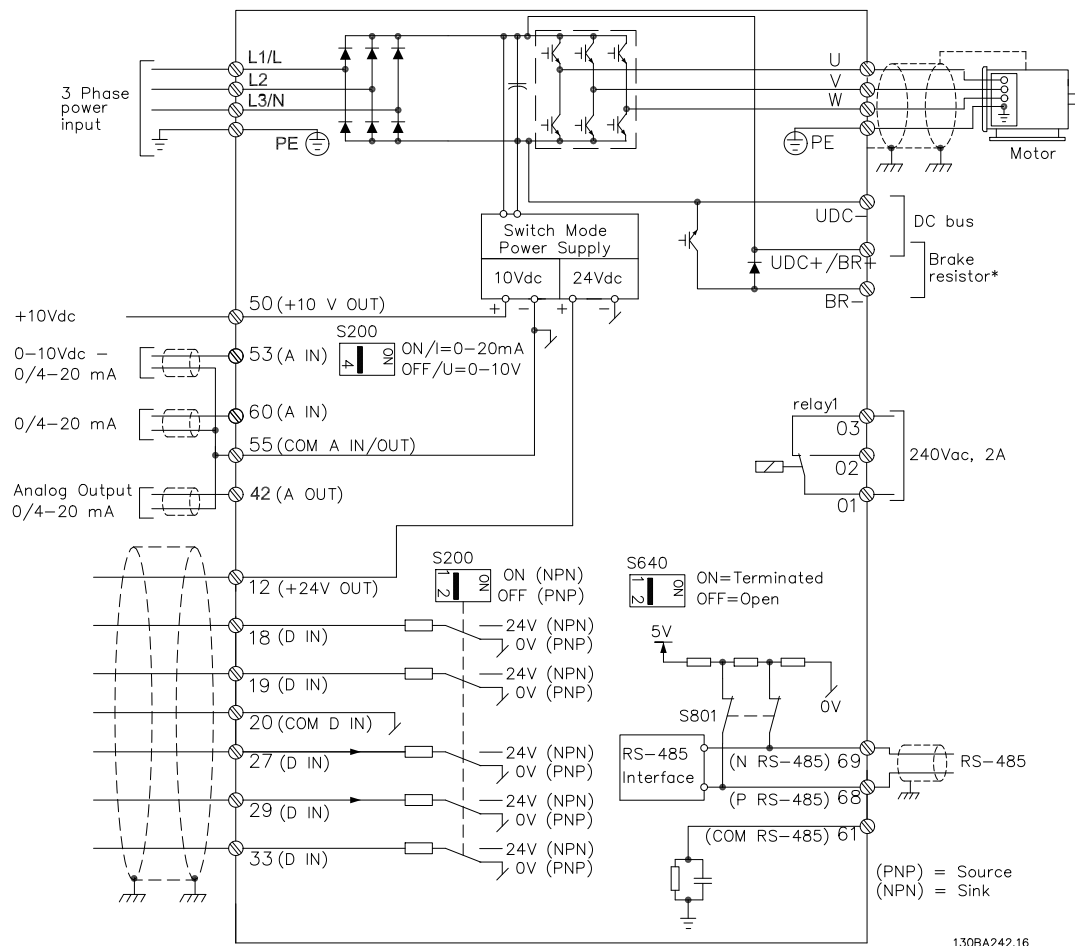
Illustration 6.12 Diagram Showing all Electrical Terminals

* Brake (BR+ and BR-) are not applicable for enclosure type M1.

Brake resistors are available from Danfoss.
Improved power factor and EMC performance can be achieved by installing optional Danfoss line filters.
Danfoss power filters can also be used for load sharing.

6.13 Electrical Installation and Control Cables

Terminal number	Terminal description	Parameter number	Factory default
1+2+3	Terminal 1+2+3 - Relay1	5-40	No operation
12	Terminal 12, DC 24V Supply	-	+24 V DC
18	Terminal 18 Digital Input	5-10	Start
19	Terminal 19 Digital Input	5-11	Reversing
20	Terminal 20 Common Digital Ground	-	Common
27	Terminal 27 Digital Input	5-12	Reset
29	Terminal 29 Digital Input	5-13	Jog
33	Terminal 33 Digital Input	5-15	Preset ref bit 0
42	Terminal 42 Analog Output/Digital Output	6-9*	No operation
50	Terminal 50 Supply for Analog Input	-	+10 V DC
53	Terminal 53 Analog Input (Voltage or Current)	3-15/6-1*	Reference
55	Terminal 55 Common Analog Ground	-	Common
60	Terminal 60 Current Input	3-16/6-2*	Reference

Table 6.3 Terminal Connections

Very long control cables and analog signals may, in rare cases and depending on installation, result in 50/60 Hz ground loops due to noise from mains supply cables.

If this occurs, break the screen or insert a 100 nF capacitor between screen and chassis.

NOTICE

The common of digital/analog inputs and outputs should be connected to separate common terminals 20, 39, and 55. This avoids ground current interference among groups. For example, it avoids switching on digital inputs disturbing analog inputs.

NOTICE

Control cables must be screened/armoured.

6.14 Control Terminals

6.14.1 Access to Control Terminals

All control cable terminals are located underneath the terminal cover in front of the frequency converter. Remove the terminal cover using a screwdriver.
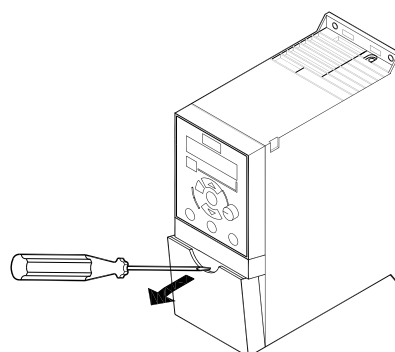
Illustration 6.13 Removing Terminal Cover

NOTICE

See back of terminal cover for outlines of control terminals and switches.

6.14.2 Connecting to Control Terminals

Illustration 6.14 shows all control terminals of the frequency converter. Applying Start (terminal 18) and an analog reference (terminals 53 or 60) make the frequency converter run.
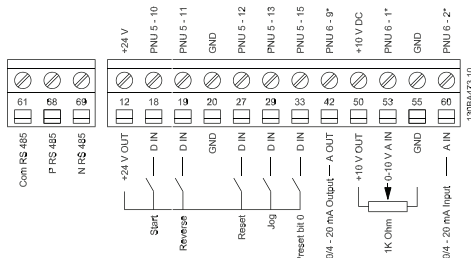
Illustration 6.14 Overview of Control Terminals in PNP-configuration and Factory Setting.

6.15 Switches

NOTICE

Do not operate switches with power on the frequency converter.

Bus termination
Switch *BUS TER* position ON terminates the RS-485 port, terminals 68, 69. See *Illustration 6.12*.

Default setting = Off
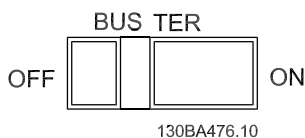
Illustration 6.15 S640 Bus Termination

S200 Switches 1-4
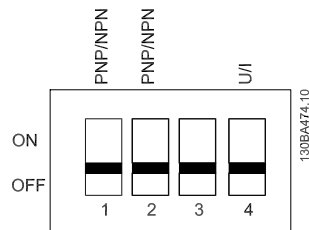
Switch 1	*Off=PNP terminals 29
	On=NPN terminals 29
Switch 2	*Off=PNP terminal 18, 19, 27 and 33
	On=NPN terminal 18, 19, 27 and 33
Switch 3	No function
Switch 4	*Off=Terminal 53 0-10 V
	On=Terminal 53 0/4-20 mA
*=default setting	

Illustration 6.16 S200 Switches 1-4

NOTICE

Parameter 6-19 Terminal 53 Mode **must be set according to Switch 4 position.**

6.16 Final Set-Up and Test

To test the set-up and ensure that the frequency converter is running, follow these steps.

Step 1. Locate the motor name plate
The motor is either star- (Y) or delta-connected (Δ). This information is located on the motor name plate data.

Step 2. Enter the motor name plate data in this parameter list
To access this list first press the [Quick Menu] key then select *Q2 Quick Setup*.

1.	Motor Power [kW]	1-20 Motor Power [kW]
	or Motor Power [HP]	1-21 Motor Power [HP]
2.	Motor Voltage	1-22 Motor Voltage
3.	Motor Frequency	1-23 Motor Frequency
4.	Motor Current	1-24 Motor Current
5.	Motor Nominal Speed	1-25 Motor Nominal Speed

Table 6.4 Parameters for Quick Setup
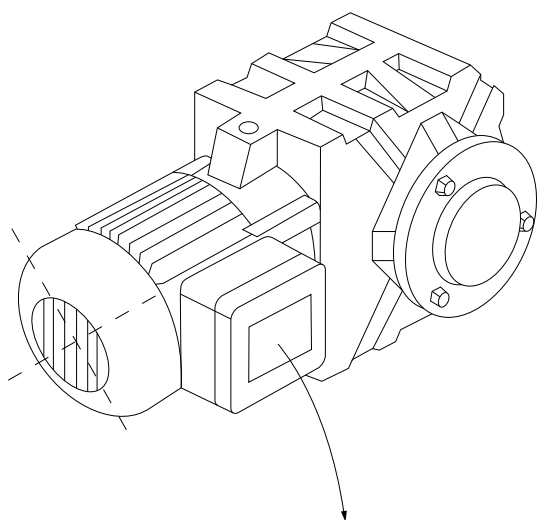
BAUER D-7 3734 ESLINGEN				
3~ MOTOR NR. 1827421 2003				
S/E005A9				
	1,5	KW		
n₂ 31,5	/min.	400	Y	V
n₁ 1400	/min.		50	Hz
COS θ 0,80			3,6	A
1,7L				
B	IP 65	H1/1A		

Illustration 6.17 Motor Name Plate Example

Step 3. Activate the Automatic Motor Tuning (AMT)
Performing an AMT ensures optimum performance. The AMT measures the values from the motor model equivalent diagram.

1. Connect terminal 27 to terminal 12 or set *5-12 Terminal 27 Digital Input* to *[0] No function*

2. Activate the AMT *1-29 Automatic Motor Adaptation (AMA)*.

3. Select between complete or reduced AMT. If an LC filter is mounted, run only the reduced AMT, or remove the LC filter during the AMT procedure.

4. Press [OK]. The display shows "Press [Hand On] to start".

5. Press [Hand On]. A progress bar indicates if the AMT is in progress.

Stop the AMT during operation

1. Press [Off] - the frequency converter enters into alarm mode and the display shows that the user terminated the AMT.

Successful AMT

1. The display shows "Press [OK] to finish AMT".

2. Press [OK] to exit the AMT state.

Unsuccessful AMT

1. The frequency converter enters into alarm mode. A description of the alarm can be found in the *Troubleshooting* section in *VLT Micro Drive FC 51 Programming Guide*.

2. "Report Value" in the [Alarm Log] shows the last measuring sequence carried out by the AMT, before the frequency converter entered alarm mode. This number along with the description of the alarm assists in troubleshooting. Contact Danfoss Service and make sure to mention number and alarm description.

Unsuccessful AMT is often caused by incorrectly registered motor name plate data or too big difference between the motor power size and the frequency converter power size.

Step 4. Set speed limit and ramp time
Set-up the desired limits for speed and ramp time.

Minimum Reference	*3-02 Minimum Reference*
Maximum Reference	*3-03 Maximum Reference*

Table 6.5 Reference Limit Parameters

Motor Speed Low Limit	*4-11 Motor Speed Low Limit [RPM]* or *4-12 Motor Speed Low Limit [Hz]*
Motor Speed High Limit	*4-13 Motor Speed High Limit [RPM]* or *4-14 Motor Speed High Limit [Hz]*

Table 6.6 Speed Limit Parameters

Ramp-up Time 1 [s]	*3-41 Ramp 1 Ramp Up Time*
Ramp-down Time 1 [s]	*3-42 Ramp 1 Ramp Down Time*

Table 6.7 Ramp Time Parameters

6.17 Parallel Connection of Motors

The frequency converter can control several parallel-connected motors. The total current consumption of the motors must not exceed the rated output current I$_{INV}$ for the frequency converter.

When motors are connected in parallel, *1-29 Automatic Motor Tuning (AMT)* cannot be used.

Problems may arise at start and at low RPM values if motor sizes are widely different because small motors' relatively high ohmic resistance in the stator calls for a higher voltage at start and at low RPM values.

The electronic thermal relay (ETR) of the frequency converter cannot be used as motor protection for the individual motor of systems with parallel-connected motors. Provide further motor protection by for example thermistors in each motor or individual thermal relays. (Circuit breakers are not suitable as protection).

6
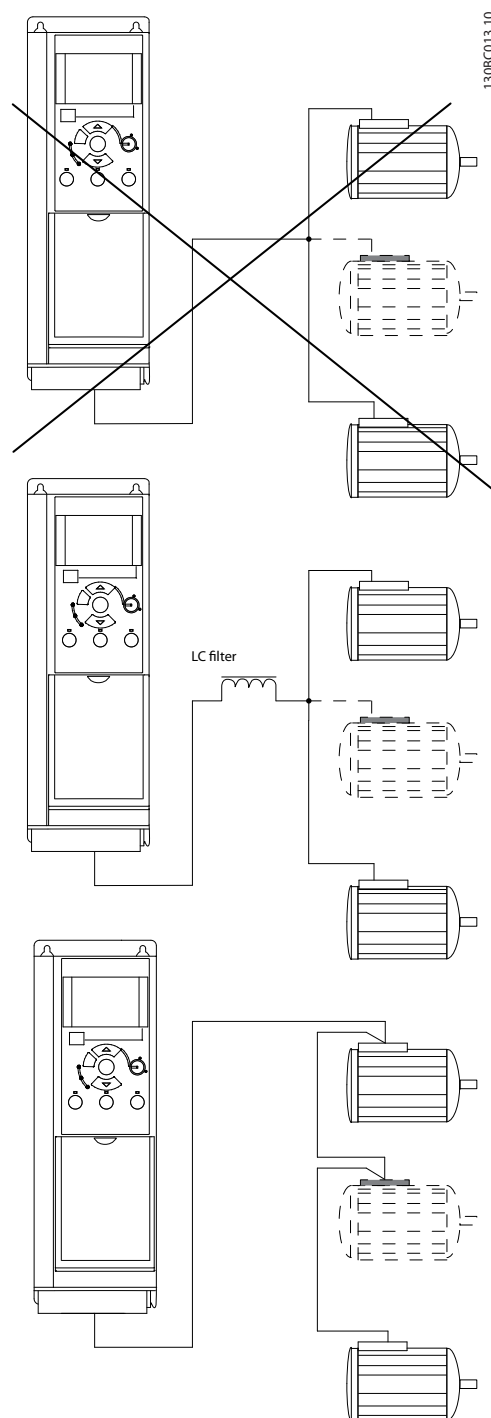
Illustration 6.18 Parallel Connection of Motors

6.18 Motor Installation

6.18.1 Motor Insulation

For motor cable lengths ≤ the maximum cable length listed in *chapter 9.1 Specifications*, the following motor insulation ratings are recommended because the peak voltage can be up to twice the DC link voltage, 2.8 times the mains voltage, due to transmission line effects in the motor cable. If a motor has lower insulation rating it recommended to use a dU/dt or sine wave filter.

Nominal Mains Voltage	Motor Insulation
U_N≤420 V	Standard U_{LL}=1300 V
420 V<U_N≤500 V	Reinforced U_{LL}=1600 V
500 V<U_N≤600 V	Reinforced U_{LL}=1800 V
600 V<U_N≤690 V	Reinforced U_{LL}=2000 V

Table 6.8 Motor Insulation Ratings

6.19 Installation of Misc. Connections

6.19.1 RS-485 Bus Connection

One or more frequency converters can be connected to a control (or master) using the RS-485 standardised interface. Terminal 68 is connected to the P signal (TX+, RX+), while terminal 69 is connected to the N signal (TX-,RX-).

If more than one frequency converter is connected to a master, use parallel connections.
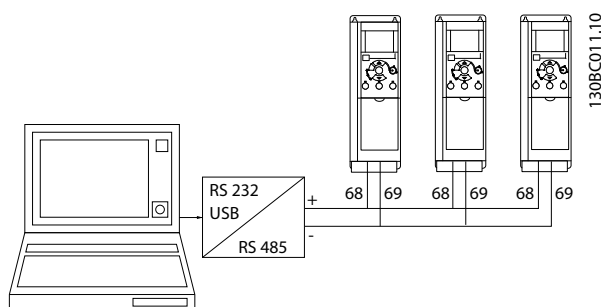
Illustration 6.19 RS-485 Bus Connection

To avoid potential equalizing currents in the screen, ground the cable screen via terminal 61, which is connected to the frame via an RC-link.

Bus termination
The RS-485 bus must be terminated by a resistor network at both ends. For this purpose, set switch S801 on the control card for "ON".
For more information, see the chapter *Switches S201, S202, and S801*.

Communication protocol must be set to *8-30 Protocol*.

6.19.2 How to Connect a PC to the Frequency Converter

To control or program the frequency converter from a PC, install the PC-based Configuration Tool MCT 10 Set-up Software.

MCT 10 Set-up Software
MCT 10 Set-up Software has been designed as an easy to use interactive tool for setting parameters in our frequency converters.
The PC-based Configuration Tool MCT 10 Set-up Software are useful for:

- Planning a communication network off-line. MCT 10 Set-up Software contains a complete frequency converter database

- Commissioning frequency converters on line

- Saving settings for all frequency converters

- Replacing a frequency converter in a network

- Expanding an existing network

- Future developed frequency converters will be supported

Save Drive Settings
1. Connect a PC to the unit via USB com port
2. Open PC-based Configuration Tool MCT 10 Set-up Software
3. Select *Read from drive*
4. Select *Save as*

All parameters are now stored in the PC.

Save Drive Settings
1. Connect a PC to the unit via USB com port
2. Open PC-based Configuration Tool MCT 10 Set-up Software
3. Select *Open* – stored files is shown
4. Open the appropriate file
5. Select *Write to drive*

All parameter settings are now transferred to the frequency converter.

A separate manual for PC-based Configuration Tool MCT 10 Set-up Software is available.

The PC-based Configuration Tool MCT 10 Set-up Software modules

The following modules are included in the software package:

	MCT 10 Set-up Software Setting parameters Copy to and from frequency converters Documentation and print out of parameter settings incl. diagrams
	Ext. User Interface Preventive Maintenance Schedule Clock settings Timed Action Programming Smart Logic Controller Set-up

Table 6.9 MCT 10 Set-up Software

Ordering number:

Order the CD containing the PC-based Configuration Tool MCT 10 Set-up Software using code number 130B1000.

MCT 10 Set-up Software can also be downloaded from the Danfoss Internet: *www.danfoss.com/BusinessAreas/DrivesSo-lutions/Softwaredownload/DDPC+Software+Program.htm*.

6.20 Safety

6.20.1 High Voltage Test

Carry out a high voltage test by short-circuiting terminals U, V, W, L_1, L_2 and L_3. Energise maximum 2.15 kV DC for 380-500 V frequency converters and 2.525 kV DC for 525-690 V frequency converters for 1 s between this short-circuit and the chassis.

⚠WARNING

When running high voltage tests of the entire instal-lation, interrupt the mains and motor connection if the leakage currents are too high.
Failure to follow recommendations could result in death or serious injury.

6.20.2 Safety Earth Connection

The frequency converter has a high leakage current and must be grounded appropriately for safety reasons according to EN 50178.

⚠WARNING

The ground leakage current from the frequency converter exceeds 3.5 mA. To ensure a good mechanical connection from the earth cable to the earth connection (terminal 95), the cable cross-section must be at least 10 mm² or 2 rated ground wires terminated separately.

6

7 Programming

7.1 How to Programme

7.1.1 Programming with MCT 10 Set-up Software

The frequency converter can be programmed from a PC via RS-485 com-port by installing the MCT 10 Set-up Software.

This software can either be ordered using code number 130B1000 or downloaded from the Danfoss Web site: *www.danfoss.com/BusinessAreas/DrivesSolutions/software-download*

Refer to *VLT® Motion Control Tools MCT 10 Set-up Software, Operating Instructions*.

7.1.2 Programming with the LCP 11 or LCP 12

The LCP is divided into 4 functional groups:

1.   Numeric display

2.   Menu key

3.   Navigation keys

4.   Operation keys and indicator lights (LEDs)
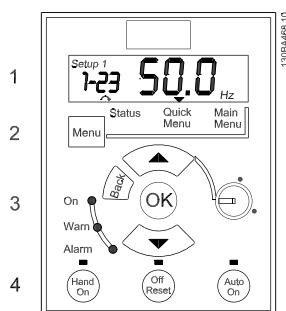
Illustration 7.1 LCP 12 with Potentiometer
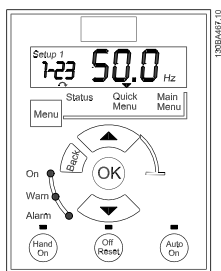
Illustration 7.2 LCP 11 without Potentiometer

The display
Different information can be read from the display.

Set-up number shows the active set-up and the edit set-up. If the same set-up acts as both active and edit set-up, only that set-up number is shown (factory setting). When active and edit set-up differ, both numbers are shown in the display (Set-up 12). The number flashing, indicates the edit set-up.

Illustration 7.3 Indicating Set-up

The small digits to the left are the selected parameter number.

Illustration 7.4 Indicating Selected Parameter Number

The large digits in the middle of the display show the value of the selected parameter.
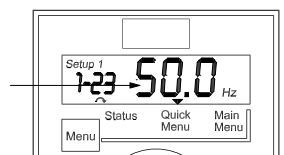
Illustration 7.5 Indicating Value of Selected Parameter

The right side of the display shows the unit of the selected parameter. This can be either Hz, A, V, kW, HP, %, s or RPM.
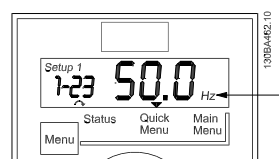
Illustration 7.6 Indicating Unit of Selected Parameter

Motor direction is shown to the bottom left of the display - indicated by a small arrow pointing either clockwise or counterclockwise.

Illustration 7.7 Indicating Motor Direction

Press [Menu] to select one of the following menus

Status Menu

The Status Menu is either in *Readout Mode* or *Hand on Mode*. In *Readout Mode* the value of the currently selected readout parameter is shown in the display.

In *Hand on Mode* the local LCP reference is displayed.

Quick Menu

Displays Quick Menu parameters and their settings. Parameters in the Quick Menu can be accessed and edited from here. Most applications can be run by setting the parameters in the Quick Menus.

Main Menu

Displays Main Menu parameters and their settings. All parameters can be accessed and edited here.

Indicator lights

- Green LED: The frequency converter is on.

- Yellow LED: Indicates a warning. See chapter *Troubleshooting* in the *VLT Micro Drive FC 51 Programming Guide*.

- Flashing red LED: Indicates an alarm. See chapter *Troubleshooting* in *VLT Micro Drive FC 51 Programming Guide*.

Navigation Keys

[Back]: For moving to the previous step or layer in the navigation structure.

[▲] [▼]: For maneuvering between parameter groups, parameters and within parameters.

[OK]: For selecting a parameter and for accepting changes to parameter settings.

Pressing [OK] for more than 1 s enters *Adjust* mode. In *Adjust* mode, it is possible to make fast adjustment by pressing [▲] [▼] combined with [OK].

Press [▲] [▼] to change value. Press [OK] to shift between digits quickly.

To exit 'Adjust' mode, press [OK] more than 1 s again with changes saving or press [Back] without changes saving.

Operation Keys

A yellow light above the operation keys indicates the active key.

[Hand On]: Starts the motor and enables control of the frequency converter via the LCP.

[Off/Reset]: The motor stops except in alarm mode. In alarm mode, the motor is reset.

[Auto On]: The frequency converter is controlled either via control terminals or serial communication.

[Potentiometer] (LCP 12): The potentiometer works in 2 ways depending on the mode in which the frequency converter is running.

In *Auto Mode* the potentiometer acts as an extra programmable analog input.

In *Hand on Mode* the potentiometer controls local reference.

7.2 Status Menu

After power up, the Status Menu is active. Press [Menu] to toggle between Status, Quick Menu and Main Menu.

[▲] and [▼] toggles between the choices in each menu.

The display indicates the status mode with a small arrow above "Status".
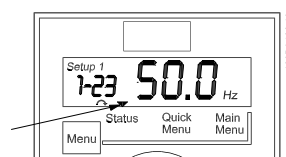
Illustration 7.8 Indicating Status Mode

7.3 Quick Menu

The Quick Menu gives easy access to the most frequently used parameters.

1. To enter the Quick Menu, press [Menu] key until indicator in display is placed above *Quick Menu*.

2. Press [▲] [▼] to select either QM1 or QM2, then press [OK].

3. Press [▲] [▼] to browse through the parameters in the Quick Menu.

4. Press [OK] to select a parameter.

5. Press [▲] [▼] to change the value of a parameter setting.

6. Press [OK] to accept the change.

7. To exit, press either [Back] twice to enter *Status*, or press [Menu] once to enter *Main Menu*.
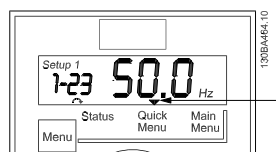
Illustration 7.9 Indicating Quick Menu Mode

7.4 Quick Menu Parameters

7.4.1 Quick Menu Parameters - Basic Settings QM1

Below are descriptions of all parameters found in the Quick Menu.

* =Factory setting.

1-20 Motor Power [kW]/[HP] (P_{m.n})		
Option:		**Function:**
		Enter motor power from nameplate data. Two sizes down, one size up from nominal VLT rating.
[1]	0.09 kW/0.12 HP	
[2]	0.12 kW/0.16 HP	
[3]	0.18kW/0.25 HP	
[4]	0.25 kW/0.33 HP	
[5]	0.37kW/0.50 HP	
[6]	0.55 kW/0.75 HP	
[7]	0.75 kW/1.00 HP	
[8]	1.10 kW/1.50 HP	
[9]	1.50 kW/2.00 HP	
[10]	2.20 kW/3.00 HP	
[11]	3.00 kW/4.00 HP	
[12]	3.70 kW/5.00 HP	
[13]	4.00 kW/5.40 HP	
[14]	5.50 kW/7.50 HP	
[15]	7.50 kW/10.0 HP	
[16]	11.00 kW/15.00 HP	
[17]	15.00 kW/20.00 HP	
[18]	18.50 kW/25.00 HP	
[19]	22.00 kW/29.50 HP	
[20]	30.00 kW/40.00 HP	

NOTICE

Changing this parameter affects parameter 1-22 to 1-25, 1-30, 1-33 and 1-35.

1-22 Motor Voltage (U_{m.n})		
Range:		**Function:**
230/400 V	[50-999 V]	Enter motor voltage from nameplate data.

1-23 Motor Frequency (f_{m.n})		
Range:		**Function:**
50 Hz*	[20-400 Hz]	Enter motor frequency from nameplate data.

1-24 Motor Current (I_{m.n})		
Range:		**Function:**
M-type dependent*	[0.01-100.00 A]	Enter motor current from nameplate data.

1-25 Motor Nominal Speed (n_{m.n})		
Range:		**Function:**
M-type Dependent*	[100-9999 RPM]	Enter motor nominal speed from nameplate data.

1-29 Automatic Motor Tuning (AMT)		
Option:		**Function:**
		Use AMT to optimise motor performance. **NOTICE** **This parameter cannot be changed while motor runs.** 1. Stop the frequency converter - make sure motor is at standstill 2. Select *[2] Enable AMT* 3. Apply start signal - Via LCP: Press [Hand On] - Or in Remote On mode: Apply start signal on terminal 18
[0] *	Off	AMT function is disabled.
[2]	Enable AMT	AMT function starts running. **NOTICE** **To gain optimum tuning of the frequency converter, run AMT on a cold motor.**

3-02 Minimum Reference		
Range:		**Function:**
0.00*	[-4999-4999]	Enter value for minimum reference. The sum of all internal and external references are clamped (limited) to the minimum reference value, *3-02 Minimum Reference*.

3-03 Maximum Reference

Range:		Function:
		Maximum Reference is adjustable in the range Minimum Reference -4999.
50.00*	[-4999-4999]	Enter value for Maximum Reference. The sum of all internal and external references are clamped (limited) to the maximum reference value, *3-03 Maximum Reference*.

3-41 Ramp1 Ramp-up Time

Range:		Function:
Size related*	[0.05-3600.00 s]	Enter ramp-up time from 0 Hz to rated motor frequency ($f_{M,N}$) set in *1-23 Motor Frequency*. Select a ramp-up time ensuring that torque limit is not exceeded, see *4-16 Torque Limit in Motor Mode*.

3-42 Ramp1 Ramp-down Time

Range:		Function:
Size related*	[0.05-3600.00 s]	Enter ramp down time from rated motor frequency ($f_{M,N}$) in *1-23 Motor Frequency* to 0 Hz. Select a ramp down time that does not cause overvoltage in the inverter due to regenerative operation of motor. Furthermore, regenerative torque must not exceed limit set in *4-17 Torque Limit in Generator Mode*.

7.4.2 Quick Menu Parameters - PI Basic Settings QM2

The following is a brief description of the parameters for the PI Basic Settings. For a more detailed description, see *VLT® Micro Drive FC 51 Programming Guide.*.

1-00 Configuration Mode

Option:		Function:
		Use this parameter for selecting the application control principle to be used when a Remote Reference is active. **NOTICE** Changing this parameter resets *3-00 Reference Range*, *3-02 Minimum Reference* and *3-03 Maximum Reference* to their default values. **NOTICE** This parameter cannot be adjusted while motor runs.
[0] *	Speed Open Loop	For normal speed control (References).

1-00 Configuration Mode

Option:		Function:
[3]	Process Closed Loop	Enables process closed loop control. See parameter group *7-3* Process PI Control* for further information on PI-controller.

3-02 Minimum Reference

Range:		Function:
0.00*	[-4999-4999]	Enter value for minimum reference. The sum of all internal and external references are clamped (limited) to the minimum reference value, *3-02 Minimum Reference*.

3-03 Maximum Reference

Range:		Function:
		Maximum Reference is adjustable in the range Minimum Reference -4999.
50.00*	[-4999-4999]	Enter value for Maximum Reference. The sum of all internal and external references are clamped (limited) to the maximum reference value, *3-03 Maximum Reference*.

3-10 Preset Reference

Option:		Function:
		Each parameter set-up contains 8 preset references which are selectable via 3 digital inputs or bus.

[18] Bit2	[17] Bit1	[16] Bit0	[16] Bit0
0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	0	6
1	1	1	7

Table 7.1 Parameter Group 5-1* Digital Inputs Option [16], [17] and [18]

Option:		Function:
[0.00] *	-100.00-100.00%	Enter the different preset references using array programming. Normally, 100%=value set in *3-03 Maximum Reference*. However, there are exceptions if *3-00 Reference Range* is set to *[0] Min - Max*. Example 1: *3-02 Minimum Reference* is set to 20 and *3-03 Maximum Reference* is set to 50. In this case 0%=0 and 100%=50. Example 2:

3-10 Preset Reference

Option:		Function:
		3-02 Minimum Reference is set to -70 and *3-03 Maximum Reference* is set to 50. In this case 0%=0 and 100%=70.

4-12 Motor Speed Low Limit

Range:		Function:
0.0 Hz*	[0.0-400.0 Hz]	Set the *Minimum Motor Speed Limit* corresponding to the minimum output frequency of the motor shaft.
		NOTICE
		As the minimum output frequency is an absolute value, it cannot be deviated from.

4-14 Motor Speed High Limit

Range:		Function:
65.0 Hz*	[0.0-400.0 Hz]	Set the *Maximum Motor Speed* corresponding to the maximum output frequency of the motor shaft.
		NOTICE
		As the maximum output frequency is an absolute value, it cannot be deviated from.

6-22 Terminal 60 Low Current

Range:		Function:
		This reference signal should correspond to minimum reference value set in *6-24 Terminal 60 Low Ref./Feedb. Value*.
0.14 mA*	[0.00-19.90 mA]	Enter low current value.

⚠CAUTION

The value must be set to min. 2 mA to activate the Live Zero Timeout function in *6-01 Live Zero Timeout Time*.

6-23 Terminal 60 High Current

Range:		Function:
		This reference signal should correspond to the high current value set in *6-25 Terminal 60 High Ref./Feedb. Value*.
20.00 mA*	[0.10-20.00 mA]	Enter high current value.

6-24 Terminal 60 Low Ref./Feedb. Value

Range:		Function:
		The scaling value corresponding to the low current set in *6-22 Terminal 60 Low Current*.
0.000*	[-4999-4999]	Enter analog input scaling value.

6-25 Terminal 60 High Ref./Feedb. Value

Range:		Function:
		The scaling value corresponding to the high current set in *6-23 Terminal 60 High Current*.
50.00*	[-4999-4999]	Enter analog input scaling value.

6-26 Terminal 60 Filter Time Constant

Range:		Function:
		A first-order digital low pass filter time constant for suppressing electrical noise in terminal 60. A high time constant value improves dampening, but also increases time delay through the filter.
		NOTICE
		This parameter cannot be changed while motor runs.
0.01 s*	[0.01-10.00 s]	Enter time constant.

7-20 Process CL Feedback Resources

Option:		Function:
		Select input to function as feedback signal.
[0] *	No Function	
[1]	Analog Input 53	
[2]	Analog Input 60	
[8]	Pulse Input 33	
[11]	Local Bus Ref.	

7-30 Process PI Normal/Inverse Control

Option:		Function:
[0] *	Normal	Feedback larger than setpoint results in a speed reduction. Feedback less than setpoint results in a speed increase.
[1]	Inverse	Feedback larger than setpoint results in a speed increase. Feedback less than setpoint results in a speed reduction.

7-31 Process PI Anti Windup

Option:		Function:
[0]	Disable	Regulation of a given error continues even when the output frequency cannot be increased/ decreased.
[1] *	Enable	PI-controller ceases from regulating a given error when the output frequency cannot be increased/ decreased.

7-32 Process PI Start Speed

Range:		Function:
0.0 Hz*	[0.0-200.0 Hz]	Until the set motor speed has been reached, the frequency converter operates in open loop mode.

7

7-33 Process PI Proportional Gain

Option:		Function:
[0.01] *	0.00-10.00	Enter the value for the P proportional gain, i.e. the multiplication factor of the error between the setpoint and the feedback signal. **NOTICE** 0.00=Off.

7-34 Process PI Integral Time

Range:		Function:
9999.00 s*	[0.10-9999.00 s]	The integrator provides an increasing gain at a constant error between the set point and the feedback signal. The integral time is the time needed by the integrator to reach the same gain as the proportional gain.

7-38 Process Feed Forward Factor

Range:		Function:
0%*	[0-400%]	The FF factor sends a part of the reference signal around the PI controller which then only affects part of the control signal. By activating the FF factor less overshoot and high dynamics are gained when changing the setpoint. This parameter is always active when *1-00 Configuration Mode* is set to *[3] Process*.

7.5 Main Menu

[Main Menu] is used for programming all parameters. The Main Menu parameters can be accessed immediately unless a password has been created via *0-60 Main Menu Password*. For most VLT® Micro Drive applications it is not necessary to access the Main Menu parameters, but instead the Quick Menu provides the simplest and quickest access to the typical required parameters.

The Main Menu accesses all parameters.

1. Press [Menu] key until indicator in display is placed above "Main Menu".

2. Use [▲] [▼] to browse through the parameter groups.

3. Press [OK] to select a parameter group.

4. Use [▲] [▼] to browse through the parameters in the specific group.

5. Press [OK] to select the parameter.

6. Use [▲] [▼] to set/change the parameter value.

Press [Back] to go back one level.

7.6 Quick Transfer of Parameter Settings between Multiple Frequency Converters

Once the set-up of a frequency converter is complete, Danfoss recommends to store the data in the LCP or on a PC via MCT 10 Set-up Software tool.

Data transfer from frequency converter to LCP:

⚠WARNING

Stop the motor before performing this operation.

1. Go to *0-50 LCP Copy*

2. Press [OK]

3. Select *[1] All to LCP*

4. Press [OK]

Connect the LCP to another frequency converter and copy the parameter settings to this frequency converter as well.

Data transfer from LCP to frequency converter:

⚠WARNING

Stop the motor before performing this operation.

1. Go to *0-50 LCP Copy*

2. Press [OK]

3. Select *[2] All from LCP*

4. Press [OK]

7.7 Read-out and Programming of Indexed Parameters

Use *chapter 7.4.2 Quick Menu Parameters - PI Basic Settings QM2* as an example.

Press [OK] for selecting a parameter and use [▲]/[▼] for maneuvering between the indexed values.

To change the parameter value, select the indexed value and press [OK].

Change the value using [▲]/[▼].

Press [OK] to accept the new setting.

Pressing [OK] for more than 1 s enters *Adjust* mode. In *Adjust* mode, it is possible to make fast adjustment by pressing [▲]/[▼] combined with [OK].

Press [▲]/[▼] to change value. Press [OK] to shift between digits quickly. To exit modification mode, press [OK] more than 1 s again with change saving or press [Back] without change saving. Press [Back] to leave the parameter.

7.8 Initialise the Frequency Converter to Default Settings in two Ways

Recommended initialisation (via *14-22 Operation Mode*)

1. Select *14-22 Operation Mode*.

2. Press [OK].

3. Select *Initialisation* and Press [OK].

4. Cut off the mains supply and wait until the display turns off.

5. Reconnect the mains supply - the frequency converter is now reset. *Except the following parameters.*

    8-30 Protocol

    8-31 Address

    8-32 Baud Rate

    8-33 Parity / Stop Bits

    8-35 Minimum Response Delay

    8-36 Maximum Response Delay

    15-00 Operating hours to *15-05 Over Volt's*

    15-03 Power Up's

    15-04 Over Temp's

    15-05 Over Volt's

    15-30 Alarm Log: Error Code

    15-4* Drive Identification parameters

2 finger initialisation:

1. Power off the frequency converter.

2. Press [OK] and [Menu].

3. Power up the frequency converter while still pressing the keys above for 10 s 2 finger initialisation

4. The frequency converter is now reset, except the following parameters:

    15-00 Operating hours

    15-03 Power Up's

    15-04 Over Temp's

    15-05 Over Volt's

    15-4* Drive identification parameters

Initialisation of parameters is confirmed by AL80 in the display after the power cycle.

8 RS-485 Installation and Set-up

8.1 RS-485 Installation and Set-up

8.1.1 Overview

RS-485 is a 2-wire bus interface compatible with multi-drop network topology, that is, nodes can be connected as a bus, or via drop cables from a common trunk line. A total of 32 nodes can be connected to one network segment. Repeaters divide network segments.

NOTICE

Each repeater functions as a node within the segment in which it is installed. Each node connected within a given network must have a unique node address across all segments.

Terminate each segment at both ends, using either the termination switch (S801) of the frequency converters or a biased termination resistor network. Always use screened twisted pair (STP) cable for bus cabling, and always follow good common installation practice.
Low-impedance ground connection of the screen at every node is important, including at high frequencies. Thus, connect a large surface of the screen to ground, for example with a cable clamp or a conductive cable gland. It may be necessary to apply potential-equalising cables to maintain the same earth potential throughout the network - particularly in installations with long cables.
To prevent impedance mismatch, always use the same type of cable throughout the entire network. When connecting a motor to the frequency converter, always use screened motor cable.

Cable	Screened twisted pair (STP)
Impedance [Ω]	120
Cable length [m]	Max. 1200 (including drop lines) Max. 500 station-to-station

Table 8.1 Cable Specifications

8.1.2 Network Connection

Connect the frequency converter to the RS-485 network as follows (see also *Illustration 8.1*):

1. Connect signal wires to terminal 68 (P+) and terminal 69 (N-) on the main control board of the frequency converter.

2. Connect the cable screen to the cable clamps.

NOTICE

Screened, twisted-pair cables are recommended to reduce noise between conductors.
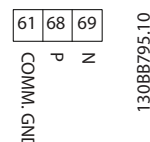

Illustration 8.1 Network Connection

8.1.3 Frequency Converter Hardware Set-up

Use the terminator dip switch on the main control board of the frequency converter to terminate the RS-485 bus.
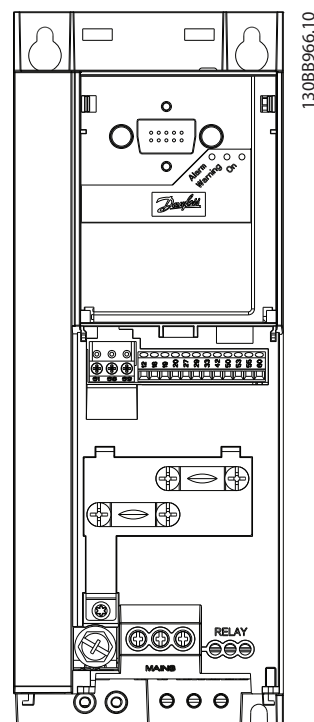
Illustration 8.2 Terminator Switch Factory Setting

The factory setting for the dip switch is OFF.

8.1.4 EMC Precautions

The following EMC precautions are recommended in order to achieve interference-free operation of the RS-485 network.

Relevant national and local regulations, for example regarding protective earth connection, must be observed. Keep the RS-485 communication cable away from motor and brake resistor cables to avoid coupling of high frequency noise from one cable to another. Normally, a distance of 200 mm (8 inches) is sufficient, but keeping the greatest possible distance between the cables is generally recommended, especially where cables run in parallel over long distances. When crossing is unavoidable, the RS-485 cable must cross motor and brake resistor cables at an angle of 90°.
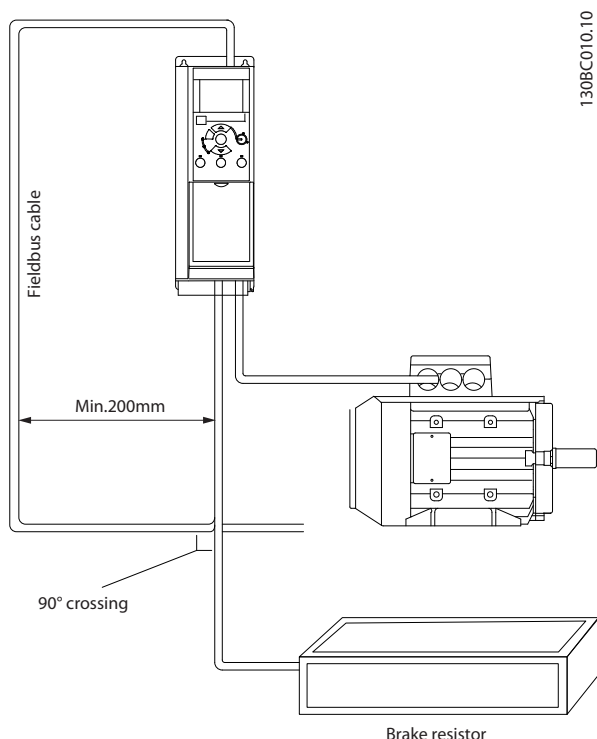
Illustration 8.3 EMC Precautions for RS-485

8.1.5 Frequency Converter Parameter Settings for Modbus Communication

The following parameters apply to the RS-485 interface (FC-port):

Parameter	Function
8-30 Protocol	Select the application protocol to run on the RS-485 interface
8-31 Address	Set the node address. **NOTICE** **The address range depends on the protocol selected in *8-30 Protocol***
8-32 Baud Rate	Set the baud rate. **NOTICE** **The default baud rate depends on the protocol selected in *8-30 Protocol***
8-33 Parity / Stop Bits	Set the parity and number of stop bits. **NOTICE** **The default selection depends on the protocol selected in *8-30 Protocol***
8-35 Minimum Response Delay	Specify a minimum delay time between receiving a request and transmitting a response. This function is for overcoming modem turnaround delays.
8-36 Maximum Response Delay	Specify a maximum delay time between transmitting a request and receiving a response.

Table 8.2 Parameters Related to RS-485 Interface

8.2 FC Protocol Overview

The FC protocol, also referred to as FC bus or Standard bus, is the Danfoss standard fieldbus. It defines an access technique according to the master-follower principle for communications via a serial bus.
One master and a maximum of 126 followers can be connected to the bus. The master selects the individual followers via an address character in the telegram. A follower itself can never transmit without first being requested to do so, and direct message transfer between the individual followers is not possible. Communications occur in the half-duplex mode.
The master function cannot be transferred to another node (single-master system).

The physical layer is RS-485, thus utilising the RS-485 port built into the frequency converter. The FC protocol supports different telegram formats:

- A short format of 8 bytes for process data

- A long format of 16 bytes that also includes a parameter channel

- A format used for texts

8.2.1 FC with Modbus RTU

The FC protocol provides access to the control word and bus reference of the frequency converter.

The control word allows the Modbus master to control several important functions of the frequency converter.

- Start

- Stop of the frequency converter in various ways:
  - Coast stop
  - Quick stop
  - DC Brake stop
  - Normal (ramp) stop

- Reset after a fault trip

- Run at various preset speeds

- Run in reverse

- Change of the active set-up

- Control of the 2 relays built into the frequency converter

The bus reference is commonly used for speed control. It is also possible to access the parameters, read their values, and where possible, write values to them. This permits a range of control options, including controlling the setpoint of the frequency converter when its internal PI controller is used.

8.3 Network Configuration

8.3.1 Frequency Converter Set-up

Set the following parameters to enable the FC protocol for the frequency converter.

Parameter	Setting
8-30 Protocol	FC
8-31 Address	1-126
8-32 Baud Rate	2400-115200
8-33 Parity / Stop Bits	Even parity, 1 stop bit (default)

Table 8.3 Network Configuration Parameters

8.4 FC Protocol Message Framing Structure

8.4.1 Content of a Character (byte)

Each character transferred begins with a start bit. Then 8 data bits are transferred, corresponding to a byte. Each character is secured via a parity bit. This bit is set at "1" when it reaches parity. Parity is when there is an equal number of 1s in the 8 data bits and the parity bit in total. A stop bit completes a character, thus consisting of 11 bits in all.
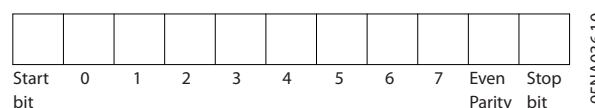
Illustration 8.4 Content of a Character

8.4.2 Telegram Structure

Each telegram has the following structure:

1. Start character (STX)=02 hex

2. A byte denoting the telegram length (LGE)

3. A byte denoting the frequency converter address (ADR)

A number of data bytes (variable, depending on the type of telegram) follows.

A data control byte (BCC) completes the telegram.

Illustration 8.5 Telegram Structure

8.4.3 Telegram Length (LGE)

The telegram length is the number of data bytes plus the address byte ADR and the data control byte BCC.

4 data bytes	LGE=4+1+1=6 bytes
12 data bytes	LGE=12+1+1=14 bytes
Telegramscontaining texts	10[1]+n bytes

Table 8.4 Length of Telegrams

[1] The 10 represents the fixed characters, while the "n'" is variable (depending on the length of the text).

8.4.4 Frequency Converter Address (ADR)

Address format 1-126

Bit 7=1 (address format 1-126 active)

Bit 0-6=frequency converter address 1-126

Bit 0-6=0 Broadcast

The follower returns the address byte unchanged to the master in the response telegram.

8.4.6 The Data Field

The structure of data blocks depends on the type of telegram. There are 3 telegram types, and the type applies for both control telegrams (master⇒follower) and response telegrams (follower⇒master).

The 3 types of telegram are:

Process block (PCD)
The PCD is made up of a data block of 4 bytes (2 words) and contains:

- Control word and reference value (from master to follower)

- Status word and present output frequency (from follower to master)

Illustration 8.6 Process Block

Parameter block
The parameter block is used to transfer parameters between master and follower. The data block is made up of 12 bytes (6 words) and also contains the process block.
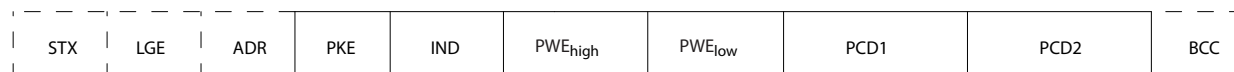
Illustration 8.7 Parameter Block

Text block
The text block is used to read or write texts via the data block.

Illustration 8.8 Text Block

8.4.5 Data Control Byte (BCC)

The checksum is calculated as an XOR-function. Before the first byte in the telegram is received, the calculated checksum is 0.

8.4.7 The PKE Field

The PKE field contains 2 subfields: Parameter command and response (AK) and Parameter number (PNU):
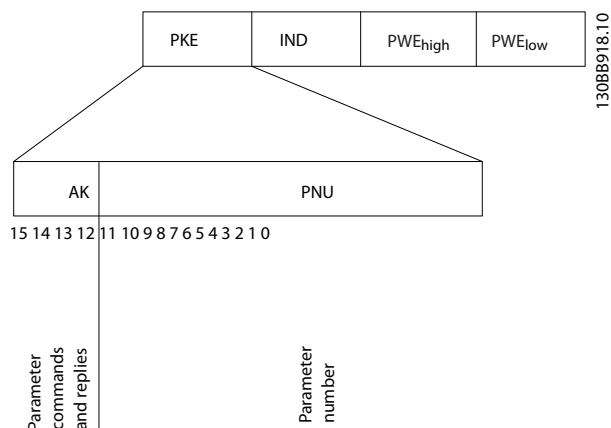
Illustration 8.9 PKE Field

Bits no. 12-15 transfer parameter commands from master to follower and return processed follower responses to the master.

Parameter commands master⇒follower				
Bit no.				**Parameter command**
15	14	13	12	
0	0	0	0	No command
0	0	0	1	Read parameter value
0	0	1	0	Write parameter value in RAM (word)
0	0	1	1	Write parameter value in RAM (double word)
1	1	0	1	Write parameter value in RAM and EEprom (double word)
1	1	1	0	Write parameter value in RAM and EEprom (word)
1	1	1	1	Read text

Table 8.5 Parameter Commands

Response follower⇒master				
Bit no.				**Response**
15	14	13	12	
0	0	0	0	No response
0	0	0	1	Parameter value transferred (word)
0	0	1	0	Parameter value transferred (double word)
0	1	1	1	Command cannot be performed
1	1	1	1	text transferred

Table 8.6 Response

If the command cannot be performed, the follower sends this response:
0111 Command cannot be performed
- and issues the following fault report in the parameter value:

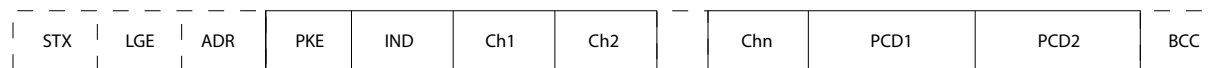| Error code	FC Specification
0	Illegal Parameter Number
1	Parameter cannot be changed.
2	Upper or lower limit exceeded
3	Subindex corrupted
4	No Array
5	Wrong Data Type
6	Not used
7	Not used
9	Description element not available
11	No parameter write access
15	No text available
17	Not while Running
18	Other error
100	
>100	
130	No bus access for this parameter
131	Write to factory set-up not possible
132	No LCP access
252	Unknown viewer
253	Request not supported
254	Unknown attribute
255	No error

Table 8.7 Follower Report

8.4.8 Parameter Number (PNU)

Bits no. 0-11 transfer parameter numbers. The function of the relevant parameter is defined in the parameter description in the *VLT® Micro Drive FC 51 Programming Guide*.

8.4.9 Index (IND)

The index is used with the parameter number to read/write-access parameters with an index, for example, *15-30 Alarm Log: Error Code*. The index consists of 2 bytes; a low byte, and a high byte. Index (IND)

Only the low byte is used as an index.

8.4.10 Parameter Value (PWE)

The parameter value block consists of 2 words (4 bytes), and the value depends on the defined command (AK). The master prompts for a parameter value when the PWE block contains no value. To change a parameter value (write),

write the new value in the PWE block and send from the master to the follower.

When a follower responds to a parameter request (read command), the present parameter value in the PWE block is transferred and returned to the master. If a parameter contains several data options, e.g. *0-01 Language*, select the data value by entering the value in the PWE block. Serial communication is only capable of reading parameters containing data type 9 (text string).

15-40 FC Type to *15-53 Power Card Serial Number* contain data type 9.
For example, read the unit size and mains voltage range in *15-40 FC Type*. When a text string is transferred (read), the length of the telegram is variable, and the texts are of different lengths. The telegram length is defined in the second byte of the telegram (LGE). When using text transfer, the index character indicates whether it is a read or a write command.

To read a text via the PWE block, set the parameter command (AK) to 'F' hex. The index character high-byte must be "4".

8.4.11 Data Types Supported by the Frequency Converter

Unsigned means that there is no operational sign in the telegram.

Data types	Description
3	Integer 16
4	Integer 32
5	Unsigned 8
6	Unsigned 16
7	Unsigned 32
9	Text string

Table 8.8 Data Types

8.4.12 Conversion

The various attributes of each parameter are displayed in the chapter *Parameter Lists* in the *Programming Guide*. Parameter values are transferred as whole numbers only. Conversion factors are therefore used to transfer decimals.

4-12 Motor Speed Low Limit [Hz] has a conversion factor of 0.1.
To preset the minimum frequency to 10 Hz, transfer the value 100. A conversion factor of 0.1 means that the value transferred is multiplied by 0.1. The value 100 is thus perceived as 10.0.

Conversion index	Conversion factor
74	3600
2	100
1	10
0	1
-1	0.1
-2	0.01
-3	0.001
-4	0.0001
-5	0.00001

Table 8.9 Conversion

8.4.13 Process Words (PCD)

The block of process words is divided into 2 blocks of 16 bits, which always occur in the defined sequence.

PCD 1	PCD 2
Control telegram (master⇒follower control word)	Reference-value
Control telegram (follower⇒master) status word	Present output frequency

Table 8.10 Process Words (PCD)

8.5 Examples

8.5.1 Writing a Parameter Value

Change *4-14 Motor Speed High Limit [Hz]* to 100 Hz. Write the data in EEPROM.

PKE=E19E hex - Write single word in *4-14 Motor Speed High Limit [Hz]*:

> IND=0000 hex
>
> PWEHIGH=0000 hex
>
> PWELOW=03E8 hex

Data value 1000, corresponding to 100 Hz, see *chapter 8.4.12 Conversion*.

The telegram looks like this:

E19E	H	0000	H	0000	H	03E8	H
PKE		IND		PWE high		PWE low	

Illustration 8.10 Telegram

130BA092.10

NOTICE

4-14 Motor Speed High Limit [Hz] **is a single word, and the parameter command for write in EEPROM is "E". Parameter 4-14 is 19E in hexadecimal.**

The response from the follower to the master is:

Illustration 8.11 Response from Master

8.5.2 Reading a Parameter Value

Read the value in *3-41 Ramp 1 Ramp Up Time*

PKE=1155 hex - Read parameter value in *3-41 Ramp 1 Ramp Up Time*
IND=0000 hex
PWE$_{HIGH}$=0000 hex
PWE$_{LOW}$=0000 hex

Illustration 8.12 Telegram

If the value in *3-41 Ramp 1 Ramp Up Time* is 10 s, the response from the follower to the master is:

Illustration 8.13 Response

3E8 hex corresponds to 1000 decimal. The conversion index for *3-41 Ramp 1 Ramp Up Time* is -2, that is, 0.01. *3-41 Ramp 1 Ramp Up Time* is of the type *Unsigned 32*.

8.6 Modbus RTU Overview

8.6.1 Assumptions

Danfoss assumes that the installed controller supports the interfaces in this document, and strictly observes all requirements and limitations stipulated in the controller and frequency converter.

8.6.2 What the User Should Already Know

The built-in Modbus RTU (Remote Terminal Unit) is designed to communicate with any controller that supports the interfaces defined in this document. It is assumed that the user has full knowledge of the capabilities and limitations of the controller.

8.6.3 Modbus RTU Overview

Regardless of the type of physical communication networks, the Modbus RTU Overview describes the process a controller uses to request access to another device. This process includes how the Modbus RTU responds to requests from another device, and how errors are detected and reported. It also establishes a common format for the layout and contents of message fields.
During communications over a Modbus RTU network, the protocol determines:

- How each controller learns its device address

- Recognises a message addressed to it

- Determines which actions to take

- Extracts any data or other information contained in the message

If a reply is required, the controller constructs the reply message and sends it.
Controllers communicate using a master-follower technique in which only the master can initiate transactions (called queries). Followers respond by supplying the requested data to the master, or by taking the action requested in the query.
The master can address individual followers, or initiate a broadcast message to all followers. Followers return a response to queries that are addressed to them individually. No responses are returned to broadcast queries from the master. The Modbus RTU protocol establishes the format for the master's query by providing the device (or broadcast) address, a function code defining the requested action, any data to be sent, and an error-checking field. The follower's response message is also constructed using Modbus protocol. It contains fields confirming the action taken, any data to be returned, and an error-checking field. If an error occurs in receipt of the message, or if the follower is unable to perform the

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requested action, the follower constructs an error message, and send it in response, or a time-out occurs.

8.6.4 Frequency Converter with Modbus RTU

The frequency converter communicates in Modbus RTU format over the built-in RS-485 interface. Modbus RTU provides access to the control word and bus reference of the frequency converter.

The control word allows the modbus master to control several important functions of the frequency converter:

- Start

- Stop of the frequency converter in various ways:
    - Coast stop
    - Quick stop
    - DC Brake stop
    - Normal (ramp) stop

- Reset after a fault trip

- Run at a variety of preset speeds

- Run in reverse

- Change the active set-up

- Control the frequency converter's built-in relay

The bus reference is commonly used for speed control. It is also possible to access the parameters, read their values, and where possible, write values to them. This permits a range of control options, including controlling the setpoint of the frequency converter when its internal PI controller is used.

8.7 Network Configuration

To enable Modbus RTU on the frequency converter, set the following parameters:

Parameter	Setting
8-30 Protocol	Modbus RTU
8-31 Address	1-247
8-32 Baud Rate	2400-115200
8-33 Parity / Stop Bits	Even parity, 1 stop bit (default)

Table 8.11 Network Configuration

8.8 Modbus RTU Message Framing Structure

8.8.1 Frequency Converter with Modbus RTU

The controllers are set up to communicate on the Modbus network using RTU (Remote Terminal Unit) mode, with each byte in a message containing 2 4-bit hexadecimal characters. The format for each byte is shown in *Table 8.12*.

Start bit	Data byte								Stop/ parity	Stop

Table 8.12 Format for Each Byte

Coding System	8-bit binary, hexadecimal 0-9, A-F. 2 hexadecimal characters contained in each 8-bit field of the message
Bits Per Byte	1 start bit 8 data bits, least significant bit sent first 1 bit for even/odd parity; no bit for no parity 1 stop bit if parity is used; 2 bits if no parity
Error Check Field	Cyclical Redundancy Check (CRC)

8.8.2 Modbus RTU Message Structure

The transmitting device places a Modbus RTU message into a frame with a known beginning and ending point. This allows receiving devices to begin at the start of the message, read the address portion, determine which device is addressed (or all devices, if the message is broadcast), and to recognise when the message is completed. Partial messages are detected and errors set as a result. Characters for transmission must be in hexadecimal 00 to FF format in each field. The frequency converter continuously monitors the network bus, also during 'silent' intervals. When the first field (the address field) is received, each frequency converter or device decodes it to determine which device is being addressed. Modbus RTU messages addressed to zero are broadcast messages. No response is permitted for broadcast messages. A typical message frame is shown in *Table 8.13*.

Start	Address	Function	Data	CRC check	End
T1-T2-T3-T4	8 bits	8 bits	N x 8 bits	16 bits	T1-T2-T3-T4

Table 8.13 Typical Modbus RTU Message Structure

8.8.3 Start/Stop Field

Messages start with a silent period of at least 3.5 character intervals. This is implemented as a multiple of character intervals at the selected network baud rate (shown as Start T1-T2-T3-T4). The first field to be transmitted is the device address. Following the last transmitted character, a similar period of at least 3.5 character intervals marks the end of the message. A new message can begin after this period. The entire message frame must be transmitted as a continuous stream. If a silent period of more than 1.5 character intervals occurs before completion of the frame, the receiving device flushes the incomplete message and assumes that the next byte is the address field of a new message. Similarly, if a new message begins before 3.5 character intervals after a previous message, the receiving device considers it a continuation of the previous message. This causes a time-out (no response from the follower), since the value in the final CRC field is not valid for the combined messages.

8.8.4 Address Field

The address field of a message frame contains 8 bits. Valid follower device addresses are in the range of 0-247 decimal. The individual follower devices are assigned addresses in the range of 1-247. (0 is reserved for broadcast mode, which all followers recognise.) A master addresses a follower by placing the follower address in the address field of the message. When the follower sends its response, it places its own address in this address field to let the master know which follower is responding.

8.8.5 Function Field

The function field of a message frame contains 8 bits. Valid codes are in the range of 1-FF. Function fields are used to send messages between master and follower. When a message is sent from a master to a follower device, the function code field tells the follower what kind of action to perform. When the follower responds to the master, it uses the function code field to indicate either a normal (error-free) response, or that some kind of error occurred (called an exception response). For a normal response, the follower simply echoes the original function code. For an exception response, the follower returns a code that is equivalent to the original function code with its most significant bit set to logic 1. In addition, the follower places a unique code into the data field of the response message. This tells the master what kind of error occurred, or the reason for the exception. Also refer to the sections *chapter 8.8.10 Function Codes Supported by Modbus RTU* and *chapter 8.8.11 Modbus Exception Codes*.

8.8.6 Data Field

The data field is constructed using sets of 2 hexadecimal digits, in the range of 00 to FF hexadecimal. These are made up of one RTU character. The data field of messages sent from a master to follower device contains additional information which the follower must use to take the action defined by the function code. This can include items such as coil or register addresses, the quantity of items to be handled, and the count of actual data bytes in the field.

8.8.7 CRC Check Field

Messages include an error-checking field, operating based on a Cyclical Redundancy Check (CRC) method. The CRC field checks the contents of the entire message. It is applied regardless of any parity check method used for the individual characters of the message. The CRC value is calculated by the transmitting device, which appends the CRC as the last field in the message. The receiving device recalculates a CRC during receipt of the message and compares the calculated value to the actual value received in the CRC field. If the 2 values are unequal, a bus time-out results. The error-checking field contains a 16-bit binary value implemented as 2 8-bit bytes. When this is done, the low-order byte of the field is appended first, followed by the high-order byte. The CRC high-order byte is the last byte sent in the message.

8.8.8 Coil Register Addressing

In Modbus, all data are organised in coils and holding registers. Coils hold a single bit, whereas holding registers hold a 2-byte word (that is 16 bits). All data addresses in Modbus messages are referenced to zero. The first occurrence of a data item is addressed as item number zero. For example: The coil known as 'coil 1' in a programmable controller is addressed as coil 0000 in the data address field of a Modbus message. Coil 127 decimal is addressed as coil 007Ehex (126 decimal).
Holding register 40001 is addressed as register 0000 in the data address field of the message. The function code field already specifies a 'holding register' operation. Therefore, the '4XXXX' reference is implicit. Holding register 40108 is addressed as register 006Bhex (107 decimal).

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Coil Number	Description	Signal Direction
1-16	Frequency converter control word (see *Table 8.15*)	Master to follower
17-32	Frequency converter speed or set-point reference Range 0x0-0xFFFF (-200% ... ~200%)	Master to follower
33-48	Frequency converter status word (see *Table 8.15*)	Follower to master
49-64	Open loop mode: Frequency converter output frequency Closed loop mode: Frequency converter feedback signal	Follower to master
65	Parameter write control (master to follower) 0 Parameter changes are written = to the RAM of the frequency converter 1 Parameter changes are written = to the RAM and EEPROM of the frequency converter.	Master to follower
66-65536	Reserved	

Table 8.14 Coil Register

Coil	0	1
01	Preset reference LSB	
02	Preset reference MSB	
03	DC brake	No DC brake
04	Coast stop	No coast stop
05	Quick stop	No quick stop
06	Freeze freq.	No freeze freq.
07	Ramp stop	Start
08	No reset	Reset
09	No jog	Jog
10	Ramp 1	Ramp 2
11	Data not valid	Data valid
12	Relay 1 off	Relay 1 on
13	Relay 2 off	Relay 2 on
14	Set up LSB	
15		
16	No reversing	Reversing

Table 8.15 Frequency Converter Control Word (FC Profile)

Coil	0	1
33	Control not ready	Control ready
34	Frequency converter not ready	Frequency converter ready
35	Coasting stop	Safety closed
36	No alarm	Alarm
37	Not used	Not used
38	Not used	Not used
39	Not used	Not used
40	No warning	Warning
41	Not at reference	At reference
42	Hand mode	Auto mode
43	Out of freq. range	In frequency range
44	Stopped	Running
45	Not used	Not used
46	No voltage warning	Voltage warning
47	Not in current limit	Current limit
48	No thermal warning	Thermal warning

Table 8.16 Frequency Converter Status Word (FC Profile)

Bus adress	Bus register[1]	PLC Register	Content	Access	Description
0	1	40001	Reserved		Reserved for Legacy Drives VLT 5000 and VLT 2800
1	2	40002	Reserved		Reserved for Legacy Drives VLT 5000 and VLT 2800
2	3	40003	Reserved		Reserved for Legacy Drives VLT 5000 and VLT 2800
3	4	40004	Free		
4	5	40005	Free		
5	6	40006	Modbus conf	Read/Write	TCP only. Reserved for Modbus TCP (p12-28 and 12-29 - store in Eeprom etc.)
6	7	40007	Last error code	Read only	Error code recieved from parameter database, refer to WHAT 38295 for details
7	8	40008	Last error register	Read only	Address of register with which last error occurred, refer to WHAT 38296 for details
8	9	40009	Index pointer	Read/Write	Sub index of parameter to be accessed. Refer to WHAT 38297 for details
9	10	40010	FC par. 0-01	Dependent on parameter access	Parameter 0-01 (Modbus Register=10 parameter number 20 bytes space reserved pr parameter in Modbus Map
19	20	40020	FC par. 0-02	Dependent on parameter access	Parameter 0-02 20 bytes space reserved pr parameter in Modbus Map
29	30	40030	FC par. xx-xx	Dependent on parameter access	Parameter 0-03 20 bytes space reserved pr parameter in Modbus Map

Table 8.17 Adress/Registers

[1] *Value written in Modbus RTU telegram must be one or less than register number. E.g. Read Modbus Register 1 by writing value 0 in telegram.*

8.8.9 How to Control the Frequency Converter

This section describes codes which can be used in the function and data fields of a Modbus RTU message.

8.8.10 Function Codes Supported by Modbus RTU

Modbus RTU supports use of the following function codes in the function field of a message.

Function	Function code (hex)
Read coils	1
Read holding registers	3
Write single coil	5
Write single register	6
Write multiple coils	F
Write multiple registers	10
Get comm. event counter	B
Report follower ID	11

Table 8.18 Function Codes

Function	Function Code	Sub-function code	Sub-function
Diagnostics	8	1	Restart communication
		2	Return diagnostic register
		10	Clear counters and diagnostic register
		11	Return bus message count
		12	Return bus communication error count
		13	Return follower error count
		14	Return follower message count

Table 8.19 Function Codes

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8.8.11 Modbus Exception Codes

For a full explanation of the structure of an exception code response, refer to *chapter 8.8.5 Function Field*.

Code	Name	Meaning
1	Illegal function	The function code received in the query is not an allowable action for the server (or follower). This may be because the function code is only applicable to newer devices, and was not implemented in the unit selected. It could also indicate that the server (or follower) is in the wrong state to process a request of this type, for example because it is not configured and is being asked to return register values.
2	Illegal data address	The data address received in the query is not an allowable address for the server (or follower). More specifically, the combination of reference number and transfer length is invalid. For a controller with 100 registers, a request with offset 96 and length 4 would succeed, a request with offset 96 and length 5 generates exception 02.
3	Illegal data value	A value contained in the query data field is not an allowable value for server (or follower). This indicates a fault in the structure of the remainder of a complex request, such as that the implied length is incorrect. It specifically does NOT mean that a data item submitted for storage in a register has a value outside the expectation of the application program, since the Modbus protocol is unaware of the significance of any particular value of any particular register.
4	Follower device failure	An unrecoverable error occurred while the server (or follower) was attempting to perform the requested action.

Table 8.20 Modbus Exception Codes

8.9 How to Access Parameters

8.9.1 Parameter Handling

The PNU (Parameter Number) is translated from the register address contained in the Modbus read or write message. The parameter number is translated to Modbus as (10 x parameter number) DECIMAL. Example: Reading *3-12 Catch up/slow Down Value* (16bit): The holding register 3120 holds the parameters value. A value of 1352 (Decimal), means that the parameter is set to 12.52%

Reading *3-14 Preset Relative Reference* (32bit): The holding registers 3410 & 3411 holds the parameters value. A value of 11300 (Decimal), means that the parameter is set to 1113.00.

For information on the parameters, size and converting index, consult the product relevant programming guide.

8.9.2 Storage of Data

The coil 65 decimal determines whether data written to the frequency converter are stored in EEPROM and RAM (coil 65=1) or only in RAM (coil 65= 0).

8.9.3 IND (Index)

Some parameters in the frequency converter are array parameters e.g. *3-10 Preset Reference*. Since the Modbus does not support arrays in the holding registers, the frequency converter has reserved the holding register 9 as pointer to the array. Before reading or writing an array parameter, set the holding register 9. Setting holding register to the value of 2 causes all following read/write to array parameters to be to the index 2. See also .

8.9.4 Text Blocks

Parameters stored as text strings are accessed in the same way as the other parameters. The maximum text block size is 20 characters. If a read request for a parameter is for more characters than the parameter stores, the response is truncated. If the read request for a parameter is for fewer characters than the parameter stores, the response is space filled.

8.9.5 Conversion Factor

The different attributes for each parameter can be seen in the section on factory settings. Since a parameter value can only be transferred as a whole number, a conversion factor must be used to transfer decimals. Refer to the *chapter 7.4 Quick Menu Parameters*.

8.9.6 Parameter Values

Standard data types
Standard data types are int 16, int 32, uint 8, uint 16 and uint 32. They are stored as 4x registers (40001–4FFFF). The parameters are read using function 03hex "Read Holding Registers." Parameters are written using the function 6hex "Preset Single Register" for 1 register (16 bits), and the function 10 hex "Preset Multiple Registers" for 2 registers (32 bits). Readable sizes range from 1 register (16 bits) up to 10 registers (20 characters).

Non-standard data types

Non-standard data types are text strings and are stored as 4x registers (40001–4FFFF). The parameters are read using function 03hex "Read Holding Registers" and written using function 10hex "Preset Multiple Registers." Readable sizes range from 1 register (2 characters) up to 10 registers (20 characters).

8.10 Examples

The following examples illustrate various Modbus RTU commands. If an error occurs, refer to *chapter 8.8.11 Modbus Exception Codes*.

8.10.1 Read Coil Status (01 hex)

Description

This function reads the ON/OFF status of discrete outputs (coils) in the frequency converter. Broadcast is never supported for reads.

Query

The query message specifies the starting coil and quantity of coils to be read. Coil addresses start at zero, that is, coil 33 is addressed as 32.

Example of a request to read coils 33-48 (status word) from follower device 01.

Field Name	Example (hex)
Follower Address	01 (frequency converter address)
Function	01 (read coils)
Starting Address HI	00
Starting Address LO	20 (32 decimals) Coil 33
No. of Points HI	00
No. of Points LO	10 (16 decimals)
Error Check (CRC)	-

Table 8.21 Query

Response

The coil status in the response message is packed as one coil per bit of the data field. Status is indicated as: 1=ON; 0=OFF. The LSB of the first data byte contains the coil addressed in the query. The other coils follow toward the high order end of this byte, and from 'low-order to high-order' in subsequent bytes.
If the returned coil quantity is not a multiple of 8, the remaining bits in the final data byte is padded with zeros (toward the high order end of the byte). The byte count field specifies the number of complete bytes of data.

Field Name	Example (hex)
Follower Address	01 (frequency converter address)
Function	01 (read coils)
Byte Count	02 (2 bytes of data)
Data (Coils 40-33)	07
Data (Coils 48-41)	06 (STW=0607hex)
Error Check (CRC)	-

Table 8.22 Response

NOTICE

Coils and registers are addressed explicitly with an offset of -1 in Modbus.
I.e. Coil 33 is addressed as Coil 32.

8.10.2 Force/Write Single Coil (05 hex)

Description

This function forces the coil to either ON or OFF. When broadcast, the function forces the same coil references in all attached followers.

Query

The query message specifies the coil 65 (parameter write control) to be forced. Coil addresses start at zero, that is, coil 65 is addressed as 64. Force Data=00 00hex (OFF) or FF 00hex (ON).

Field Name	Example (hex)
Follower Address	01 (Frequency converter address)
Function	05 (write single coil)
Coil Address HI	00
Coil Address LO	40 (64 decimal) Coil 65
Force Data HI	FF
Force Data LO	00 (FF 00=ON)
Error Check (CRC)	-

Table 8.23 Query

Response

The normal response is an echo of the query, returned after the coil state has been forced.

Field Name	Example (hex)
Follower Address	01
Function	05
Force Data HI	FF
Force Data LO	00
Quantity of Coils HI	00
Quantity of Coils LO	01
Error Check (CRC)	-

Table 8.24 Response

8.10.3 Force/Write Multiple Coils (0F hex)

Description
This function forces each coil in a sequence of coils to either ON or OFF. When broadcasting the function forces the same coil references in all attached followers.

Query
The query message specifies the coils 17 to 32 (speed setpoint) to be forced.

Field Name	Example (hex)
Follower Address	01 (frequency converter address)
Function	0F (write multiple coils)
Coil Address HI	00
Coil Address LO	10 (coil address 17)
Quantity of Coils HI	00
Quantity of Coils LO	10 (16 coils)
Byte Count	02
Force Data HI (Coils 8-1)	20
Force Data LO (Coils 16-9)	00 (ref.=2000 hex)
Error Check (CRC)	-

Table 8.25 Query

Response
The normal response returns the follower address, function code, starting address, and quantity of coils forced.

Field Name	Example (hex)
Follower Address	01 (frequency converter address)
Function	0F (write multiple coils)
Coil Address HI	00
Coil Address LO	10 (coil address 17)
Quantity of Coils HI	00
Quantity of Coils LO	10 (16 coils)
Error Check (CRC)	-

Table 8.26 Response

8.10.4 Read Holding Registers (03 hex)

Description
This function reads the contents of holding registers in the follower.

Query
The query message specifies the starting register and quantity of registers to be read. Register addresses start at zero, that is, registers 1-4 are addressed as 0-3.

Example: Read *3-03 Maximum Reference*, register 03030.

Field Name	Example (hex)
Follower Address	01
Function	03 (read holding registers)
Starting Address HI	0B (Register address 3029)
Starting Address LO	D5 (Register address 3029)
No. of Points HI	00
No. of Points LO	02 - (*3-03 Maximum Reference* is 32 bits long, i.e. 2 registers)
Error Check (CRC)	-

Table 8.27 Query

Response
The register data in the response message are packed as 2 bytes per register, with the binary contents right justified within each byte. For each register, the first byte contains the high-order bits and the second contains the low-order bits.

Example: hex 000088B8=35.000=35 Hz.

Field Name	Example (hex)
Follower Address	01
Function	03
Byte Count	04
Data HI (Register 3030)	00
Data LO (Register 3030)	16
Data HI (Register 3031)	E3
Data LO (Register 3031)	60
Error Check (CRC)	-

Table 8.28 Response

8.10.5 Preset Single Register (06 hex)

Description
This function presets a value into a single holding register.

Query
The query message specifies the register reference to be preset. Register addresses start at zero, that is, register 1 is addressed as 0.

Example: Write to *1-00 Configuration Mode*, register 1000.

Field Name	Example (hex)
Follower Address	01
Function	06
Register Address HI	03 (Register address 999)
Register Address LO	E7 (Register address 999)
Preset Data HI	00
Preset Data LO	01
Error Check (CRC)	-

Table 8.29 Query

Response

The normal response is an echo of the query, returned after the register contents have been passed.

Field Name	Example (hex)
Follower Address	01
Function	06
Register Address HI	03
Register Address LO	E7
Preset Data HI	00
Preset Data LO	01
Error Check (CRC)	-

Table 8.30 Response

8.10.6 Preset Multiple Registers (10 hex)

Description

This function presets values into a sequence of holding registers.

Query

The query message specifies the register references to be preset. Register addresses start at zero, that is, register 1 is addressed as 0. Example of a request to preset 2 registers (set *1-24 Motor Current* to 738 (7.38 A)):

Field Name	Example (hex)
Follower Address	01
Function	10
Starting Address HI	04
Starting Address LO	07
No. of Registers HI	00
No. of registers LO	02
Byte Count	04
Write Data HI (Register 4: 1049)	00
Write Data LO (Register 4: 1049)	00
Write Data HI (Register 4: 1050)	02
Write Data LO (Register 4: 1050)	E2
Error Check (CRC)	-

Table 8.31 Query

Response

The normal response returns the follower address, function code, starting address, and quantity of registers preset.

Field Name	Example (hex)
Follower Address	01
Function	10
Starting Address HI	04
Starting Address LO	19
No. of Registers HI	00
No. of registers LO	02
Error Check (CRC)	-

Table 8.32 Response

8.11 FC Drive Control Profile

8.11.1 Control Word According to FC Profile (8-10 Protocol = FC profile)

Modbus Holding Register numbers for Input data – CTW and REF – and Output data – STW and MAV – are defined in *Table 8.33*:

50000 Input data	Frequency converter Control Word register (CTW)
50010 Input data	Bus Reference register (REF)
50200 Output data	Frequency converter Status Word register (STW)
50210 Output data	Frequency converter Main Value register (MAV)

Table 8.33 Modbus Holding Register Numbers for Input and Output Data

In VLT Micro Drives after the software version 2.32 the new feature has been implemented by copying the Input/Output data to also be available in a lower holding register areas:

02810 Input data	Frequency converter Control Word register (CTW)
02811 Input data	Bus Reference register (REF)
02910 Output data	Frequency converter Status Word register (STW)
02911 Output data	Frequency converter Main Value register (MAV)

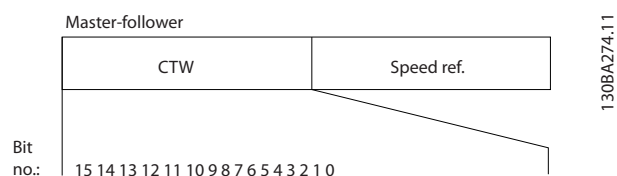**Table 8.34 Lower Register Numbers for Input and Output Data**

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Illustration 8.14

Bit	Bit value=0	Bit value=1
00	Reference value	external selection lsb
01	Reference value	external selection msb
02	DC brake	Ramp
03	Coasting	No coasting
04	Quick stop	Ramp
05	Hold output frequency	use ramp
06	Ramp stop	Start
07	No function	Reset
08	No function	Jog
09	Ramp 1	Ramp 2
10	Data invalid	Data valid
11	Relay 01 open	Relay 01 active
12	Relay 02 open	Relay 02 active
13	Parameter set-up	selection lsb
15	No function	Reverse

Table 8.35 Definition of Control Bits

Explanation of the Control Bits
Bits 00/01
Bits 00 and 01 are used to select between the 4 reference values, which are pre-programmed in *3-10 Preset Reference* according to the *Table 8.36*.

Programmed ref. value	Parameter	Bit 01	Bit 00
1	*3-10 Preset Reference* [0]	0	0
2	*3-10 Preset Reference* [1]	0	1
3	*3-10 Preset Reference* [2]	1	0
4	*3-10 Preset Reference* [3]	1	1

Table 8.36 Control bits

NOTICE

Make a selection in *8-56 Preset Reference Select* to define how Bit 00/01 gates with the corresponding function on the digital inputs.

Bit 02, DC brake
Bit 02='0' leads to DC braking and stop. Set braking current and duration in *2-01 DC Brake Current* and *2-02 DC Braking Time*.
Bit 02='1' leads to ramping.

Bit 03, Coasting
Bit 03='0': The frequency converter immediately "lets go" of the motor, (the output transistors are "shut off") and it coasts to a standstill.
Bit 03='1': The frequency converter starts the motor if the other starting conditions are met.

Make a selection in *8-50 Coasting Select* to define how Bit 03 gates with the corresponding function on a digital input.

Bit 04, Quick stop
Bit 04='0': Makes the motor speed ramp down to stop (set in *3-81 Quick Stop Ramp Time*).

Bit 05, Hold output frequency
Bit 05='0': The present output frequency (in Hz) freezes. Change the frozen output frequency only with the digital inputs (*5-10 Terminal 18 Digital Input* to *5-13 Terminal 29 Digital Input*) programmed to *Speed up=21* and *Slow down=22*.

NOTICE

If Freeze output is active, the frequency converter can only be stopped by the following:

- **Bit 03 Coasting stop**

- **Bit 02 DC braking**

- **Digital input (*5-10 Terminal 18 Digital Input* to *5-13 Terminal 29 Digital Input*) programmed to *DC braking=5, Coasting stop=2,* or *Reset and coasting stop=3*.**

Bit 06, Ramp stop/start
Bit 06='0': Causes a stop and makes the motor speed ramp down to stop via the selected ramp down parameter. Bit 06='1': Permits the Frequency converter to start the motor, if the other starting conditions are met.

Make a selection in *8-53 Start Select* to define how Bit 06 Ramp stop/start gates with the corresponding function on a digital input.

Bit 07, Reset
Bit 07='0': No reset.
Bit 07='1': Resets a trip. Reset is activated on the signal's leading edge, i.e. when changing from logic '0' to logic '1'.

Bit 08, Jog
Bit 08='1': The output frequency is determined by *3-11 Jog Speed [Hz]*.

Bit 09, Selection of ramp 1/2
Bit 09='0': Ramp 1 is active (*3-41 Ramp 1 Ramp Up Time* to *3-42 Ramp 1 Ramp Down Time*).
Bit 09='1': Ramp 2 (*3-51 Ramp 2 Ramp Up Time* to *3-52 Ramp 2 Ramp Down Time*) is active.

Bit 10, Data not valid/Data valid
Tell the frequency converter whether to use or ignore the control word.

Bit 10='0': The control word is ignored.
Bit 10='1': The control word is used.
This function is relevant because the telegram always contains the control word, regardless of the telegram type. Turn off the control word if not wanting to use it when updating or reading parameters.

Bit 11, Relay 01

Bit 11='0': Relay not activated.
Bit 11='1': Relay 01 activated provided that *Control word bit 11=36* is selected in *5-40 Function Relay*.

Bit 12, Relay 02

Bit 12='0': Relay 02 is not activated.
Bit 12='1': Relay 02 is activated provided that *Control word bit 12=37* is selected in *5-40 Function Relay*.

Bit 13, Selection of set-up

Use bit 13 to select from the 2 menu set-ups according to *Table 8.37*.

Set-up	Bit 13
1	0
2	1

Table 8.37 Set-up Selection

The function is only possible when *Multi Set-Ups=9* is selected in *0-10 Active Set-up*.

Make a selection in *8-55 Set-up Select* to define how Bit 13 gates with the corresponding function on the digital inputs.

Bit 15 Reverse

Bit 15='0': No reversing.
Bit 15='1': Reversing. In the default setting, reversing is set to digital in *8-54 Reversing Select*. Bit 15 causes reversing only when Ser. communication, Logic or Logic and is selected.

8.11.2 Status Word According to FC Profile (STW) (*8-30 Protocol* = FC profile)
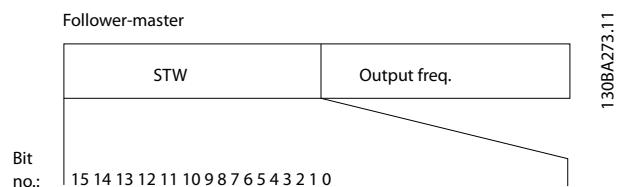
Illustration 8.15 Status Word

Bit	Bit=0	Bit=1
00	Control not ready	Control ready
01	Drive not ready	Drive ready
02	Coasting	Enable
03	No error	Trip
04	No error	Error (no trip)
05	Reserved	-
06	No error	Triplock
07	No warning	Warning
08	Speed ≠ reference	Speed=reference
09	Local operation	Bus control
10	Out of frequency limit	Frequency limit OK
11	No operation	In operation
12	Drive OK	Stopped, auto start
13	Voltage OK	Voltage exceeded
14	Torque OK	Torque exceeded
15	Timer OK	Timer exceeded

Table 8.38 Status Word According to FC Profile

Explanation of the status bits

Bit 00, Control not ready/ready

Bit 00='0': The frequency converter trips.
Bit 00='1': The frequency converter controls are ready but the power component does not necessarily receive any power supply (in case of external 24 V supply to controls).

Bit 01, Drive ready

Bit 01='0': The frequency converter is not ready.

Bit 01='1': The frequency converter is ready for operation but the coasting command is active via the digital inputs or via serial communication.

Bit 02, Coasting stop

Bit 02='0': The frequency converter releases the motor.
Bit 02='1': The frequency converter starts the motor with a start command.

Bit 03, No error/trip

Bit 03='0' : The frequency converter is not in fault mode.
Bit 03='1': The frequency converter trips. To re-establish operation, press [Reset].

Bit 04, No error/error (no trip)

Bit 04='0': The frequency converter is not in fault mode.
Bit 04='1': The frequency converter shows an error but does not trip.

Bit 05, Not used

Bit 05 is not used in the status word.

Bit 06, No error / triplock

Bit 06='0': The frequency converter is not in fault mode. Bit 06="1": The frequency converter is tripped and locked.

Bit 07, No warning/warning

Bit 07='0': There are no warnings.
Bit 07='1': A warning has occurred.

Bit 08, Speed≠ reference/speed=reference

Bit 08='0': The motor is running but the present speed is different from the preset speed reference. It might for example, be the case when the speed ramps up/down during start/stop.

Bit 08='1': The motor speed matches the preset speed reference.

Bit 09, Local operation/bus control

Bit 09='0': [Off/Reset] is activate on the control unit or *Local control* in *3-13 Reference Site* is selected. It is not possible to control the frequency converter via serial communication.

Bit 09='1' It is possible to control the frequency converter via the fieldbus/serial communication.

Bit 10, Out of frequency limit

Bit 10='0': The output frequency has reached the value in *4-12 Motor Speed Low Limit [Hz]* or *4-14 Motor Speed High Limit [Hz]*.

Bit 10="1": The output frequency is within the defined limits.

Bit 11, No operation/in operation

Bit 11='0': The motor is not running.

Bit 11='1': The coasting has a start signal or the output frequency is greater than 0 Hz.

Bit 12, Drive OK/stopped, autostart

Bit 12='0': There is no temporary over temperature on the inverter.

Bit 12='1': The inverter stops because of over temperature but the unit does not trip and resumes operation once the over temperature stops.

Bit 13, Voltage OK/limit exceeded

Bit 13='0': There are no voltage warnings.

Bit 13='1': The DC voltage in the frequency converter's intermediate circuit is too low or too high.

Bit 14, Torque OK/limit exceeded

Bit 14='0': The motor current is lower than the torque limit selected in *4-18 Current Limit*.

Bit 14='1': The torque limit in *4-18 Current Limit* is exceeded.

Bit 15, Timer OK/limit exceeded

Bit 15='0': The timers for motor thermal protection and thermal protection are not exceeded 100%.

Bit 15='1': One of the timers exceeds 100%.

8.11.3 Bus Speed Reference Value

Speed reference value is transmitted to the frequency converter in a relative value in %. The value is transmitted in the form of a 16-bit word; in integers (0-32767) the value 16384 (4000 hex) corresponds to 100%. Negative figures are formatted by means of 2's complement. The actual output frequency (MAV) is scaled in the same way as the bus reference.
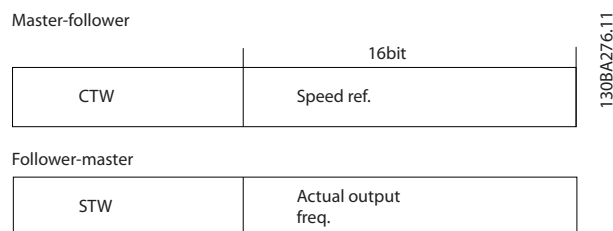
Illustration 8.16 Actual Output Frequency (MAV)

The reference and MAV are scaled as follows:
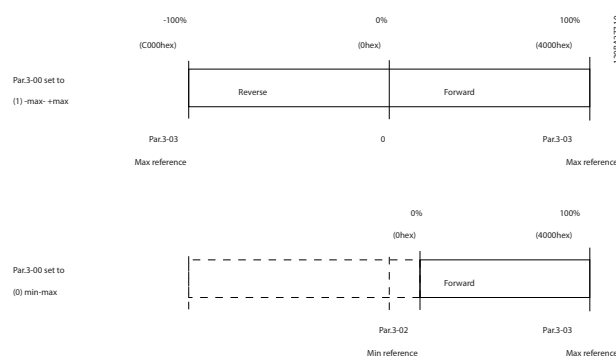
Illustration 8.17 Reference and MAV

9 Specifications

9.1.1 Mains Supply 1x200-240 V AC

Normal overload 150% for 1 minute					
Frequency converter	PK18	PK37	PK75	P1K5	P2K2
Typical Shaft Output [kW]	**0.18**	**0.37**	**0.75**	**1.5**	**2.2**
Typical Shaft Output [HP]	0.25	0.5	1	2	3
IP20	M1	M1	M1	M2	M3
Output current					
Continuous (1x200-240 V AC) [A]	1.2	2.2	4.2	6.8	9.6
Intermittent (1x200-240 V AC) [A]	1.8	3.3	6.3	10.2	14.4
Max. cable size:					
(mains, motor) [mm²/AWG]	4/10				
Max. input current					
Continuous (1x200-240 V) [A]	3.3	6.1	11.6	18.7	26.4
Intermittent (1x200-240 V) [A]	4.5	8.3	15.6	26.4	37.0
Max. mains fuses [A]	See *chapter 6.6.1 Fuses*				
Environment					
Estimated power loss [W],	12.5/	20.0/	36.5/	61.0/	81.0/
Best case/Typical[1]	15.5	25.0	44.0	67.0	85.1
Weight enclosure IP20 [kg]	1.1	1.1	1.1	1.6	3.0
Efficiency [%],	95.6/	96.5/	96.6/	97.0/	96.9/
Best case/Typical[1]	94.5	95.6	96.0	96.7	97.1

Table 9.1 Mains Supply 1x200-240 V AC

[1] At rated load conditions

9.1.2 Mains Supply 3x200-240 V AC

Normal overload 150% for 1 min						
Frequency converter	PK25	PK37	PK75	P1K5	P2K2	P3K7
Typical Shaft Output [kW]	**0.25**	**0.37**	**0.75**	**1.5**	**2.2**	**3.7**
Typical Shaft Output [HP]	0.33	0.5	1	2	3	5
IP20	M1	M1	M1	M2	M3	M3
Output current						
Continuous (3x200-240 V) [A]	1.5	2.2	4.2	6.8	9.6	15.2
Intermittent (3x200-240 V) [A]	2.3	3.3	6.3	10.2	14.4	22.8
Max. cable size:						
(mains, motor) [mm²/AWG]	4/10					
Max. input current						
Continuous (3x200-240 V) [A]	2.4	3.5	6.7	10.9	15.4	24.3
Intermittent (3x200-240 V) [A]	3.2	4.6	8.3	14.4	23.4	35.3
Max. mains fuses [A]	See *chapter 6.6.1 Fuses*					
Environment						
Estimated power loss [W]	14.0/	19.0/	31.5/	51.0/	72.0/	115.0/
Best case/Typical[1]	20.0	24.0	39.5	57.0	77.1	122.8
Weight enclosure IP20 [kg]	1.1	1.1	1.1	1.6	3.0	3.0
Efficiency [%]	96.4/	96.7/	97.1/	97.4/	97.2/	97.3/
Best case/Typical[1]	94.9	95.8	96.3	97.2	97.4	97.4

Table 9.2 Mains Supply 3x200-240 V AC

[1] At rated load conditions.

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9.1.3 Mains Supply 3x380-480 V AC

Normal overload 150% for 1 min		PK37	PK75	P1K5	P2K2	P3K0	P4K0
Frequency converter		**PK37**	**PK75**	**P1K5**	**P2K2**	**P3K0**	**P4K0**
Typical Shaft Output [kW]		**0.37**	**0.75**	**1.5**	**2.2**	**3.0**	**4.0**
Typical Shaft Output [HP]		0.5	1	2	3	4	5
IP 20		Frame M1	Frame M1	Frame M2	Frame M2	Frame M3	Frame M3
Output current							
Continuous (3x380-440 V) [A]		1.2	2.2	3.7	5.3	7.2	9.0
Intermittent (3x380-440 V) [A]		1.8	3.3	5.6	8.0	10.8	13.7
Continuous (3x440-480 V) [A]		1.1	2.1	3.4	4.8	6.3	8.2
Intermittent (3x440-480 V) [A]		1.7	3.2	5.1	7.2	9.5	12.3
Max. cable size:							
(mains, motor) [mm²/ AWG]		4/10					
Max. input current							
Continuous (3x380-440 V) [A]		1.9	3.5	5.9	8.5	11.5	14.4
Intermittent (3x380-440 V) [A]		2.6	4.7	8.7	12.6	16.8	20.2
Continuous (3x440-480 V) [A]		1.7	3.0	5.1	7.3	9.9	12.4
Intermittent (3x440-480 V) [A]		2.3	4.0	7.5	10.8	14.4	17.5
Max. mains fuses [A]		See *chapter 6.6 Fuses*					
Environment							
Estimated power loss [W], Best case/ Typical[1]		18.5/ 25.5	28.5/ 43.5	41.5/ 56.5	57.5/ 81.5	75.0/ 101.6	98.5/ 133.5
Weight enclosure IP20 [kg]		1.1	1.1	1.6	1.6	3.0	3.0
Efficiency [%], Best case/Typical[1]		96.8/ 95.5	97.4/ 96.0	98.0/ 97.2	97.9/ 97.1	98.0/ 97.2	98.0/ 97.3

Table 9.3 Mains Supply 3x380-480 V AC

[1] *At rated load conditions.*

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Normal overload 150% or 1 min		**P5K5**	**P7K5**	**P11K**	**P15K**	**P18K**	**P22K**
Frequency converter		**P5K5**	**P7K5**	**P11K**	**P15K**	**P18K**	**P22K**
Typical Shaft Output [kW]		**5.5**	**7.5**	**11**	**15**	**18.5**	**22**
Typical Shaft Output [HP]		7.5	10	15	20	25	30
IP 20		Frame M3	Frame M3	Frame M4	Frame M4	Frame M5	Frame M5
Output current							
Continuous (3x380-440 V) [A]		12.0	15.5	23.0	31.0	37.0	42.0
Intermittent (3x380-440 V) [A]		18.0	23.5	34.5	46.5	55.5	63.0
Continuous (3x440-480 V) [A]		11.0	14.0	21.0	27.0	34.0	40.0
Intermittent (3x440-480 V) [A]		16.5	21.3	31.5	40.5	51.0	60.0
Max. cable size:							
(mains, motor) [mm²/AWG]		4/10		16/6			
Max. input current							
Continuous (3x380-440 V) [A]		19.2	24.8	33.0	42.0	34.7	41.2
Intermittent (3x380-440 V) [A]		27.4	36.3	47.5	60.0	49.0	57.6
Continuous (3x440-480 V) [A]		16.6	21.4	29.0	36.0	31.5	37.5
Intermittent (3x440-480 V) [A]		23.6	30.1	41.0	52.0	44.0	53.0
Max. mains fuses [A]		See *chapter 6.6 Fuses*					
Environment							
Estimated power loss [W], Best case/ Typical[1]		131.0/ 166.8	175.0/ 217.5	290.0/ 342.0	387.0/ 454.0	395.0/ 428.0	467.0/ 520.0
Weight enclosure IP20 [kg]		3.0	3.0				
Efficiency [%], Best case/Typical[1]		98.0/ 97.5	98.0/ 97.5	97.8/ 97.4	97.7/ 97.4	98.1/ 98.0	98.1/ 97.9

Table 9.4 Mains Supply 3x380-480 V AC

[1] At rated load conditions.

9

Protection and features

- Electronic thermal motor protection against overload.

- Temperature monitoring of the heat sink ensures that the frequency converter trips in case of overtemperature

- The frequency converter is protected against short-circuits between motor terminals U, V, W.

- When a motor phase is missing, the frequency converter trips and issues an alarm.

- When a mains phase is missing, the frequency converter trips or issues a warning (depending on the load).

- Monitoring of the intermediate circuit voltage ensures that the frequency converter trips, when the intermediate circuit voltage is too low or too high.

- The frequency converter is protected against ground faults on motor terminals U, V, W.

Mains supply (L1/L, L2, L3/N)

Supply voltage	200-240 V ±10%
Supply voltage	380-480 V ±10%
Supply frequency	50/60 Hz
Max. imbalance temporary between mains phases	3.0% of rated supply voltage
True Power Factor	≥0.4 nominal at rated load
Displacement Power Factor (cosφ) near unity	(>0.98)
Switching on input supply L1/L, L2, L3/N (power-ups)	maximum 2 times/min.
Environment according to EN60664-1	overvoltage category III/pollution degree 2

The unit is suitable for use on a circuit capable of delivering not more than 100.000 RMS symmetrical Amperes, 240/480 V maximum.

Motor output (U, V, W)

Output voltage	0-100% of supply voltage
Output frequency	0-200 Hz (VVC^{plus}), 0-400 Hz (u/f)
Switching on output	Unlimited
Ramp times	0.05-3600 s

Cable lengths and cross sections

Max. motor cable length, screened/armoured (EMC correct installation)	15 m
Max. motor cable length, unscreened/unarmoured	50 m
Max. cross section to motor, mains*	
Connection to load sharing/brake (M1, M2, M3)	6.3 mm insulated Faston Plugs
Max. cross section to load sharing/brake (M4, M5)	16 mm^2/6 AWG
Maximum cross section to control terminals, rigid wire	1.5 mm^2/16 AWG (2x0.75 mm^2)
Maximum cross section to control terminals, flexible cable	1 mm^2/18 AWG
Maximum cross section to control terminals, cable with enclosed core	0.5 mm^2/20 AWG
Minimum cross section to control terminals	0.25 mm^2

* See chapter 9 Specifications for more information!

Digital inputs (pulse/encoder inputs)

Programmable digital inputs (pulse/encoder)	5 (1)
Terminal number	18, 19, 27, 29, 33,
Logic	PNP or NPN
Voltage level	0-24 V DC
Voltage level, logic'0' PNP	<5 V DC
Voltage level, logic'1' PNP	>10 V DC
Voltage level, logic '0' NPN	>19 V DC
Voltage level, logic '1' NPN	<14 V DC
Maximum voltage on input	28 V DC
Input resistance, R_i	approx. 4 kΩ
Max. pulse frequency at terminal 33	5000 Hz
Min. pulse frequency at terminal 33	20 Hz

Analog inputs

Number of analog inputs	2
Terminal number	53, 60
Voltage mode (Terminal 53)	Switch S200=OFF(U)
Current mode (Terminal 53 and 60)	Switch S200=ON(I)
Voltage level	0-10 V
Input resistance, R_i	approx. 10 kΩ
Max. voltage	20 V
Current level	0/4 to 20 mA (scaleable)
Input resistance, R_i	approx. 200 Ω
Max. current	30 mA

Analog output

Number of programmable analog outputs	1
Terminal number	42
Current range at analog output	0/4-20 mA
Max. load to common at analog output	500 Ω
Max. voltage at analog output	17 V
Accuracy on analog output	Max. error: 0.8% of full scale
Scan interval	4 ms
Resolution on analog output	8 bit
Scan interval	4 ms

Control card, RS-485 serial communication

Terminal number	68 (P,TX+, RX+), 69 (N,TX-, RX-)
Terminal number 61	Common for terminals 68 and 69

Control card, 24 V DC output

Terminal number	12
Max. load (M1 and M2)	100 mA
Max. load (M3)	50 mA
Max. load (M4 and M5)	80 mA

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Relay output

Relay output	
Programmable relay output	1
Relay 01 Terminal number	01-03 (break), 01-02 (make)
Max. terminal load (AC-1)[1] on 01-02 (NO) (Resistive load)	250 V AC, 2 A
Max. terminal load (AC-15)[1] on 01-02 (NO) (Inductive load @ cosφ 0.4)	250 V AC, 0.2 A
Max. terminal load (DC-1)[1] on 01-02 (NO) (Resistive load)	30 V DC, 2 A
Max. terminal load (DC-13)[1] on 01-02 (NO) (Inductive load)	24 V DC, 0.1 A
Max. terminal load (AC-1)[1] on 01-03 (NC) (Resistive load)	250 V AC, 2 A
Max. terminal load (AC-15)[1] on 01-03 (NC) (Inductive load @ cosφ 0.4)	250 V AC, 0.2 A
Max. terminal load (DC-1)[1] on 01-03 (NC) (Resistive load)	30 V DC, 2 A
Min. terminal load on 01-03 (NC), 01-02 (NO)	24 V DC 10 mA, 24 V AC 20 mA
Environment according to EN 60664-1	overvoltage category III/pollution degree 2

[1] *IEC 60947 part 4 and 5*

Control card, 10 V DC output

Control card, 10 V DC output	
Terminal number	50
Output voltage	10.5 V ±0.5 V
Max. load	25 mA

NOTICE

All inputs, outputs, circuits, DC supplies and relay contacts are galvanically isolated from the supply voltage (PELV) and other high-voltage terminals.

Surroundings

Surroundings	
Enclosure	IP20
Enclosure kit available	IP21, TYPE 1
Vibration test	1.0 g
Max. relative humidity	5%-95 % (IEC 60721-3-3; Class 3K3 (non-condensing) during operation
Aggressive environment (IEC 60721-3-3), coated	class 3C3
Test method according to IEC 60068-2-43 H2S (10 days)	
Ambient temperature	Max. 40 °C

Derating for high ambient temperature, see chapter 4.2.2 Derating for Ambient Temperature

Minimum ambient temperature during full-scale operation	0 °C
Minimum ambient temperature at reduced performance	- 10 °C
Temperature during storage/transport	-25 to +65/70 °C
Maximum altitude above sea level without derating	1000 m
Maximum altitude above sea level with derating	3000 m

Derating for high altitude, see chapter 4.2 Special Conditions

Safety standards	EN/IEC 61800-5-1, UL 508C
EMC standards, Emission	EN 61800-3, EN 61000-6-3/4, EN 55011, IEC 61800-3
EMC standards, Immunity	EN 61800-3, EN 61000-6-1/2, EN 61000-4-2, EN 61000-4-3, EN 61000-4-4, EN 61000-4-5, EN 61000-4-6

See chapter 4.2 Special Conditions

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