MAKING MODERN LIVING POSSIBLE

Design Guide
VLT® Compressor Drive CDS 803

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VLT® THE REAL DRIVE

Contents

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1 Introduction

1.1 Purpose of the Manual

This design guide is intended for project and systems engineers, design consultants, and application and product specialists. Technical information is provided to understand the capabilities of the frequency converter for integration into motor control and monitoring systems. Details concerning operation, requirements, and recommendations for system integration are described. Information is proved for input power characteristics, output for motor control, and ambient operating conditions for the converter.

Also included are safety features, fault condition monitoring, operational status reporting, serial communication capabilities, and programmable options and features. Design details such as site requirements, cables, fuses, control wiring, the size and weight of units, and other critical information necessary to plan for system integration is also provided.

Reviewing the detailed product information in the design stage will enable developing a well-conceived system with optimal functionality and efficiency.

VLT® is a registered trademark

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
MG18N1xx		1.00

Table 1.1 Document and Software Version

1.3 Safety Symbols

The following symbols are used in this document:

⚠WARNING

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

⚠CAUTION

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

NOTICE

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

1.4 Abbreviations

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

Table 1.2 Abbreviations

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1.5 Additional Resources

- *VLT® Compressor Drive CDS 803 Quick Guide*
- *VLT® Compressor Drive CDS 803 Programming Guide* provides information on how to programme and includes complete parameter descriptions.
- *VLT® Compressor Drive CDS 803 Design Guide* entails all technical information about the frequency converter and customer design and applications.
- *MCT 10 Set-up Software* enables the user to configure the frequency converter from a Windows™ based PC environment.

Danfoss technical literature is available in print from your local Danfoss Sales Office or at: *www.danfoss.com/BusinessAreas/DrivesSolutions/Documentations/Technical+Documentation.htm*

1.6 Definitions

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.

Input

The connected compressor can start and stop 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 Control Commands

Compressor

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

f_M
The motor frequency.

f_{MAX}
The maximum compressor frequency.

f_{MIN}
The minimum compressor 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

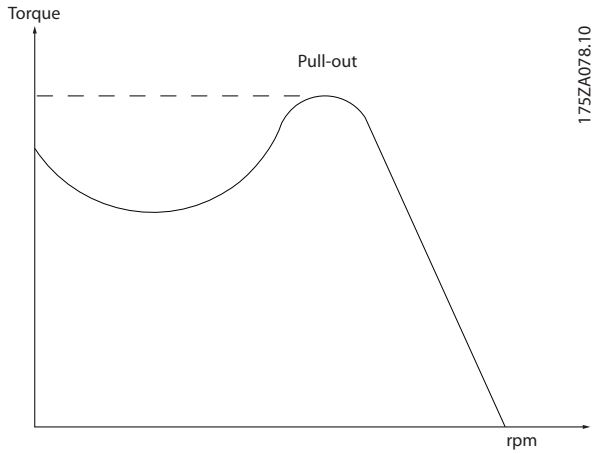

Illustration 1.1 Break-away Torque

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.

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*

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 Adaptation, AMA
AMA algorithm determines the electrical parameters for the connected compressor at standstill.

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

Digital outputs
The frequency converter features 2 Solid State outputs that can supply a 24 V DC (max. 40 mA) signal.

Relay outputs
The frequency converter features 2 programmable Relay Outputs.

ETR
Electronic Thermal Relay is a thermal load calculation based on present load and time. Its purpose is to estimate the compressor 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 (LCP) 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, i.e. in a front panel by means of 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. Press [OK] to activate off-line parameters.

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
Parameter settings in 2 set-ups can be saved. 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 compressor slip by giving the frequency a supplement that follows the measured compressor load keeping the compressor 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 compressor).

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 compressor, process or mechanism. Restart is prevented until the cause of the fault has disappeared and the trip state is cancelled by activating reset or, in some cases, by being programmed to reset automatically. Trip may not be used for personal safety.

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 cancelled by cutting off mains, removing the cause of the fault, and reconnecting the frequency converter. Restart is prevented until the trip state is cancelled by activating reset or, in some cases, by being programmed to reset automatically. Trip locked may not be used for personal safety.

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VT characteristics
Variable torque characteristics used for pumps and fans.

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

1.7 Power Factor

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

$$Power\ factor = \frac{\sqrt{3} \times U \times I1 \times COS\varphi}{\sqrt{3} \times U \times I_{RMS}}$$

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.

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

In addition, a high power factor indicates that the different harmonic currents are low.
The frequency converters built-in DC coils produce a high power factor, which minimizes the imposed load on the mains supply.

2 Product Overview

2.1 Safety

2.1.1 Safety Precautions

Safety Regulations

1. Disconnect the frequency converter from mains, if repair work is to be carried out. Check that the mains supply has been disconnected and that the necessary time has passed before removing compressor and mains plugs.
2. The [Off/Reset] key does not disconnect the equipment from mains and is thus not to be used as a safety switch.
3. Correct protective earthing of the equipment must be established, the user must be protected against supply voltage, and the compressor must be protected against overload in accordance with applicable national and local regulations.
4. The earth leakage currents are higher than 3.5 mA.
5. Protection against motor overload is set by *1-90 Motor Thermal Protection*. If this function is desired, set *1-90 Motor Thermal Protection* to data value *[4], [6], [8], [10] ETR trip]* or data value *[3], [5], [7], [9]ETR warning*.
   Note: The function is initialised at 1.16 x rated motor current and rated motor frequency. For the North American market: The ETR functions provide class 20 motor overload protection in accordance with NEC.
6. Do not remove the plugs for the compressor and mains supply while the frequency converter is connected to mains. Check that the mains supply has been disconnected and that the necessary time has elapsed before removing compressor and mains plugs.
7. Check that all voltage inputs have been disconnected and that the necessary time has elapsed before commencing repair work.

Installation at high altitudes

⚠CAUTION

At altitudes above 2 km, contact Danfoss regarding PELV.Installation, high altitudes

⚠WARNING

HIGH VOLTAGE

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

⚠WARNING

UNINTENDED START

When the frequency converter is connected to AC mains, the motor may start at any time. The frequency converter, motor, and any driven equipment must be in operational readiness. Failure to be in operational readiness when the frequency converter is connected to AC mains could result in death, serious injury, equipment, or property damage.

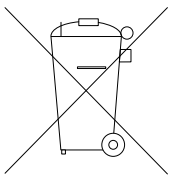
⚠WARNING

DISCHARGE TIME

Frequency converters contain DC-link capacitors that can remain charged even when the frequency converter is not powered. To avoid electrical hazards, disconnect AC mains, any permanent magnet type motors, and any remote DC-link power supplies, including battery back-ups, UPS, and DC-link connections to other frequency converters. Wait for the capacitors to fully discharge before performing any service or repair work. The amount of wait time is listed in the *Discharge Time* table. Failure to wait the specified time after power has been removed before doing service or repair could result in death or serious injury.

Voltage [V]	Cooling capacity [TR]	Minimum waiting time (minutes)
3x200	4-6.5	15
3x400	4-5	4
3x400	6.5	15

Table 2.1 Discharge Time



Equipment containing electrical components can 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.

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2.2 CE Labeling

2.2.1 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.

2.2.2 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 2.2.3 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.

2.2.3 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.

2.2.4 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.

2.3 Air Humidity

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

2.4 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. 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.

2.5 Vibration and Shock

The frequency converter has been tested according to the procedure based on the shown standards, *Table 2.2*

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 2.2 Standards

2.6 Control Structures

2

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

2.6.1 Control Structure Open Loop

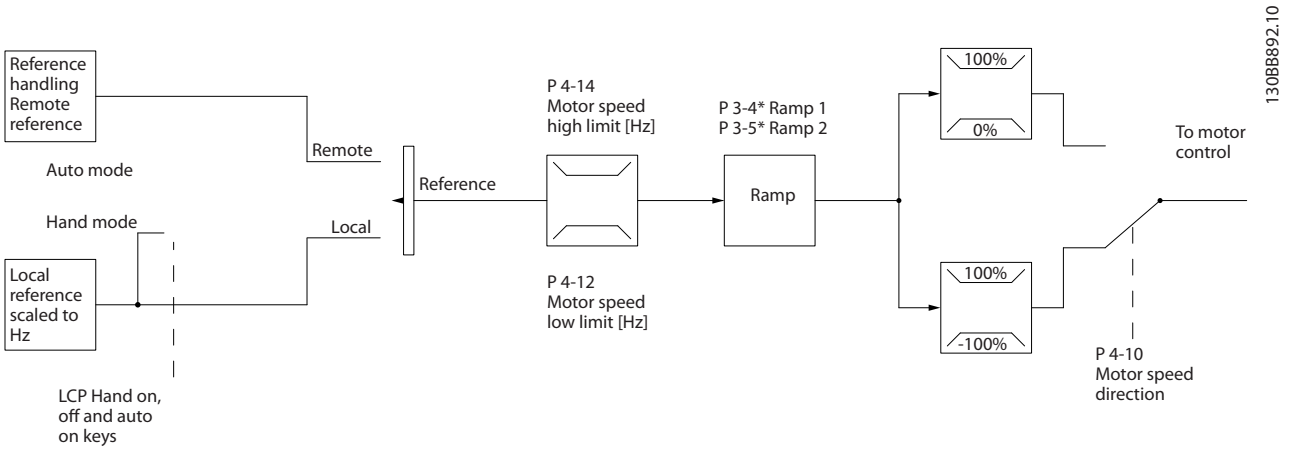

Illustration 2.1 Open Loop Structure

In the configuration shown in *Illustration 2.1*, *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.

2.6.2 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 using the [Hand On] and [Off/Reset] keys. Alarms can be reset via the [Off/Reset] key.

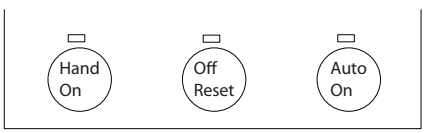

Illustration 2.2 LCP Keys

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.

2.6.3 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 an application where the speed 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.

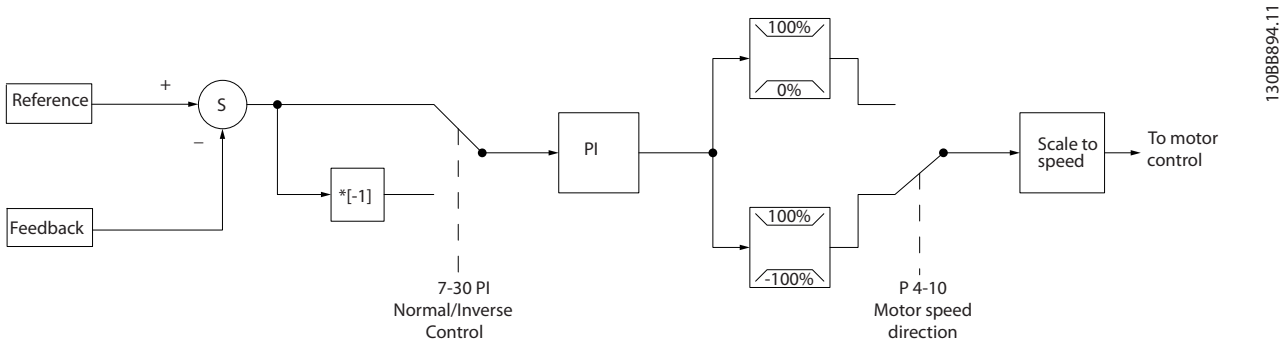

Illustration 2.3 Control Structure Closed Loop

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.

2.6.4 Feedback Conversion

In some applications it may be useful to convert the feedback signal. One example of this is using a pressure signal to provide flow feedback. Since the square root of pressure is proportional to flow, the square root of the pressure signal yields a value proportional to the flow. See *Illustration 2.4*.

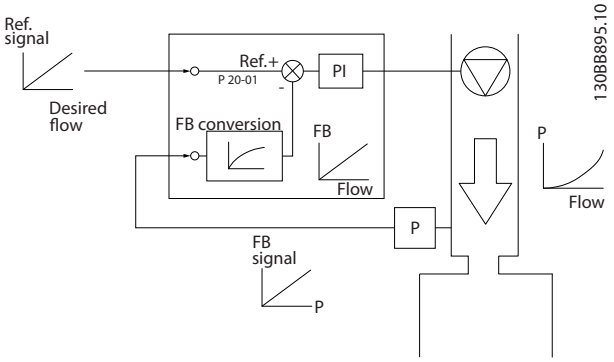

Illustration 2.4 Feedback Signal Conversion

2.6.5 Reference Handling

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Details for open loop and closed loop operation.

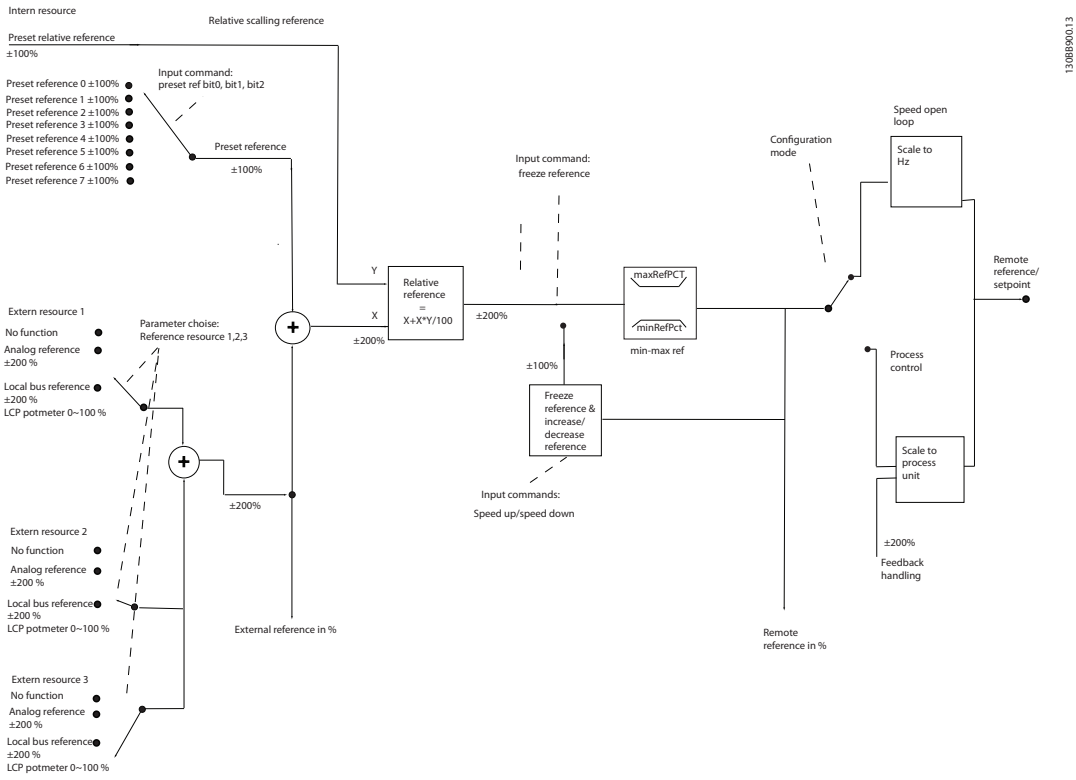


Illustration 2.5 Block Diagram Showing Remote Reference

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.

2.6.6 Closed Loop Set-up Wizard

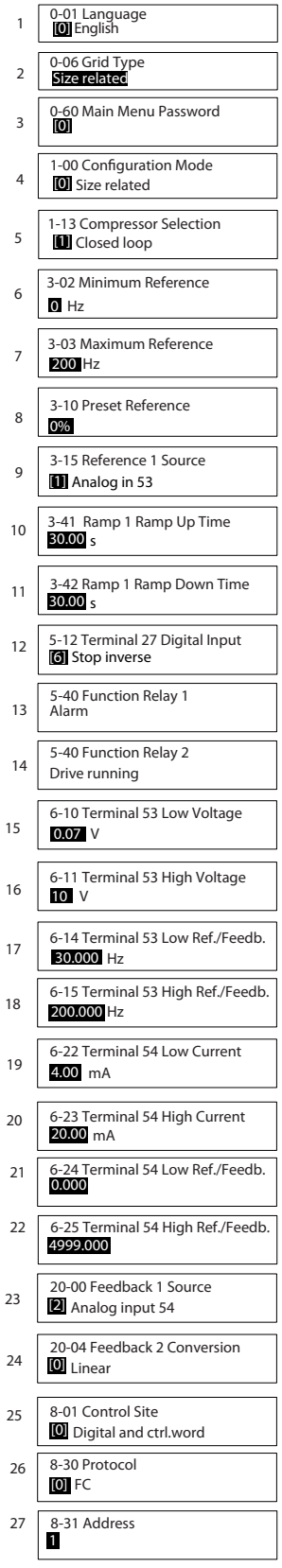


Illustration 2.6 Closed Loop Set-up Wizard

2

Closed loop wizard

Parameter	Option	Default	Function
0-01 Language	[0] English [1] Deutsch [2] Francais [3] Dansk [4] Spanish [5] Italiano [28] Bras.port	0	Select the language for the display.
0-06 GridType	[0] 200-240 V/50 Hz/IT-grid [1] 200-240 V/50 Hz/Delta [2] 200-240 V/50 Hz [10] 380-440 V/50 Hz/IT-grid [11] 380-440 V/50 Hz/Delta [12] 380-440 V/50 Hz [20] 440-480 V/50 Hz/IT-grid [21] 440-480 V/50 Hz/Delta [22] 440-480 V/50 Hz [30] 525-600 V/50 Hz/IT-grid [31] 525-600 V/50 Hz/Delta [32] 525-600 V/50 Hz [100] 200-240 V/60 Hz/IT-grid [101] 200-240 V/60 Hz/Delta [102] 200-240 V/60 Hz [110] 380-440 V/60 Hz/IT-grid [111] 380-440 V/60 Hz/Delta [112] 380-440 V/60 Hz [120] 440-480 V/60 Hz/IT-grid [121] 440-480 V/60 Hz/Delta [122] 440-480 V/60 Hz [130] 525-600 V/60 Hz/IT-grid [131] 525-600 V/60 Hz/Delta [132] 525-600 V/60 Hz	Size related	Select the operating mode for restart upon reconnection of the frequency converter to mains voltage after power down.
0-60 Main Menu Password	0-999	0	Define the password for access to the LCP.
1-00 Configuration Mode	[0] Open loop [3] Closed loop	[0] Open loop	Select closed loop.
1-13 Compressor Selection	[24] VZH028-R410A [25] VZH035-R410A [26] VZH044-R410A	Size related	Select the used compressor.
3-02 Minimum Reference	-4999.0 - 200 Hz	0 Hz	The minimum reference is the lowest value obtainable by summing all references.
3-03 Maximum Reference	0 - 200 Hz	200 Hz	The maximum reference is the highest obtainable by summing all references
3-10 Preset Reference	-100 - 100 %	0 %	Setup a fix set point n preset reference [0].
3-15 Reference 1 Source	[0] No function [1] Analog in 53 [2] Analog in 54 [7] Pulse input 29 [11] Local bus reference	[1] Analog in 53	Select the input to be used for the reference signal.
3-41 Ramp 1 Ramp Up Time	0.05-3600.0 s	30.00 s	Ramp up time from 0 to *1-25 Motor Nominal Speed*.
3-42 Ramp 1 Ramp Down Time	0.05-3600.0 s	30.00 s	Ramp-down time from rated motor speed to 0.

Parameter	Option	Default	Function
5-12 Terminal 27 Digital Input	[0] No operation [1] Reset [2] Coast inverse [3] Coast and reset inverse [4] Quick stop inverse [5] DC-brake inverse [6] Stop inverse [7] External Interlock [8] Start [9] Latched start [10] Reversing [11] Start reversing [14] Jog [16] Preset ref bit 0 [17] Preset ref bit 1 [18] Preset ref bit 2 [19] Freeze reference [20] Speed up [22] Speed down [23] Set-up select bit 0 [34] Ramp bit 0 [52] Run permissive [53] Hand start [54] Auto start [60] Counter A (up) [61] Counter A (down) [62] Reset Counter A [63] Counter B (up) [64] Counter B (down) [65] Reset Counter B	[6] Stop inverse	Select the input function for terminal 27.
5-40 Function Relay [0] Function relay	See 5-40 Function Relay	Alarm	Select the function to control output relay 1.
5-40 Function Relay [1] Function relay	See 5-40 Function Relay	Drive running	Select the function to control output relay 2.
6-10 Terminal 53 Low Voltage	0-10 V	0.07 V	Enter the voltage that corresponds to the low reference value.
6-11 Terminal 53 High Voltage	0-10 V	10 V	Enter the voltage that corresponds to the high reference value.
6-14 Terminal 53 Low Ref./Feedb. Value	-4999 - 4999	30	Enter the reference value that corresponds to the voltage set in *6-10 Terminal 53 Low Voltage*.
6-15 Terminal 53 High Ref./Feedb. Value	-4999 - 4999	200	Enter the reference value that corresponds to the voltage set in *6-11 Terminal 53 High Voltage*.
6-22 Terminal 54 Low Current	0.00-20.00 mA	4.00 mA	Enter the current that corresponds to the low reference value.
6-23 Terminal 54 High Current	0-10 V	10 V	Enter the current that corresponds to the high reference value.
6-24 Terminal 54 Low Ref./Feedb. Value	-0.00-20.00 mA	20.00 mA	Enter the reference value that corresponds to the current set in *6-20 Terminal 54 Low Voltage*.
6-25 Terminal 54 High Ref./Feedb. Value	-4999 - 4999	Size related	Enter the reference value that corresponds to the current set in *6-21 Terminal 54 High Voltage*.
8-01 Control Site	[0] Digital and ctrl.word [1] Digital only [2] Controlword only	[0] Digital and ctrl.word	Select if digital, bus, or a combination of both should control the frequency converter.

2

Parameter	Option	Default	Function
8-30 Protocol	[0] FC [2] Modbus RTU	[0] FC	Select the protocol for the integrated RS-485 port.
8-32 Baud Rate	[0] 2400 Baud [1] 4800 Baud [2] 9600 Baud [3] 19200 Baud [4] 38400 Baud [5] 57600 Baud [6] 76800 Baud [7] 115200 Baud	[2] 9600 Baud	Select the baud rate for the RS-485 port.
20-00 Feedback 1 Source	[0] No function [1] Analog Input 53 [2] Analog Input 54 [3] Pulse input 29 [100] Bus Feedback 1 [101] Bus Feedback 2	[0] No function	Select which input will be used as the source of the feedback signal.
20-01 Feedback 1 Conversion	[0] Linear [1] Square root	[0] Linear	Select how the feedback should be calculated

Table 2.3 Closed Loop Applications Set-up

2.6.7 Tuning the Drive Closed Loop Controller

Once the frequency converter's closed loop controller has been set up, the performance of the controller should be tested. In many cases, its performance may be acceptable using the default values of *20-93 PI Proportional Gain* and *20-94 PI Integral Time*. However, in some cases it may be helpful to optimize these parameter values to provide faster system response while still controlling speed overshoot.

2.6.8 Manual PI Adjustment

1. Start the compressor.
2. Set *20-93 PI Proportional Gain* to 0.3 and increase it until the feedback signal begins to oscillate. If necessary, start and stop the frequency converter or make step changes in the set-point reference to attempt to cause oscillation. Next reduce the PI proportional gain until the feedback signal stabilises. Then reduce the proportional gain by 40-60%.
3. Set *20-94 PI Integral Time* to 20 s and reduce it until the feedback signal begins to oscillate. If necessary, start and stop the frequency converter or make step changes in the set-point reference to attempt to cause oscillation. Next, increase the PI integral time until the feedback signal stabilises. Then increase of the integral time by 15-50%.

2.7 General Aspects of EMC

2.7.1 General Aspects of EMC Emissions

Frequency converter (and other electrical devices) generate electronic or magnetic fields that may interfere with their environment. The electromagnetic compatibility (EMC) of these effects depends on the power and the harmonic characteristics of the devices.

Uncontrolled interaction between electrical devices in a system can degrade compatibility and impair reliable operation. Interference may take the form of mains harmonics distortion, electrostatic discharges, rapid voltage fluctuations, or high-frequency interference. Electrical devices generate interference along with being affected by interference from other generated sources.

Electrical interference usually arises 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 compressor. Capacitive currents in the motor cable coupled with a high dU/dt from the compressor voltage generate leakage currents, as shown in *Illustration 2.7*.
The use of a screened motor cable increases the leakage current (see *Illustration 2.7*) 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 2.7*.

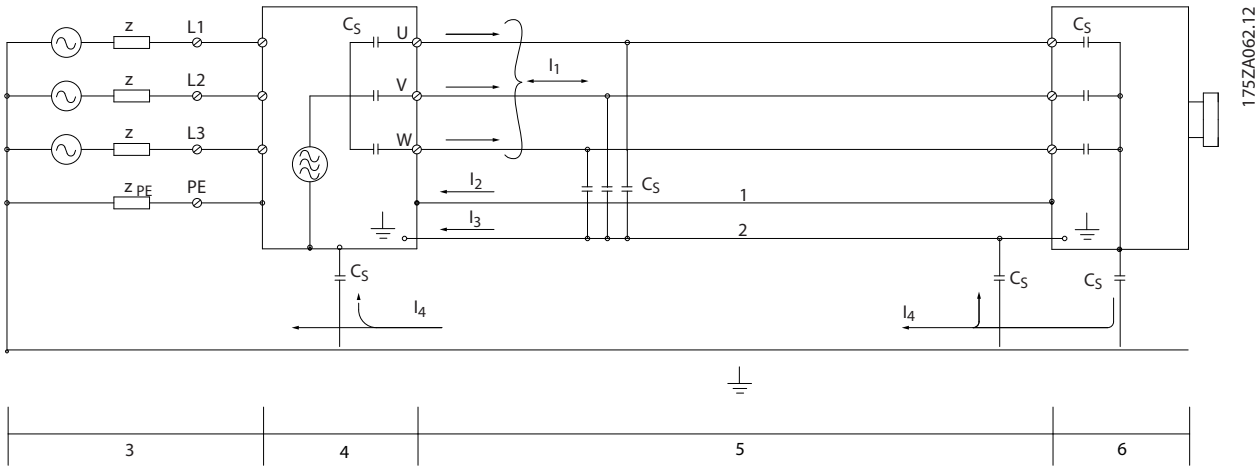
The screen reduces the radiated interference, but increases the low-frequency interference on the mains. Connect the motor cable screen to the frequency converter enclosure as well as on the compressor enclosure. This is best done by using integrated screen clamps so as to avoid twisted screen ends (pigtails). 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.

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 compressor and brake cables as short as possible. Avoid placing cables with a sensitive signal level alongside compressor and brake cables. Radio interference higher than 50 MHz (airborne) is especially generated by the control electronics.

2



1	Ground wire	3	AC mains supply	5	Screened motor cable
2	Screen	4	Frequency converter	6	Motor

Illustration 2.7 Generation of Leakage Currents

2.7.2 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 2.4* 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. Make an EMC plan.

Table 2.4 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 2.5*.

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 2.5 Correlation between Generic Emission Standards and EN 55011

2.7.3 EMC Test Results

The following test results have been obtained using a system with a frequency converter, a screened control cable, a control box with potentiometer, as well as a motor screened cable.

RFI Filter Type	Conduct emission. Maximum shielded cable length [m]						Radiated emission			
	Industrial environment				Housing, trades and light industries		Industrial environment		Housing, trades and light industries	
	EN 55011 Class A2		EN 55011 Class A1		EN 55011 Class B		EN 55011 Class A1		EN 55011 Class B	
	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
H4 RFI filter (Class A1)										
CDS 803 IP20			25	50		20	Yes	Yes		No

Table 2.6 Test Results

2.7.4 General Aspects of Harmonics Emission

A frequency converter takes up a non-sinusoidal current from mains, which increases the input current I_{RMS}. A non-sinusoidal current is transformed with a Fourier analysis and split into sine-wave currents with different frequencies, that is, different harmonic currents I_n with 50 Hz basic frequency:

	I_1	I_5	I_7
Hz	50	250	350

Table 2.7 Harmonic Currents

The harmonics do not affect the power consumption directly, but increase the heat losses in the installation (transformer, cables). So, in plants with a high percentage of rectifier load, maintain harmonic currents at a low level to avoid overload of the transformer and high temperature in the cables.

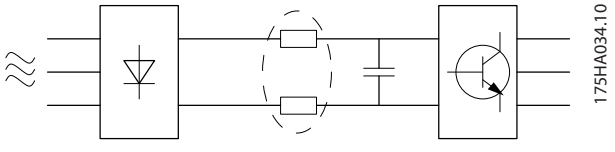


Illustration 2.8 Intermediate Circuit Coils

To ensure low harmonic currents, the frequency converter is equipped with intermediate circuit coils as standard. This normally reduces the input current I_{RMS} by 40%.

The voltage distortion on the mains supply voltage depends on the size of the harmonic currents multiplied by the mains impedance for the frequency in question. The total voltage distortion THD is calculated based on the individual voltage harmonics using this formula:

$$THD\% = \sqrt{U_5^2 + U_7^2 + \ldots + U_N^2}$$

(U_N% of U)

2.7.5 Harmonics Emission Requirements

Equipment connected to the public supply network

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 16-75 A and professional equipment as from 1 kW up to 16 A phase current.

Table 2.8 Connected Equipment

NOTICE

Some of the harmonic currents might disturb communication equipment connected to the same transformer or cause resonance with power-factor correction batteries.

2

2.7.6 Harmonics Test Results (Emission)

Power sizes up to PK75 in T4 and P3K7 in T2 complies with IEC/EN 61000-3-2 Class A. Power sizes from P1K1 and up to P18K in T2 and up to P90K in T4 complies with IEC/EN 61000-3-12, Table 4.

	Individual Harmonic Current I_n/I_1 (%)			
	I_5	I_7	I_{11}	I_{13}
Actual 6.0-10 kW, IP20, 200 V (typical)	32.6	16.6	8.0	6.0
Limit for R_{sce}≥120	40	25	15	10
	Harmonic current distortion factor (%)			
	THD		**PWHD**	
Actual 6.0-10 kW, 200 V (typical)	39		41.4	
Limit for R_{sce}≥120	48		46	

Table 2.9 Harmonic Current 6.0-10 kW, 200 V

	Individual Harmonic Current I_n/I_1 (%)			
	I_5	I_7	I_{11}	I_{13}
Actual 6.0-10 kW, IP20, 380-480 V (typical)	36.7	20.8	7.6	6.4
Limit for R_{sce}≥120	40	25	15	10
	Harmonic current distortion factor (%)			
	THD		**PWHD**	
Actual 6.0-10 kW, 380-480 V (typical)	44.4		40.8	
Limit for R_{sce}≥120	48		46	

Table 2.10 Harmonic Current 6.0-10 kW, 380-480 V

It is the responsibility of the installer or user of the equipment to ensure, by consultation with the distribution network operator if necessary, that the equipment is connected only to a supply with a short-circuit power S_{sc} greater than or equal to specified above.
Other power sizes can be connected to the public supply network by consultation with the distribution network operator.

Compliance with various system level guidelines:
The harmonic current data in *Table 2.9* to are given in accordance with IEC/EN 61000-3-12 with reference to the Power Drive Systems product standard. They may be used as the basis for calculation of the harmonic currents' influence on the power supply system and for the documentation of compliance with relevant regional guidelines: IEEE 519 -1992; G5/4.
If there is a need for further reduction of harmonic currents, passive or active filters in front of the frequency converters can be installed. Consult Danfoss for further information.

2.7.7 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.

2.8 Galvanic Isolation (PELV)

2.8.1 PELV - Protective Extra Low Voltage

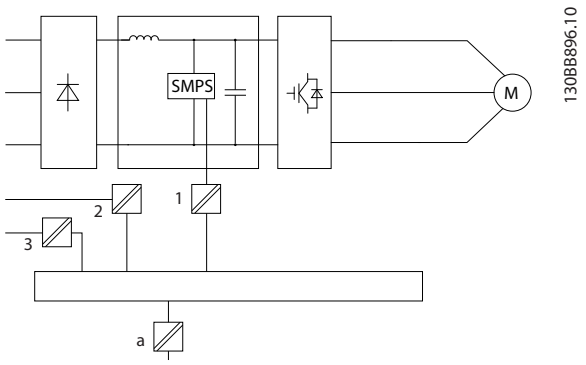
PELV offers protection by way of extra low voltage. Protection against electric shock is ensured when the electrical supply is of the PELV type and the installation is made as described in local/national regulations on PELV supplies.

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 2.9*.

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



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

Illustration 2.9 Galvanic Isolation

⚠CAUTION

Installation at high altitude:
At altitudes above 2000 m, contact Danfoss regarding PELV.

2.9 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 compressor 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.

2.10 Extreme Running Conditions

Short circuit (compressor phase – phase)
Current measurement in each of the 3 compressor 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 compressor 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.

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 compressor load determines how long it takes for the frequency converter to coast.

3 Selection

3.1 Options and Accessories

3

3.1.1 Local Control Panel (LCP)

Ordering no.	Description
120Z0581	LCP for all IP20 units

Table 3.1 Ordering Number

Enclosure	IP55 front
Max. cable length to unit	10 ft (3 m)
Communication std.	RS-485

Table 3.2 Technical Data

3.1.2 Mounting of LCP in Panel Front

Ordering no.	Description
132B0201	LCP kit for remote mounting

Table 3.3 Ordering Number

Step 1
Fit gasket on LCP.

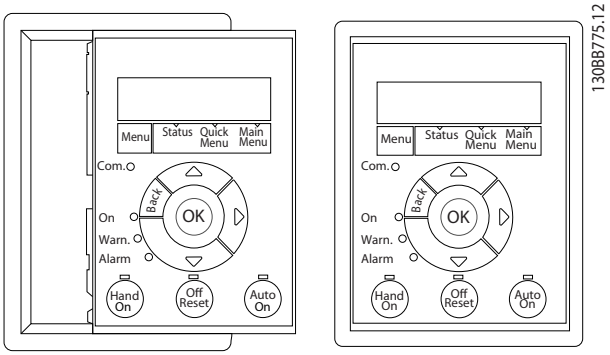


Illustration 3.1 Fit Gasket

Step 2
Place LCP on panel, see dimensions of hole on *Illustration 3.2*.

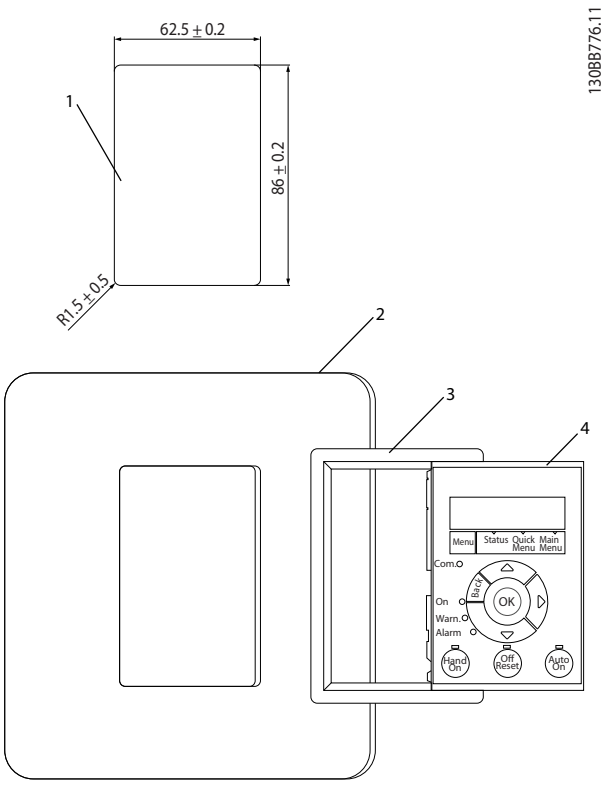


Illustration 3.2 Place LCP on Panel

Step 3
Place bracket on back of the LCP, then slide down. Tighten screws and connect cable female side to LCP.

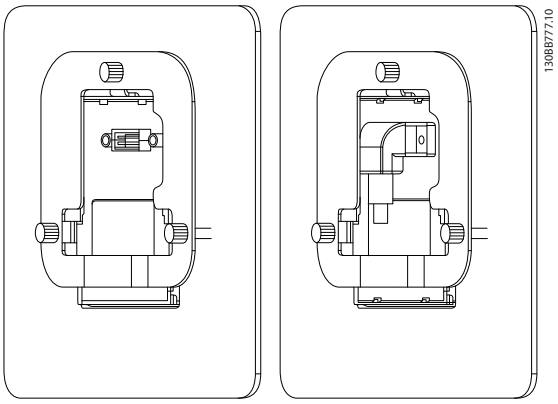


Illustration 3.3 Place Bracket on LCP

Step 4
Connect cable to frequency converter.

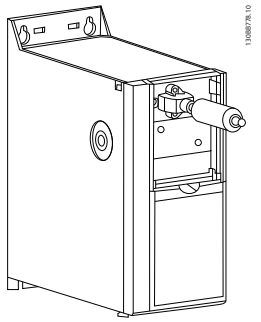


Illustration 3.4 Connect Cable

NOTICE

Use the provided thread cutting screws to fasten connector to the frequency converter, tightening torque 1.3 Nm.

If the enclosure kit is used, an IP20 unit is upgraded to comply with enclosure IP21/TYPE 1.

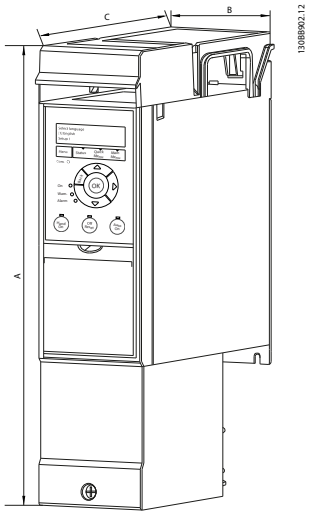


Illustration 3.5 H3-H5

3.1.3 IP21/TYPE 1 Enclosure Kit

IP21/TYPE 1 is an optional enclosure element available for IP20 units.

Frame	Cooling capacity		Height [mm] A	Width [mm] B	Depth [mm] C	IP21 kit ordering no.	Type 1 kit ordering no.
	3x200-240 V	3x380-480 V					
H3		4-5 TR	346	106	210	132B0214	132B0224
H4	4-5 TR	6.5 TR	374	141	245	132B0215	132B0225
H5	6.5 TR		418	161	260	132B0216	132B0226

Table 3.4 Enclosure Kit Specifications

3.1.4 Decoupling Plate

Use the decoupling plate for EMC correct installation.

Shown here on a H3 enclosure.

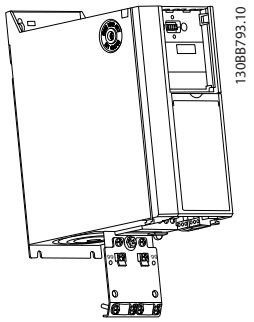


Illustration 3.6 Decoupling Plate

	Length [mm]	Width [mm
H3	80.8	72.0
H4/H5	85.0	84.8

Table 3.5 Dimensions, Decoupling Plate

	Cooling capacity		Decoupling plate
Frame	3x200-240 V	3x380-480 V	
H3		4-5 TR	120Z0582
H4	4-5 TR	6.5 TR	120Z0583
H5	6.5 TR		120Z0583

Table 3.6 Decoupling Plate Specifications

4 How to Order

4.1 Configuration

4.1.1 Type Code String

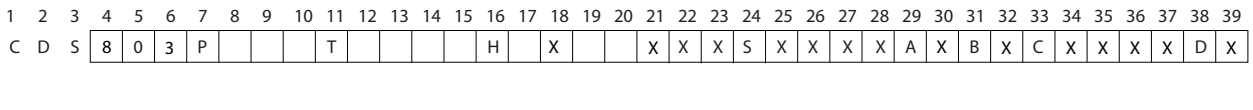


Illustration 4.1 Type Code

Description	Pos.	Possible choice
Product group & FC series	1-6	CDS 803
Power rating	7-10	6.0-10 kW (P6K0-P10K)
Number of phases	11	Three phases (T)
Mains voltage	11-12	T2: 200-240 V AC T4: 380-480 V AC
Enclosure	13-15	E20: IP20/Chassis
RFI filter	16-17	H4: RFI filter class A1
Brake	18	X: No brake chopper included
Display	19	A: Alpha Numeric Local Control Panel X: No Local Control Panel
Coating PCB	20	X: No coated PCB C: Coated PCB
Mains option	21	X: No mains option
Adaption	22	X: No adaption
Adaption	23	X: No adaption
Software release	24-27	SXXXX: Latest release - std. software
Software language	28	X: Standard
A options	29-30	AX: No A options
B options	31-32	BX: No B options
C0 options MCO	33-34	CX: No C options
C1 options	35	X: No C1 options
C option software	36-37	XX: No options
D options	38-39	DX: No D0 options

Table 4.1 Type Code Descriptions

4.2 Ordering Numbers

4.2.1 External RFI Filter

External filters to fulfil A1 50 m/B1 20 m.

Power [kW] Size 380-480 V	Type	A	B	C	D	E	F	G	H	I	J	K	L1	Torque [Nm]	Weight [kg]	Ordering Number
6-7.5	FN3258-16-45	250	45	70	220	235	25	4.5	1	10.6	M5	22.5	31	0.7-0.8	0.8	132B0245
10	FN3258-30-47	270	50	85	240	255	30	5.4	1	10.6	M5	25	40	1.9-2.2	1.2	132B0246

Table 4.2 RFI Filters - Details

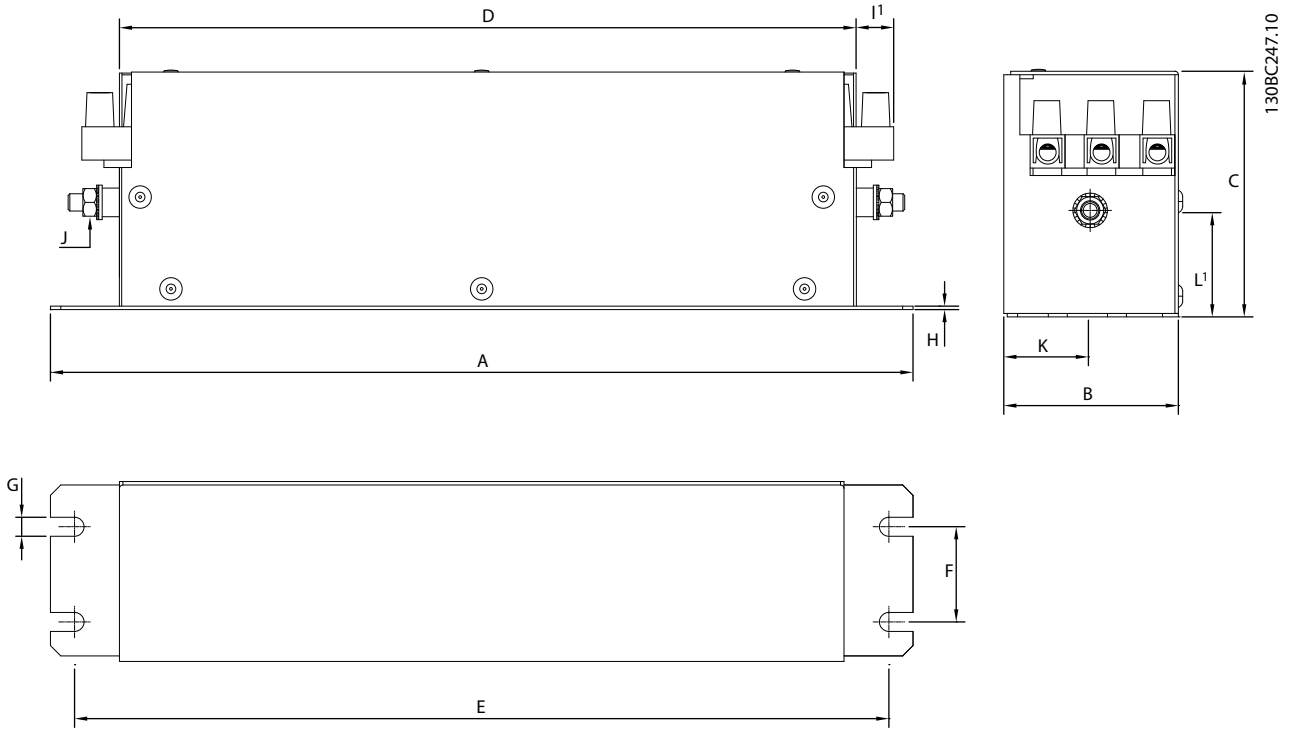


Illustration 4.2 RFI Filter

5 How to Install

5.1 Mechanical Dimensions

5.1.1 Side-by-Side Installation

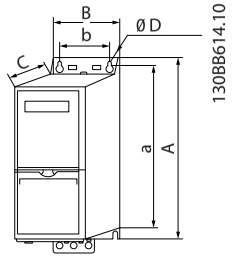
The frequency converter can be mounted side-by-side but requires the clearance above and below for cooling.

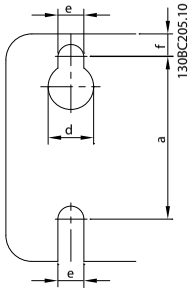
		Power [kW(HP)]			Clearance above/below [mm(in)]
Frame	**IP class**	**3x200-240 V**	**3x380-480 V**	**3x525-600 V**	
H1	IP20	0.25-1.5 (0.33-2)	0.37-1.5 (0.5-2)	–	100 (4)
H2	IP20	2.2 (3)	2.2-4 (3-5)	–	100 (4)
H3	IP20	3.7 (5)	5.5-7.5 (7.5-10)	–	100 (4)
H4	IP20	5.5-7.5 (7.5-10)	11-15 (15-20)	–	100 (4)
H5	IP20	11 (15)	18.5-22 (25-30)	–	100 (4)
H6	IP20	15-18.5 (20-25)	30-45 (40-60)	18.5-30 (25-40)	200 (7.9)
H7	IP20	22-30 (30-40)	55-75 (70-100)	37-55 (50-70)	200 (7.9)
H8	IP20	37-45 (50-60)	90 (125)	75-90 (100-125)	225 (8.9)
H9	IP20	–	–	2.2-7.5 (3-10)	100 (4)
H10	IP20	–	–	11-15 (15-20)	200 (7.9)
I2	IP54	–	0.75-4.0 (1-5)	–	100 (4)
I3	IP54	–	5.5-7.5 (7.5-10)	–	100 (4)
I4	IP54	–	11-18.5 (15-25)	–	100 (4)
I6	IP54	–	22-37 (30-50)	–	200 (7.9)
I7	IP54	–	45-55 (60-70)	–	200 (7.9)
I8	IP54	–	75-90 (100-125)	–	225 (8.9)

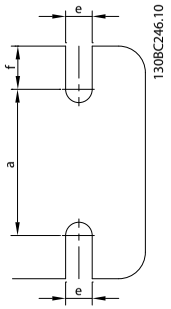
Table 5.1 Clearance Required for Cooling

NOTICE

With IP21/NEMA Type1 option kit mounted, a distance of 50 mm (2 in) between the units is required.





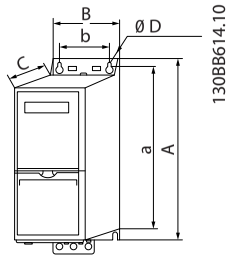


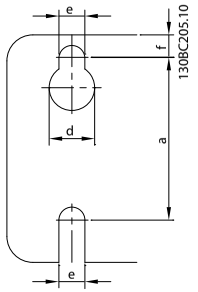
Enclosure		Power [kW(HP)]			Height [mm (in)]			Width [mm(in)]		Depth [mm(in)]	Mounting hole [mm(in]			Max. Weight
Size	IP Class	3x200-240 V	3x380-480 V	3x525-600 V	A	A[1)]	a	B	b	C	d	e	f	kg(lb)
H1	IP20	0.25–1.5 (0.33–2)	0.37–1.5 (0.5–2)	–	195 (7.7)	273 (10.7)	183 (7.2)	75 (3.0)	56 (2.2)	168 (6.6)	9 (0.35)	4.5 (0.18)	5.3 (0.21)	2.1 (4.6)
H2	IP20	2.2 (3)	2.2–4.0 (3–5)	–	227 (8.9)	303 (11.9)	212 (8.3)	90 (3.5)	65 (2.6)	190 (7.5)	11 (0.43)	5.5 (0.22)	7.4 (0.29)	3.4 (7.5)
H3	IP20	3.7 (5)	5.5–7.5 (7.5-10)	–	255 (10.0)	329 (13.0)	240 (9.4)	100 (3.9)	74 (2.9)	206 (8.1)	11 (0.43)	5.5 (0.22)	8.1 (0.32)	4.5 (9.9)
H4	IP20	5.5–7.5 (7.5-10)	11–15 (15-20)	–	296 (11.7)	359 (14.1)	275 (10.8)	135 (5.3)	105 (4.1)	241 (9.5)	12.6 (0.50)	7 (0.28)	8.4 (0.33)	7.9 (17.4)
H5	IP20	11 (15)	18.5–22 (25-30)	–	334 (13.1)	402 (15.8)	314 (12.4)	150 (5.9)	120 (4.7)	255 (10)	12.6 (0.50)	7 (0.28)	8.5 (0.33)	9.5 (20.9)
H6	IP20	15–18.5 (20–25)	30–45 (40–60)	18.5–30 (25-40)	518 (20.4)	595 (23.4)/635 (25) (45 kW)	495 (19.5)	239 (9.4)	200 (7.9)	242 (9.5)	–	8.5 (0.33)	15 (0.6)	24.5 (54)
H7	IP20	22–30 (30–40)	55–75 (70–100)	37–55 (50–70)	550 (21.7)	630 (24.8)/690 (27.2) (75 kW)	521 (20.5)	313 (12.3)	270 (10.6)	335 (13.2)	–	8.5 (0.33)	17 (0.67)	36 (79)
H8	IP20	37–45 (50–60)	90 (125)	75–90 (100–125)	660 (26)	800 (31.5)	631 (24.8)	375 (14.8)	330 (13)	335 (13.2)	–	8.5 (0.33)	17 (0.67)	51 (112)
H9	IP20	–	–	2.2–7.5 (3–10)	269 (10.6)	374 (14.7)	257 (10.1)	130 (5.1)	110 (4.3)	205 (8)	11 (0.43)	5.5 (0.22)	9 (0.35)	6.6 (14.6)
H10	IP20	–	–	11–15 (15-20)	399 (15.7 (	419 (16.5)	380 (15)	165 (6.5)	140 (5.5)	248 (9.8)	12 (0.47)	6.8 (0.27)	7.5 (0.30)	12 (26.5)

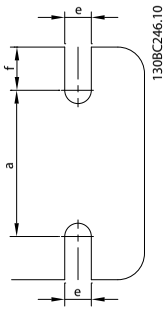
1) Including decoupling plate

The dimensions are only for the physical units. When installing in an application it is necessary to allow space above and below the units for cooling. The amount of space for free air passage is listed in *Table 5.1*.

Table 5.3 Dimensions, Enclosure Size H1-H10







Enclosure		Power [kW(HP)]			Height [mm (in)]			Width [mm(in)]		Depth [mm(in)]	Mounting hole [mm(in]			Max. Weight
Size	IP Class	3x200-240 V	3x380-480 V	3x525-600 V	A	A[1)]	a	B	b	C	d	e	f	kg(lb)
I2	IP54	–	0.75–4.0 (1–5)	–	332 (13.1)	–	318.5 (12.53)	115 (4.5)	74 (2.9)	225 (8.9)	11 (0.43)	5.5 (0.22)	9 (0.35)	5.3 (11.7)
I3	IP54	–	5.5–7.5 (7.5-10)	–	368 (14.5)	–	354 (13.9)	135 (5.3)	89 (3.5)	237 (9.3)	12 (0.47)	6.5 (0.26)	9.5 (0.37)	7.2 (15.9)
I4	IP54	–	11–18.5 (15–25)	–	476 (18.7)	–	460 (18.1)	180 (7)	133 (5.2)	290 (11.4)	12 (0.47)	6.5 (0.26)	9.5 (0.37)	13.8 (30.42)
I6	IP54	–	22-37 (30-50)	–	650 (25.6)	–	624 (24.6)	242 (9.5)	210 (8.3)	260 (10.2)	19 (0.75)	9 (0.35)	9 (0.35)	27 (59.5)
I7	IP54	–	45-55 (60-70)	–	680 (26.8)	–	648 (25.5)	308 (12.1)	272 (10.7)	310 (12.2)	19 (0.75)	9 (0.35)	9.8 (0.39)	45 (99.2)
I8	IP54	–	75-90 (100-125)	–	770 (30)	–	739 (29.1)	370 (14.6)	334 (13.2)	335 (13.2)	19 (0.75)	9 (0.35)	9.8 (0.39)	65 (143.3)

1) Including decoupling plate

The dimensions are only for the physical units. When installing in an application it is necessary to allow space above and below the units for cooling. The amount of space for free air passage is listed in *Table 5.1*.

Table 5.4 Dimensions, Enclosure Size I2-I8

5.1.3 Shipping Dimensions

Enclosure frame size Mains voltage	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	I2	I3	I4	I6	I7	I8
200-240 V AC [kW/Hp]	0.25-1.5/ 0.33-2	2.2/3	3.7/5	5.5-7.5/ 7.5-10	11/15	15-18.5/ 20	22-30/ 30-40	37-45/ 50-60								
380-480 V AC [kW/Hp]	0.37-1.5/ 0.5-2	2.2-4/ 3-5.4	5.5-7.5/ 7.5-10	11-15/ 15-20	18.5-22/ 25-30	30-45/ 40-60	55-75/ 73-100	90/ 125			0.75/ 1.0-5.0	5.5-7.5/ 7.5-10	11-18.5/ 15-25	22-37/ 30-50	45-55/ 60-70	75-90/ 125
3x525-600 V AC) [kW/Hp]						18.5-30/ 30-40	37-55/ 60-70	75-90/ 100-125	2.2-7.5/ 3.0-10	11-15/ 15-20						
IP frame	**IP20**										**IP54**					
Maximum weight [kg]	2.1	3.4	4.5	7.9	9.5	24.5	36	51	6.6	11.5	6.1	7.8	13.8	28.3	41.5	60.5
Shipping dimensions																
Height [mm/inch]	255/10.0	300/ 11.8	330/ 13.0	380/ 15.0	420 / 16.5	850	850	850	380	500	440	470	588	850	850	950
Width [mm/inch]	154/6.1	170/ 6.7	188/ 7.4	250/ 9.8	290/ 11.4	370	410	490	290	330	200	240	285	370	410	490
Depth [mm/inch]	235/9.3	260/ 10.2	282/ 11.1	375/ 14.8	375/ 14.8	460	540	490	200	350	300	330	385	460	540	490

Table 5.5 Shipping Dimensions

5.1.4 Field Mounting

For field mounting, IP21/TYPE 1 kits are recommended.

5.2 Electrical Data

5.2.1 Electrical Overview

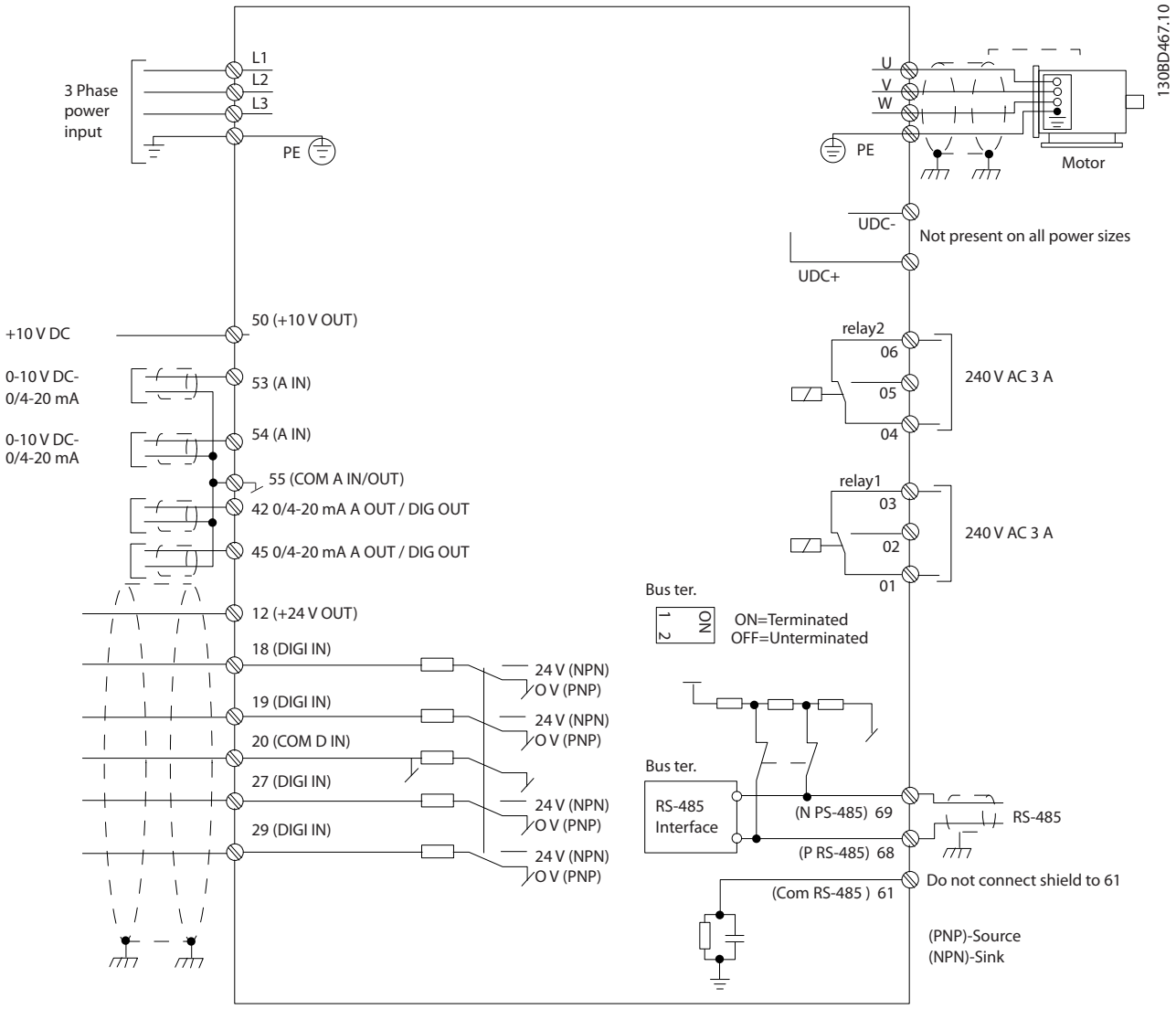


Illustration 5.1 Basic Wiring Schematic Drawing

5.2.2 Electrical Installation in General

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

Enclosure		Torque [Nm]					
Frame	IP class	Line	Compressor connection	DC connection	Control terminals	Ground	Relay
H3	IP20	1.4	0.8	0.8	0.5	0.8	0.5
H4	IP20	1.2	1.2	1.2	0.5	0.8	0.5
H5	IP20	1.2	1.2	1.2	0.5	0.8	0.5

Table 5.6 Enclosure H3-H5

5.2.3 Connecting to Mains and Compressor

The frequency converter is designed to operate Danfoss VZH Compressors. For maximum cross-section on wires see *chapter 8.2 General Specifications*.

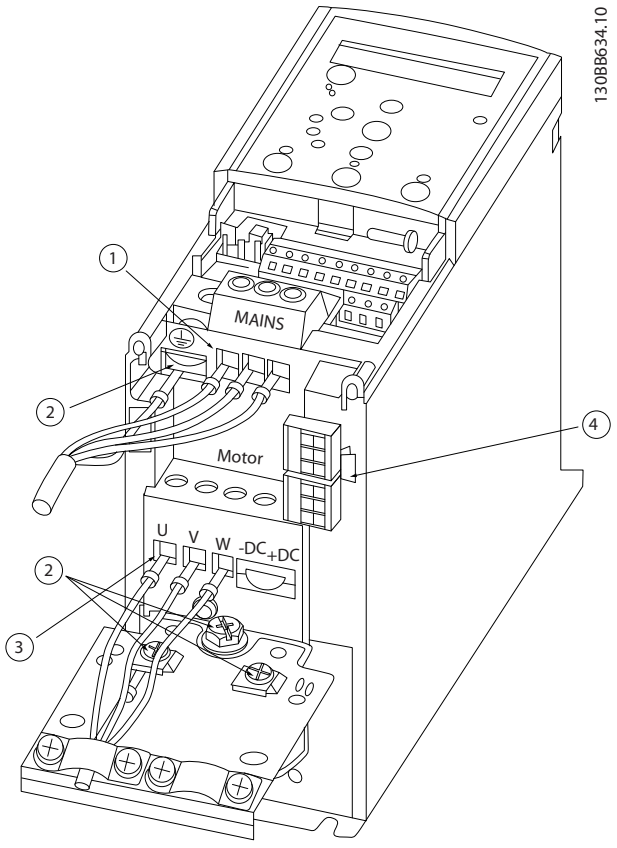
- Use a shielded/armored compressor cable to comply with EMC emission specifications, and connect this cable to both the decoupling plate and the compressor metal.
- Keep compressor cable as short as possible to reduce the noise level and leakage currents.
- For further details on mounting of the decoupling plate, see *VLT® Compressor Drive CDS 803 Decoupling Plate Installation Instructions*.
- Also see *EMC-Correct Installation in the VLT® Compressor Drive CDS 803 Design Guide*.

1. Mount the ground wires to ground terminal.
2. Connect compressor to terminals U, V and W, see *Table 5.7*.

U	T1
V	T2
W	T3

Table 5.7 Connection of Compressor to Terminals

3. Mount mains supply to terminals L1, L2 and L3 and tighten.



1	Line
2	Ground
3	Compressor
4	Relays

Illustration 5.2 H3-H5 Frame
IP20 200-240 V 4-6.5 tons
IP20 380-480 V 4-6.5 tons

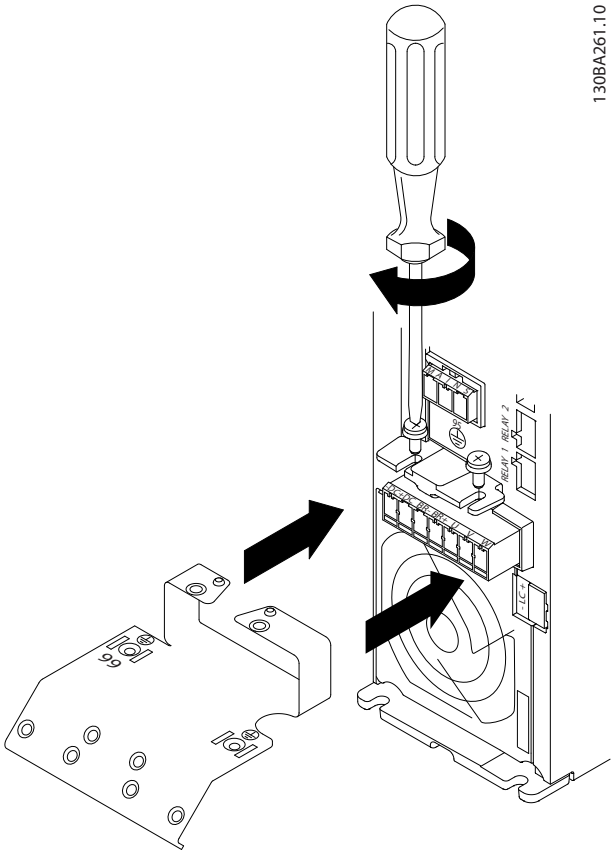


Illustration 5.3 Mount the 2 screws in the mounting plate, slide it into place and tighten fully.

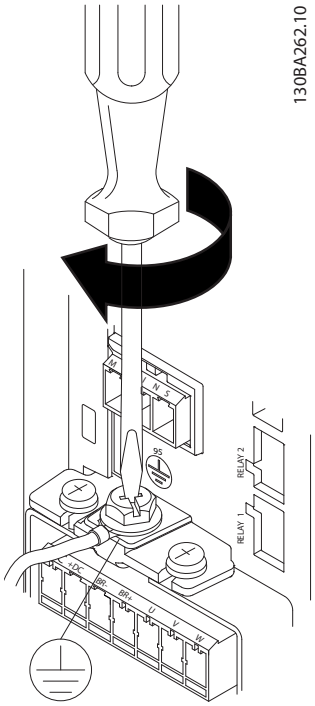


Illustration 5.5 When mounting cables, first mount and tighten ground cable.

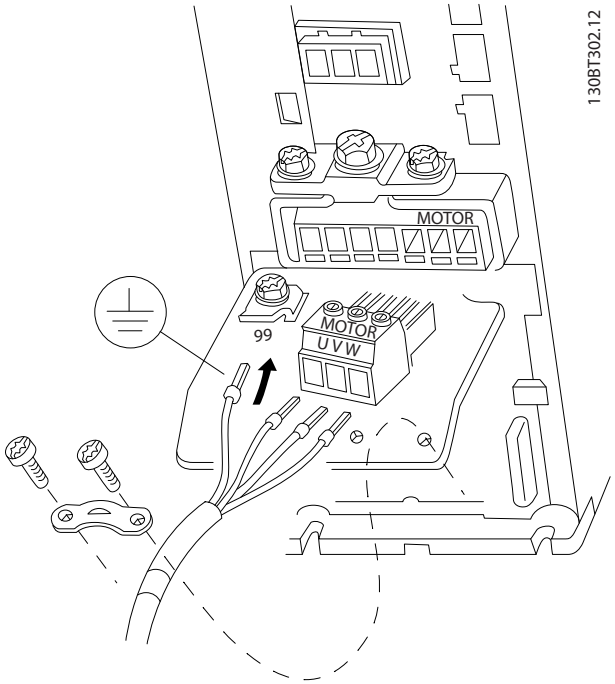


Illustration 5.4 H3-H5 Frame

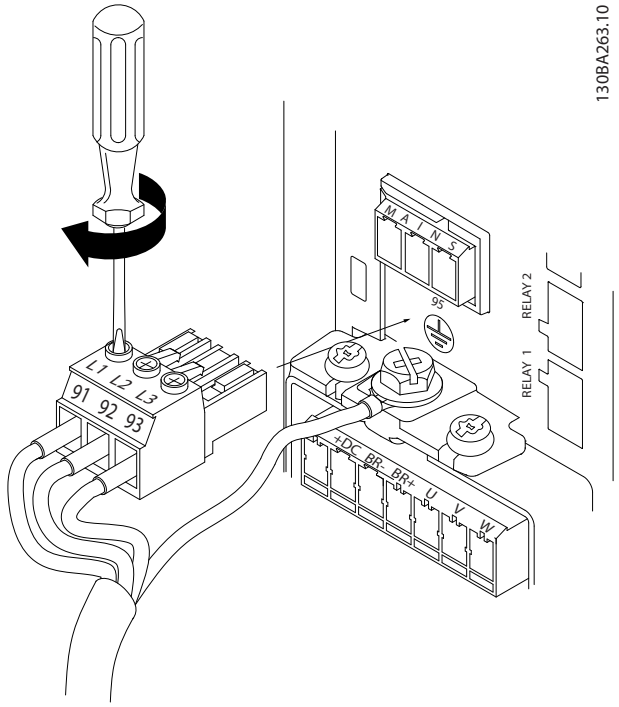


Illustration 5.6 Mount mains plug and tighten wires.

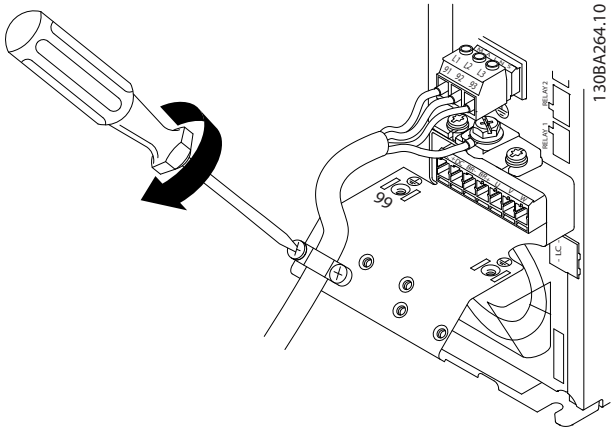


Illustration 5.7 Tighten support bracket on mains wires.

5

5.2.4 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-circuit and overcurrent protected according to national and local regulations.

Short circuit protection
Danfoss recommends using the fuses listed in *Table 5.8* to protect service personnel or 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 compressor.

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

UL/Non UL compliance
Use the fuses listed in *Table 5.8* to ensure compliance with UL or IEC 61800-5-1.

NOTICE

In the event of malfunction, failure to follow the protection recommendation may result in damage to the frequency converter.

	Fuse				
	UL				Non UL
	Bussmann	Bussmann	Bussmann	Bussmann	Max fuse
CDS 803	Type RK5	Type RK1	Type J	Type T	Type G
3x200-240 V IP20					
4 TR/VZH028	FRS-R-50	KTN-R50	JKS-50	JJN-50	50
5 TR/VZH035	FRS-R-50	KTN-R50	JKS-50	JJN-50	50
6.5 TR/VZH044	FRS-R-80	KTN-R80	JKS-80	JJN-80	65
3x380-480 V IP20					
4 TR/VZH028	FRS-R-25	KTS-R25	JKS-25	JJS-25	25
5 TR/VZH035	FRS-R-25	KTS-R25	JKS-25	JJS-25	25
6.5 TR/VZH044	FRS-R-50	KTS-R50	JKS-50	JJS-50	50

Table 5.8 Fuses

5.2.5 EMC Compliant 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.

5

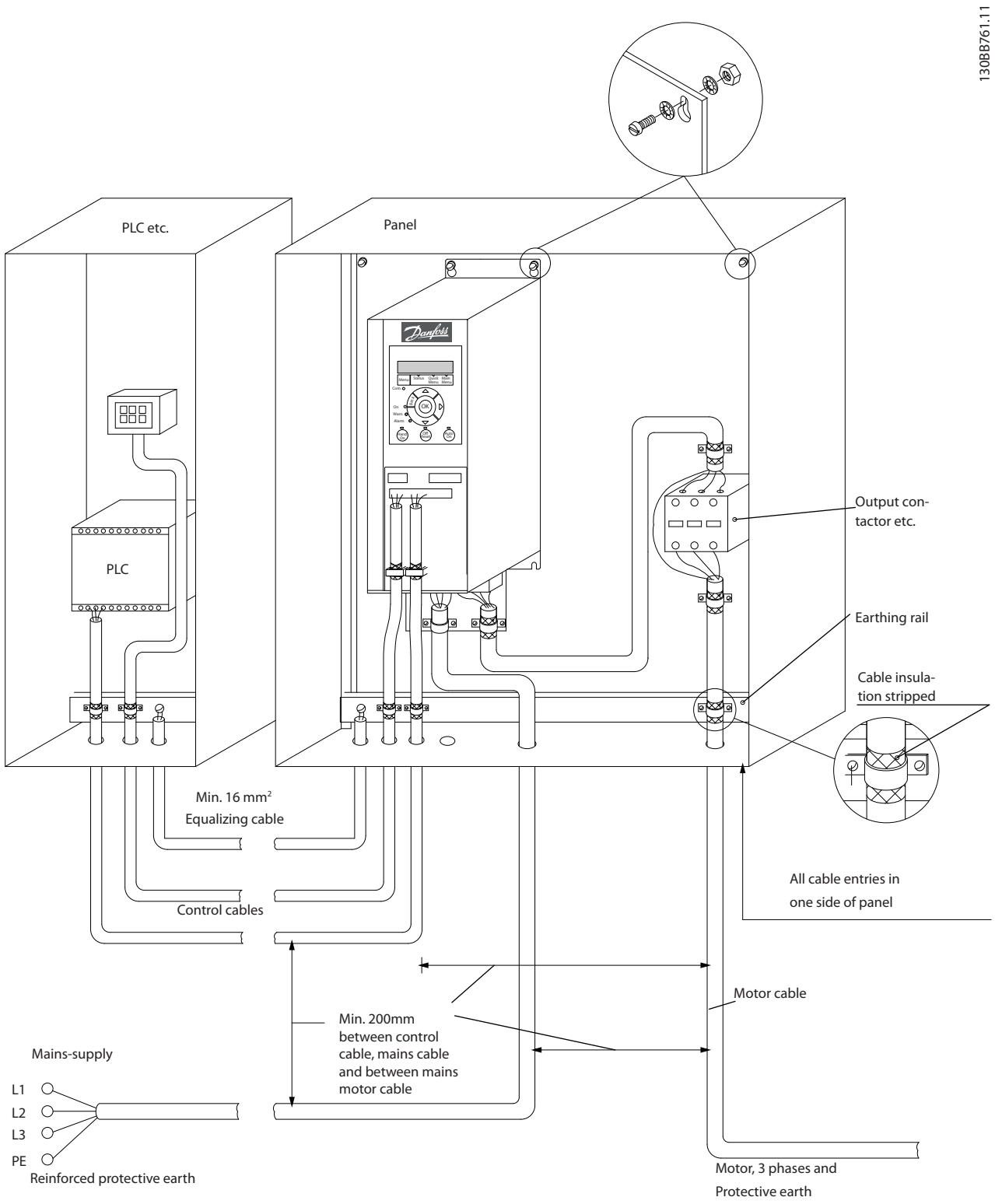


Illustration 5.8 EMC-correct Electrical Installation

NOTICE

For North America use metal conduits instead of shielded cables.

5.2.6 Control Terminals

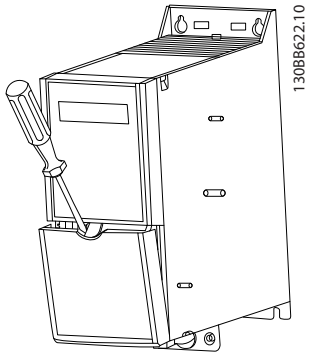


Illustration 5.9 Location of Control Terminals

1. Place a screwdriver behind the terminal cover to activate the snap.
2. Tilt the screwdriver outwards to open the cover.

Control terminals
To make the compressor run:

1. Apply start signal on terminal 18
2. Connect terminals 12, 27 and terminal 53, 54 or 55

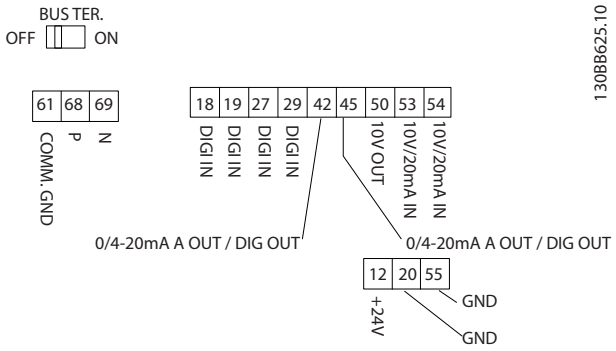


Illustration 5.10 Control Terminals

Set the functions of digital input 18, 19 and 27 in *5-00 Digital Input Mode* (PNP is default value). Set the function of digital input 29 in *5-03 Digital Input 29 Mode* (PNP is default value).

6 How to Programme

6.1 Programming with MCT 10 Set-up Software

The frequency converter can be programmed from a PC via RS-485 COM port by using the MCT 10 Set-up Software. Contact the local supplier for the software, or download it from *www.danfoss.com/BusinessAreas/DrivesSolutions/softwaredownload*

6.2 Local Control Panel (LCP)

6

The LCP is divided into 4 functional sections.

A. Display

B. Menu key

C. Navigation keys and indicator lights (LEDs)

D. Operation keys and indicator lights (LEDs)

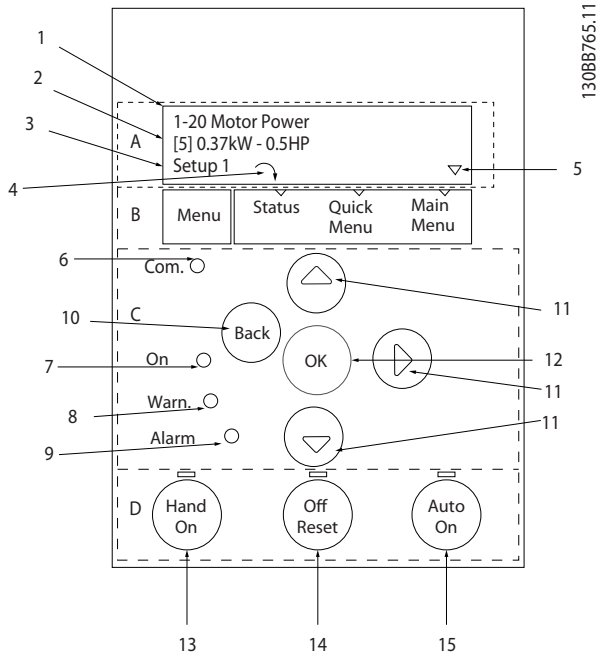


Illustration 6.1 Local Control Panel (LCP)

A. Display
The LCD-display is back-lit with 2 alphanumeric lines. All data is displayed on the LCP.

Illustration 6.1 describes the information that can be read from the display.

1	Parameter number and name.
2	Parameter value.
3	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.
4	Motor direction is shown to the bottom left of the display – indicated by a small arrow pointing either clockwise or counterclockwise.
5	The triangle indicates if the LCP is in status, quick menu or main menu.

Table 6.1 Legend to *Illustration 6.1*

B. Menu key
Press [Menu] to select between status, quick menu or main menu.

C. Navigation keys and indicator lights (LEDs)

6	Com LED: Flashes when bus communication is communicating.
7	Green LED/On: Control section is working correctly.
8	Yellow LED/Warn.: Indicates a warning.
9	Flashing Red LED/Alarm: Indicates an alarm.
10	[Back]: For moving to the previous step or layer in the navigation structure.
11	[▲] [▼] [►]: For navigating among parameter groups, parameters and within parameters. They can also be used for setting local reference.
12	[OK]: For selecting a parameter and for accepting changes to parameter settings.

Table 6.2 Legend to *Illustration 6.1*

D. Operation keys and indicator lights (LEDs)

13	[Hand On]: Starts the motor and enables control of the frequency converter via the LCP. ***NOTICE*** ***[2] coast inverse* is the default option for *5-12 Terminal 27 Digital Input*. This means that [Hand On] does not start the motor if there is no 24 V supply to terminal 27. Connect terminal 12 to terminal 27.**
14	[Off/Reset]: Stops the motor (Off). If in alarm mode, the alarm is reset.
15	[Auto On]: Frequency converter is controlled either via control terminals or serial communication.

Table 6.3 Legend to *Illustration 6.1*

6.3 Menus

6.3.1 Status Menu

In the *Status* menu, the selection options are:

- Motor Frequency [Hz], *16-13 Frequency*.
- Motor Current [A], *16-14 Motor current*.
- Motor Speed Reference in Percentage [%], *16-02 Reference [%]*.
- Feedback, *16-52 Feedback[Unit]*.
- Motor Power [kW] (if *0-03 Regional Settings* is set to *[1] North America*, Motor Power is shown in the unit of hp instead of kW), *16-10 Power [kW]* for kW, *16-11 Power [hp]* for hp.
- Custom Readout *16-09 Custom Readout*.

6.3.2 Quick Menu

Use the Quick Menu to programme the most common functions. The Quick Menu consists of:

- Wizard for open loop applications
- Closed loop set-up wizard
- Changes made

6.3.3 The Start-up Wizard

The built-in wizard menu guides the installer through the set-up of the frequency converter in a clear and structured way to set-up an open loop application. An open loop application is here an application with a start signal, analog reference (voltage or current) and optionally also relay signals (but no feedback signal from the process applied).

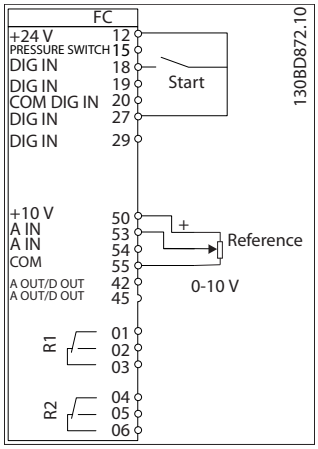


Illustration 6.2 Open Loop Application

The wizard is initially shown after power-up until any parameter has been changed. The wizard can always be accessed again through the *Quick Menu*. Press [OK] to start the wizard. Press [Back] to return to the status screen.

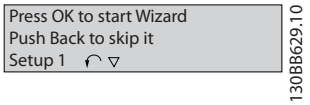
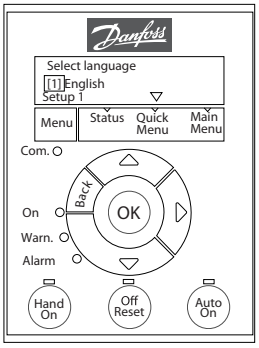


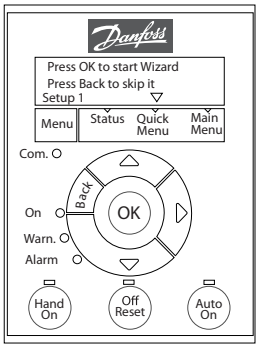
Illustration 6.3 Start-up/Quit Wizard

At power up the user is asked to choose the prefered laguage.



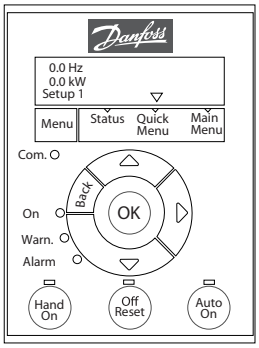
Power Up Screen

The next screen will be the Wizard screen.



Wizard Screen

if

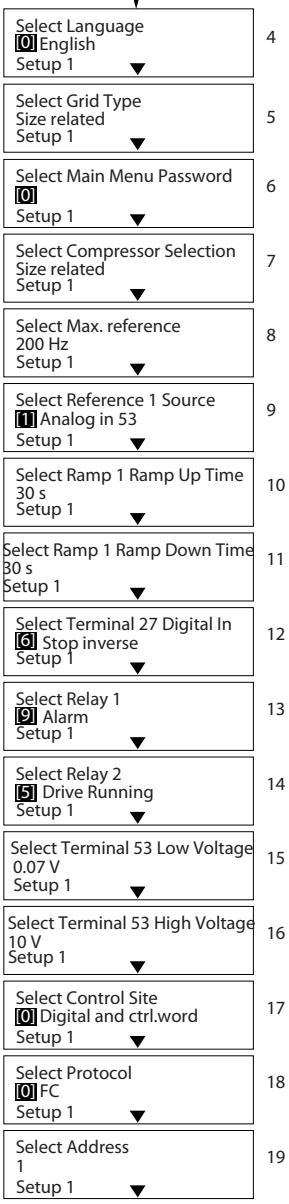


Status Screen

The Wizard can always be reentered via the Quick Menu!

if

... the CDS 803 Wizard starts



130BD873.12

The Start-up wizard for open-loop applications

Parameter	Option	Default	Function
0-01 Language	[0] English [1] Deutsch [2] Francais [3] Dansk [4] Spanish [5] Italiano [28] Bras.port	[0] English	Select the language for the display.
0-06 GridType	[0] 200-240 V/50 Hz/IT-grid [1] 200-240 V/50 Hz/Delta [2] 200-240 V/50 Hz [10] 380-440 V/50 Hz/IT-grid [11] 380-440 V/50 Hz/Delta [12] 380-440 V/50 Hz [20] 440-480 V/50 Hz/IT-grid [21] 440-480 V/50 Hz/Delta [22] 440-480 V/50 Hz [30] 525-600 V/50 Hz/IT-grid [31] 525-600 V/50 Hz/Delta [32] 525-600 V/50 Hz [100] 200-240 V/60 Hz/IT-grid [101] 200-240 V/60 Hz/Delta [102] 200-240 V/60 Hz [110] 380-440 V/60 Hz/IT-grid [111] 380-440 V/60 Hz/Delta [112] 380-440 V/60 Hz [120] 440-480 V/60 Hz/IT-grid [121] 440-480 V/60 Hz/Delta [122] 440-480 V/60 Hz [130] 525-600 V/60 Hz/IT-grid [131] 525-600 V/60 Hz/Delta [132] 525-600 V/60 Hz	Size related	Select operating mode for restart upon reconnection of the frequency converter to mains voltage after power-down.
0-60 Main Menu Password	0-999	0	Define the password for access to the LCP.
1-13 Compressor Selection	[24] VZH028-R410A [25] VZH035-R410A [26] VZH044-R410A	Size related	Select the used compressor.
3-03 Maximum Reference	0-200 Hz	200 Hz	The maximum reference is the highest obtainable by summing all references.
3-15 Reference 1 Source	[0] No function [1] Analog in 53 [2] Analog in 54 [7] Pulse input 29 [11] Local bus reference	[1] Analog in 53	Select the input to be used for the reference signal.
3-41 Ramp 1 Ramp Up Time	0.05-3600.0 s	30.00 s	Ramp-up time from 0 to *1-25 Motor Nominal Speed*.
3-42 Ramp 1 Ramp Down Time	0.05-3600.0 s	30.00 s	Ramp down time from rated motor speed to 0.

Parameter	Option	Default	Function
5-12 Terminal 27 Digital Input	[0] No operation [1] Reset [2] Coast inverse [3] Coast and reset inverse [4] Quick stop inverse [5] DC-brake inverse [6] Stop inverse [7] External Interlock [8] Start [9] Latched start [10] Reversing [11] Start reversing [14] Jog [16] Preset ref bit 0 [17] Preset ref bit 1 [18] Preset ref bit 2 [19] Freeze reference [20] Speed up [22] Speed down [23] Set-up select bit 0 [34] Ramp bit 0 [52] Run permissive [53] Hand start [54] Auto start [60] Counter A (up) [61] Counter A (down) [62] Reset Counter A [63] Counter B (up) [64] Counter B (down) [65] Reset Counter B	[6] Stop inverse	Select the input function for terminal 27.
5-40 Function Relay [0] Function relay	See *5-40 Function Relay*	Alarm	Select the function to control output relay 1.
5-40 Function Relay [1] Function relay	See *5-40 Function Relay*	Drive running	Select the function to control output relay 2.
6-10 Terminal 53 Low Voltage	0-10 V	0.07 V	Enter the voltage that corresponds to the low reference value.
6-11 Terminal 53 High Voltage	0-10 V	10 V	Enter the voltage that corresponds to the high reference value.
8-01 Control Site	[0] Digital and ctrl.word [1] Digital only [2] Controlword only	[0] Digital and ctrl. word	Select if digital, bus, or a combination of both should control the frequency converter.
8-30 Protocol	[0] FC [2] Modbus RTU	[0] FC	Select the protocol for the integrated RS-485 port.
8-32 Baud Rate	[0] 2400 Baud [1] 4800 Baud *[2] 9600 Baud [3] 19200 Baud 4] 38400 Baud 5] 57600 Baud [6] 76800 Baud [7] 115200 Baud	9600	Select the baud rate for the RS-485 port.

Table 6.4 Open-loop Applications Set-up

The Start-up wizard for compressor functions

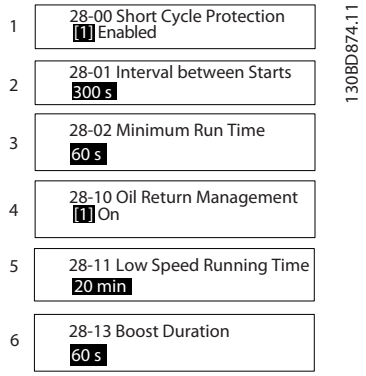


Illustration 6.5 Compressor Function Wizard

Compressor function wizard

Parameter	Option	Default	Function
28-00 Short Cycle Protection	[0] Disabled [1] Enabled	[1] Enabled	Select if short cycle protection is to be used.
28-01 Interval between Starts	0-3600 s	300 s	Enter the minimum allowed time between starts.
28-02 Minimum Run Time	10-3600 s	60 s	Enter the minimum allowed time to run before stop.
28-10 Oil Return Management	[0] Off [1] On	[1] On	Select if oil return management is to be used.
28-11 Low Speed Running Time	1-1400 min	20 min	Enter the low speed running time.
28-13 Boost Duration	10-3600 s	60 s	Enter the boost duration for the oil return.

Table 6.5 Compressor Function

The Start-up wizard for compressor closed-loop applications

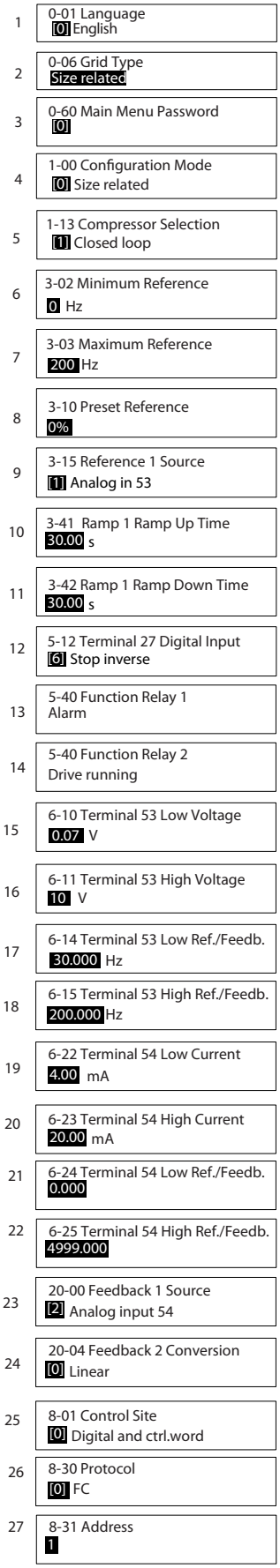


Illustration 6.6 Closed-loop Wizard

Closed-loop wizard

Parameter	Option	Default	Function
0-01 Language	[0] English [1] Deutsch [2] Francais [3] Dansk [4] Spanish [5] Italiano [28] Bras.port	0	Select the language for the display.
0-06 GridType	[0] 200-240 V/50 Hz/IT-grid [1] 200-240 V/50 Hz/Delta [2] 200-240 V/50 Hz [10] 380-440 V/50 Hz/IT-grid [11] 380-440 V/50 Hz/Delta [12] 380-440 V/50 Hz [20] 440-480 V/50 Hz/IT-grid [21] 440-480 V/50 Hz/Delta [22] 440-480 V/50 Hz [30] 525-600 V/50 Hz/IT-grid [31] 525-600 V/50 Hz/Delta [32] 525-600 V/50 Hz [100] 200-240 V/60 Hz/IT-grid [101] 200-240 V/60 Hz/Delta [102] 200-240 V/60 Hz [110] 380-440 V/60 Hz/IT-grid [111] 380-440 V/60 Hz/Delta [112] 380-440 V/60 Hz [120] 440-480 V/60 Hz/IT-grid [121] 440-480 V/60 Hz/Delta [122] 440-480 V/60 Hz [130] 525-600 V/60 Hz/IT-grid [131] 525-600 V/60 Hz/Delta [132] 525-600 V/60 Hz	Size related	Select the operating mode for restart upon reconnection of the frequency converter to mains voltage after power down.
0-60 Main Menu Password	0-999	0	Define the password for access to the LCP.
1-00 Configuration Mode	[0] Open loop [3] Closed loop	[0] Open loop	Select closed loop.
1-13 Compressor Selection	[24] VZH028-R410A [25] VZH035-R410A [26] VZH044-R410A	Size related	Select the used compressor.
3-02 Minimum Reference	-4999.0 - 200 Hz	0 Hz	The minimum reference is the lowest value obtainable by summing all references.
3-03 Maximum Reference	0 - 200 Hz	200 Hz	The maximum reference is the highest obtainable by summing all references.
3-10 Preset Reference	-100 - 100 %	0 %	Set-up a fix setpoint in preset reference [0].
3-15 Reference 1 Source	[0] No function [1] Analog in 53 [2] Analog in 54 [7] Pulse input 29 [11] Local bus reference	[1] Analog in 53	Select the input to be used for the reference signal.
3-41 Ramp 1 Ramp Up Time	0.05-3600.0 s	30.00 s	Ramp-up time from 0 to *1-25 Motor Nominal Speed*.
3-42 Ramp 1 Ramp Down Time	0.05-3600.0 s	30.00 s	Ramp-down time from rated motor speed to 0.

Parameter	Option	Default	Function
5-12 Terminal 27 Digital Input	[0] No operation [1] Reset [2] Coast inverse [3] Coast and reset inverse [4] Quick stop inverse [5] DC-brake inverse [6] Stop inverse [7] External Interlock [8] Start [9] Latched start [10] Reversing [11] Start reversing [14] Jog [16] Preset ref bit 0 [17] Preset ref bit 1 [18] Preset ref bit 2 [19] Freeze reference [20] Speed up [22] Speed down [23] Set-up select bit 0 [34] Ramp bit 0 [52] Run permissive [53] Hand start [54] Auto start [60] Counter A (up) [61] Counter A (down) [62] Reset Counter A [63] Counter B (up) [64] Counter B (down) [65] Reset Counter B	[6] Stop inverse	Select the input function for terminal 27.
5-40 Function Relay [0] Function relay	See *5-40 Function Relay*	Alarm	Select the function to control output relay 1.
5-40 Function Relay [1] Function relay	See *5-40 Function Relay*	Drive running	Select the function to control output relay 2.
6-10 Terminal 53 Low Voltage	0-10 V	0.07 V	Enter the voltage that corresponds to the low reference value.
6-11 Terminal 53 High Voltage	0-10 V	10 V	Enter the voltage that corresponds to the high reference value.
6-14 Terminal 53 Low Ref./Feedb. Value	-4999 - 4999	30	Enter the reference value that corresponds to the voltage set in *6-10 Terminal 53 Low Voltage*.
6-15 Terminal 53 High Ref./Feedb. Value	-4999 - 4999	200	Enter the reference value that corresponds to the voltage set in *6-11 Terminal 53 High Voltage*.
6-22 Terminal 54 Low Current	0.00-20.00 mA	4.00 mA	Enter the current that corresponds to the low reference value.
6-23 Terminal 54 High Current	0-10 V	10 V	Enter the current that corresponds to the high reference value.
6-24 Terminal 54 Low Ref./Feedb. Value	-0.00-20.00 mA	20.00 mA	Enter the reference value that corresponds to the current set in *6-20 Terminal 54 Low Voltage*.
6-25 Terminal 54 High Ref./Feedb. Value	-4999 - 4999	Size related	Enter the reference value that corresponds to the current set in *6-21 Terminal 54 High Voltage*.
8-01 Control Site	[0] Digital and ctrl.word [1] Digital only [2] Controlword only	[0] Digital and ctrl.word	Select if digital, bus, or a combination of both should control the frequency converter.

Parameter	Option	Default	Function
8-30 Protocol	[0] FC [2] Modbus RTU	[0] FC	Select the protocol for the integrated RS-485 port.
8-32 Baud Rate	[0] 2400 Baud [1] 4800 Baud [2] 9600 Baud [3] 19200 Baud [4] 38400 Baud [5] 57600 Baud [6] 76800 Baud [7] 115200 Baud	[2] 9600 Baud	Select the baud rate for the RS-485 port.
20-00 Feedback 1 Source	[0] No function [1] Analog Input 53 [2] Analog Input 54 [3] Pulse input 29 [100] Bus Feedback 1 [101] Bus Feedback 2	[0] No function	Select which input to use as the source of the feedback signal.
20-01 Feedback 1 Conversion	[0] Linear [1] Square root	[0] Linear	Select how calculate the feedback.

Table 6.6 Closed-loop Applications Set-up

Changes made
Changes Made lists all parameters changed from default settings.

- The list shows only parameters which have been changed in the current edit-setup.
- Parameters which have been reset to default values are not listed.
- The message *Empty* indicates that no parameters have been changed.

To change parameter settings

1. Press [Menu] to enter the *Quick Menu* until indicator in display is placed above *Quick Menu*.
2. Press [▲] [▼] to select wizard, closed-loop set-up, compressor set-up or changes made, 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. Press either [Back] twice to enter *Status*, or press [Menu] once to enter *Main Menu*.

The *Main Menu* accesses all parameters

1. Press [Menu] until indicator in display is placed above *Main Menu*.
2. Press [▲] [▼] to browse through the parameter groups.
3. Press [Ok] to select a parameter group.
4. Press [▲] [▼] to browse through the parameters in the specific group.
5. Press [Ok] to select the parameter.
6. Press [▲] [▼] to set/change the parameter value.

6.3.4 Main Menu

[Main Menu] is used for access to and programming of all parameters. The Main Menu parameters can be accessed readily unless a password has been created via *0-60 Main Menu Password*.
For the majority of VLT® HVAC Basic 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] until indicator in display is placed above “Main Menu”.
2. Press [▲] [▼] to browse through the parameter groups.
3. Press [OK] to select a parameter group.
4. Press [▲] [▼] to browse through the parameters in the specific group.
5. Press [OK] to select the parameter.
6. Press [▲] [▼] to set/change the parameter value.

Press [Back] to go back one level.

6.4 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]

6.5 Read-out and Programming of Indexed Parameters

Select the parameter, press [OK], and press [▲]/[▼] to scroll through the indexed values. To change the parameter value, select the indexed value and press [OK]. Change the value by pressing [▲]/[▼]. Press [OK] to accept the new setting. Press [Cancel] to abort. Press [Back] to leave the parameter.

6.6 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 *[2] 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
- 8-37 Maximum Inter-char delay
- 8-70 BACnet Device Instance
- 8-72 MS/TP Max Masters
- 8-73 MS/TP Max Info Frames
- 8-74 "I am" Service
- 8-75 Intialisation Password
- 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
- 1-06 Clockwise Direction

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.
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.

7 RS-485 Installation and Set-up

7.1 RS-485

7.1.1 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, see *Illustration 7.1*.

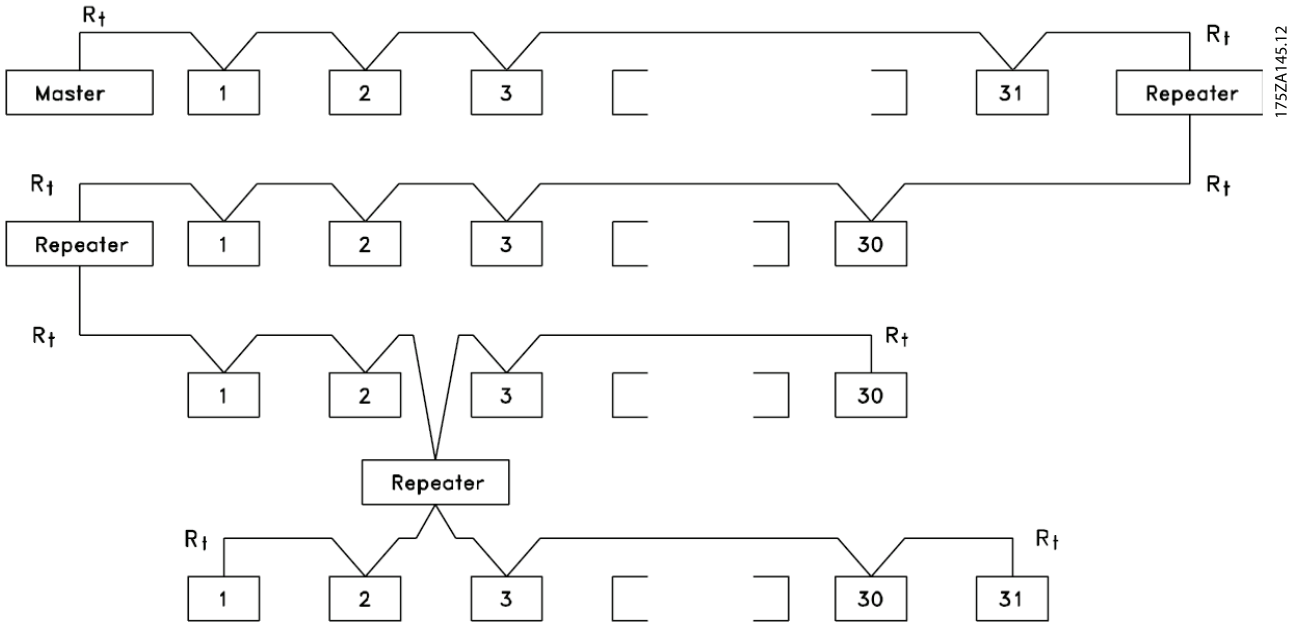


Illustration 7.1 RS-485 Bus Interface

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 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 7.1 Cable Specifications

7.1.2 Network Connection

Connect the frequency converter to the RS-485 network as follows (see also *Illustration 7.2*):

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.

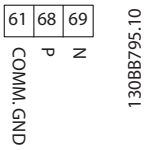


Illustration 7.2 Network Connection

7.1.3 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.

The factory setting for the dip switch is OFF.

7.1.4 Parameter Settings for Modbus Communication

Parameter	Function
8-30 Protocol	Select the application protocol to run for 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.
8-37 Maximum Inter-char delay	If transmission is interrupted, specify a maximum delay time between two received bytes to ensure time-out. ***NOTICE*** **The default selection depends on the protocol selected in *8-30 Protocol***

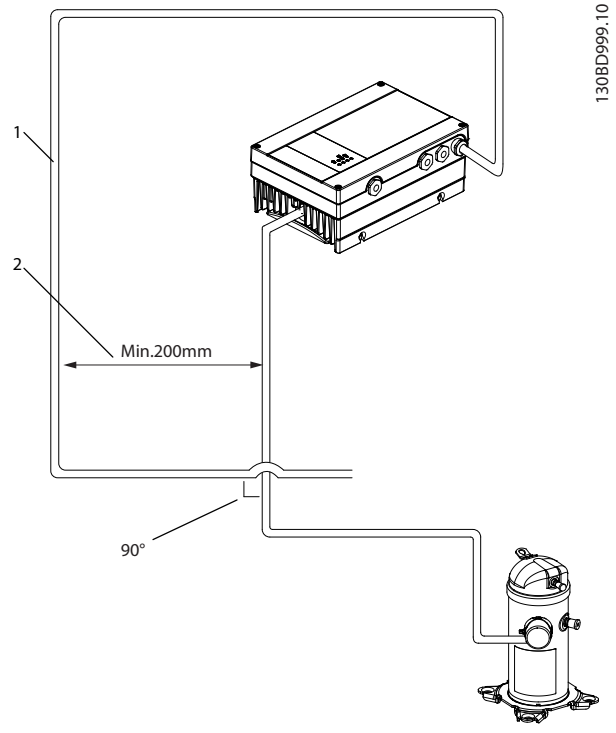
Table 7.2 Modbus Communication Parameter Settings

7.1.5 EMC Precautions

To achieve interference-free operation of the RS485 network, Danfoss recommends the following EMC precautions.

NOTICE

Observe relevant national and local regulations, for example regarding protective earth connection. To avoid coupling of high-frequency noise between the cables, the RS485 communication cable must be kept away from motor and brake resistor cables. Normally, a distance of 200 mm (8 inches) is sufficient. Maintain the greatest possible distance between the cables, especially where cables run in parallel over long distances. When crossing is unavoidable, the RS485 cable must cross motor and brake resistor cables at an angle of 90°.



1	Fieldbus cable
2	Minimum 200 mm distance

Illustration 7.3 Minimum Distance between Communication and Power Cables

7.2 FC Protocol Overview

7.2.1 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

7.2.2 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.

7.3 Network Configuration

7.3.1 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 7.3 Network Configuration Parameters

7.4 FC Protocol Message Framing Structure

7.4.1 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 7.4 Content of a Character

7.4.2 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.

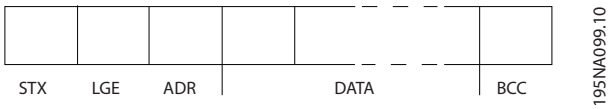


Illustration 7.5 Telegram Structure

7.4.3 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 7.4 Length of Telegrams

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

7.4.4 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.

7.4.5 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.

7.4.6 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 7.6 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.

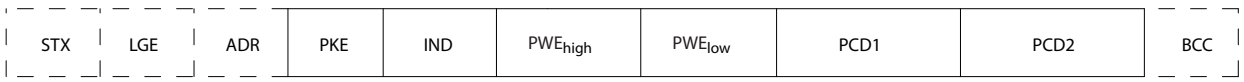


Illustration 7.7 Parameter Block

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

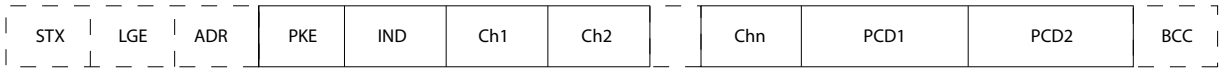


Illustration 7.8 Text Block

7.4.7 The PKE Field

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

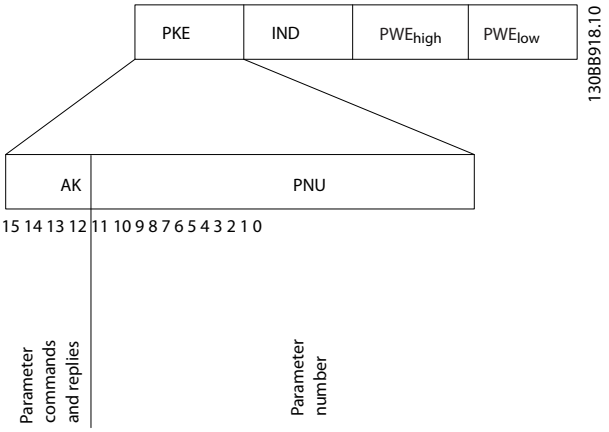


Illustration 7.9 PKE Field

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 7.5 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 7.6 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 7.7 Follower Report

7.4.8 Parameter Number (PNU)

Bits no. 0-11 transfer parameter numbers. The function of the relevant parameter is defined in the parameter description in *chapter 6 How to Programme*.

7.4.9 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.

Only the low byte is used as an index.

7.4.10 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".

7.4.11 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 7.8 Data Types

7.4.12 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 7.9 Conversion

7.4.13 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 7.10 Process Words (PCD)

7.5 Examples

7.5.1 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 7.4.12 Conversion*.

The telegram looks like this:

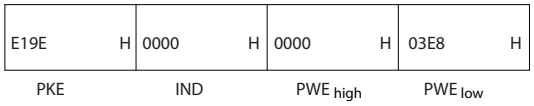


Illustration 7.10 Telegram

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:

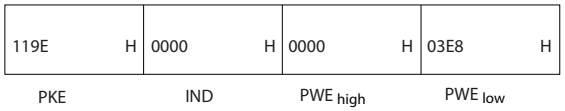


Illustration 7.11 Response from Master

7.5.2 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

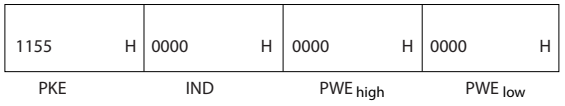


Illustration 7.12 Telegram

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

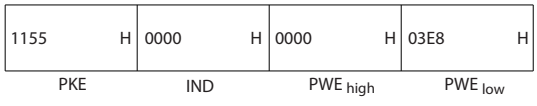


Illustration 7.13 Response

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*.

7.6 Modbus RTU Overview

7.6.1 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.

7.6.2 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.

7.6.3 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

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

7.6.4 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.

7.7 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 7.11 Network Configuration

7.8 Modbus RTU Message Framing Structure

7.8.1 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 7.12*.

Start bit	Data byte								Stop/ parity	Stop

Table 7.12 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)

7.8.2 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 7.13*.

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 7.13 Typical Modbus RTU Message Structure

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7.8.3 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.

7.8.4 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.

7.8.5 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
chapter 7.8.10 Function Codes Supported by Modbus RTU and
chapter 7.8.11 Modbus Exception Codes

7.8.6 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.

7.8.7 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.

7.8.8 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).

Coil Number	Description	Signal Direction
1-16	Frequency converter control word (see *Table 7.15*)	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 7.16*)	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 7.14 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 7.15 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 7.16 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 7.17 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.

7.8.9 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.

7.8.10 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 7.18 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 communi-cation error count
		13	Return follower error count
		14	Return follower message count

Table 7.19 Function Codes

7.8.11 Modbus Exception Codes

For a full explanation of the structure of an exception code response, refer to *chapter 7.8.5 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 7.20 Modbus Exception Codes

7.9 How to Access Parameters

7.9.1 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.

7.9.2 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).

7.9.3 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.

7.9.4 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.

7.9.5 Conversion Factor

A parameter value can only be transferred as a whole number. Use a conversion factor to transfer decimals.

7.9.6 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).

7.10 Examples

The following examples illustrate various Modbus RTU commands.

7.10.1 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 7.21 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 7.22 Response

NOTICE

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

7.10.2 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 7.23 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 7.24 Response

7.10.3 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 set-point) 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 7.25 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 7.26 Response

7.10.4 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 7.27 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 7.28 Response

7.10.5 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 7.29 Query

7

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 7.30 Response

7.10.6 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 7.31 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 7.32 Response

7.11 Danfoss FC Control Profile

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

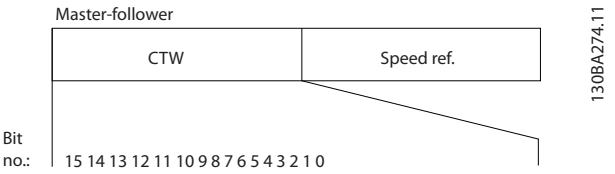

Illustration 7.14 Control Word According to FC Profile

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 7.33 Control Word According to FC Profile

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 7.34*.

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 7.34 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 compressor, (the output transistors are "shut off") and it coasts to a standstill.
Bit 03='1': The frequency converter starts the compressor 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 compressor 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 compressor speed ramp down to stop via the selected ramp down parameter.
Bit 06='1': Permits the Frequency converter to start the compressor, 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, that is, 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 chosen 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 chosen 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 7.35*.

Set-up	Bit 13
1	0
2	1

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 Serial communication, Logic or Logic and is selected.

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

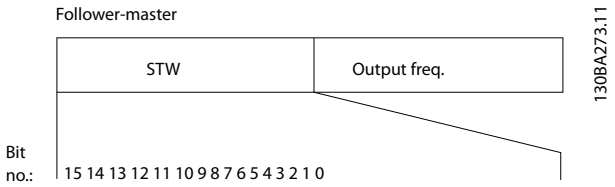

Illustration 7.15 Status Word

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 7.35 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 compressor.
Bit 02='1': The frequency converter starts the compressor 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 compressor 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 compressor 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 compressor 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 compressor 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 compressor thermal protection and thermal protection are not exceeded 100%.

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

7.11.3 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.

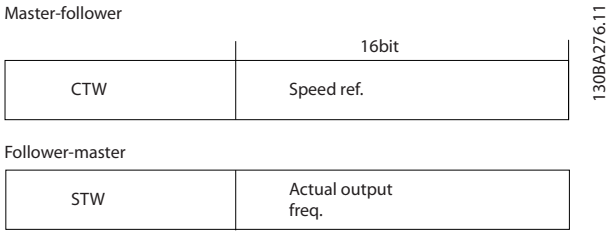

Illustration 7.16 Actual Output Frequency (MAV)

The reference and MAV are scaled as follows:

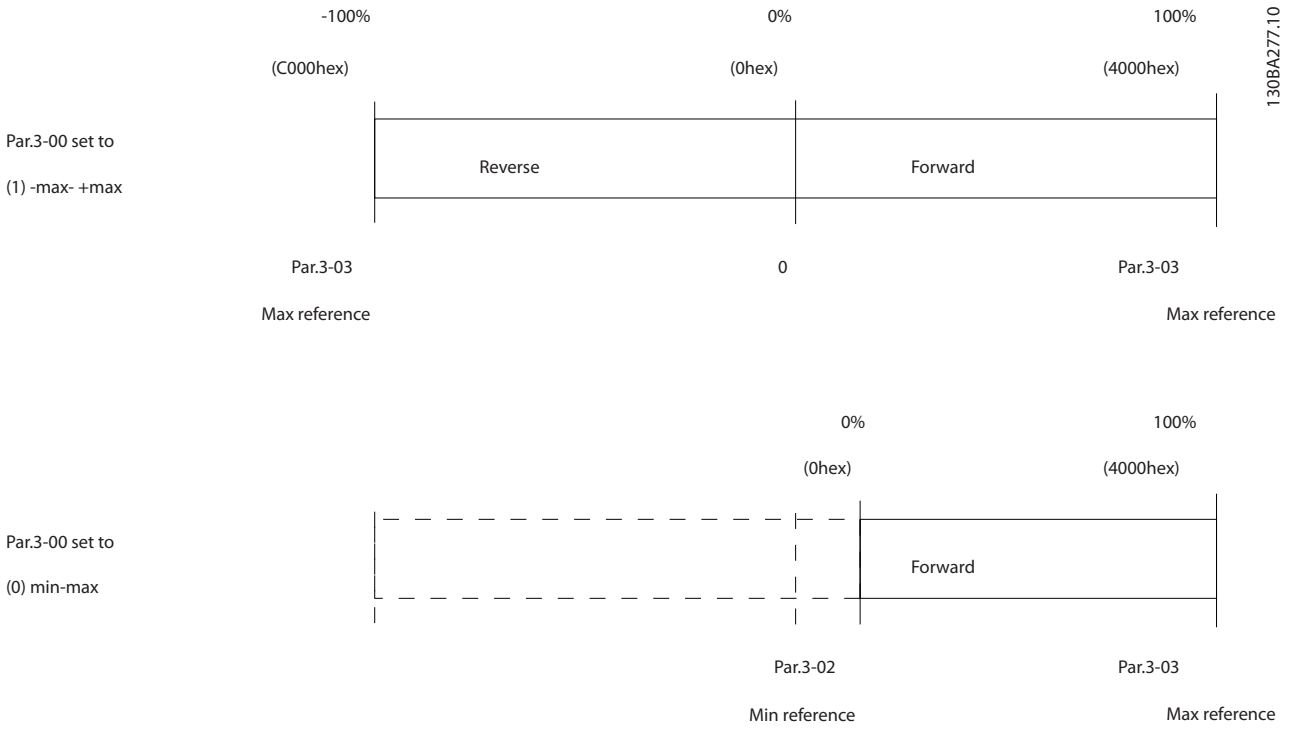

Illustration 7.17 Reference and MAV

8 General Specifications

8.1 Mains Supply Specifications

8.1.1 Mains Supply 3x200-240 V AC

Frequency converter	4 TR/VZH028	5 TR/VZH035	6.5 TR/VZH044
Typical shaft output [kW]	6.0	7.5	10
IP20 enclosure protection	H4	H4	H5
Maximum cable size in terminals (mains, compressor) [mm²/AWG]	16/6	16/6	16/6
Output current			
Continuous (3x200-240 V) [A]	20.7	25.9	33.7
Intermittent (3x200-240 V) [A]	-	-	37.1
Maximum input current			
Continuous 3x200-240 V) [A]	23.0	28.3	37.0
Intermittent (3x200-240 V) [A]	-	-	41.5
Maximum mains fuses, see *Table 5.8*			
Estimated power loss [W], Best case/typical[1)]	182/ 204	229/ 268	369/ 386
Weight enclosure protection P20 [kg]	7.9	7.9	9.5
Efficiency [%], best case/ typical[1)]	97.3/ 97.0	98.5/ 97.1	97.2/ 97.1

Table 8.1 3x200-240 V AC

1) At rated load conditions

8.1.2 Mains Supply 3x380-480 V AC

Frequency converter	4 TR/VZH028	5 TR/VZH035	6.5 TR/VZH044
Typical shaft output [kW]	6.0	7.5	10
IP20 enclosure protection	H3	H3	H4
Maximum cable size in terminals (mains, compressor) [mm²/AWG]	4/10	4/10	16/6
Output current			
Continuous (3x380-440 V) [A]	11.6	14.3	16.4
Intermittent (3x380-440 V) [A]			18.0
Continuous (3x440-480 V) [A]	9.8	12.3	15.5
Intermittent (3x440-480 V) [A]			17.0
Maximum input current			
Continuous (3x380-440 V) [A]	12.7	15.1	18.0
Intermittent (3x380-440 V) [A]			19.8
Continuous (3x440-480 V) [A]	10.8	12.6	17.0
Intermittent (3x440-480 V) [A]			18.7
Maximum mains fuses			
Estimated power loss [W], best case/typical[1)]	104/131	159/198	248/274
Weight enclosure protection IP20 [kg]	4.3	4.5	7.9
Efficiency [%], best case/typical[1)]	98.4/98.0	98.2/97.8	98.1/97.9

Table 8.2 3x380-480 V AC

1) At rated load conditions

8

8.2 General Specifications

Protection and features

- Electronic thermal compressor 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 compressor terminals U, V, W.
- When a compressor 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 compressor terminals U, V, W.

Mains supply (L1, L2, L3)	
Supply voltage	200-240 V ±10%
Supply voltage	380-480 V ±10%
Supply frequency	50/60 Hz
Maximum imbalance temporary between mains phases	3.0% of rated supply voltage
True power factor (λ)	≥0.9 nominal at rated load
Displacement power factor (cosφ) near unity	(>0.98)
Switching on the input supply L1, L2, L3 (power-ups)	Maximum 2 times/min.
Environment according to EN 60664-1	Overvoltage category III/pollution degree 2
The unit is suitable for use on a circuit capable of delivering not more than 100000 RMS symmetrical Amperes, 240/480 V maximum.	

Compressor output (U, V, W)	
Output voltage	0-100% of supply voltage
Output frequency	0-200 Hz (VVC+), 0-400 Hz (u/f)
Switching on output	Unlimited
Ramp times	0.05-3600 s

Cable lengths and cross-sections	
Maximum compressor cable length, screened/armoured (EMC correct installation)	See *chapter 2.7.3 EMC Test Results*
Maximum compressor cable length, unscreened/unarmoured	50 m
Maximum cross-section to compressor, mains[1)]	
Cross-section DC terminals for filter feedback on enclosure size H1-H3, I2, I3, I4	4 mm^2/11 AWG
Cross-section DC terminals for filter feedback on enclosure size H4-H5	16 mm^2/6 AWG
Maximum cross-section to control terminals, rigid wire	2.5 mm^2/14 AWG)
Maximum cross-section to control terminals, flexible cable	2.5 mm^2/14 AWG)
Minimum cross-section to control terminals	0.05 mm^2/30 AWG

1) See chapter 8.1.2 Mains Supply 3x380-480 V AC for more information

8.2.1 Digital Inputs

Programmable digital inputs	4
Terminal number	18, 19, 27, 29
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	Approximately 4 kΩ
Digital input 29 as thermistor input	Fault: >2.9 kΩ and no fault: <800 Ω
Digital input 29 as Pulse input	Maximum frequency 32 kHz push-pull-driven & 5 kHz (O.C.)

8.2.2 Analog Inputs

Number of analog inputs	2
Terminal number	53, 54
Terminal 53 mode	Parameter 6-19: 1=voltage, 0=current
Terminal 54 mode	Parameter 6-29: 1=voltage, 0=current
Voltage level	0–10 V
Input resistance, R_i	approximately 10 kΩ
Maximum voltage	20 V
Current level	0/4 to 20 mA (scalable)
Input resistance, R_i	<500 Ω
Maximum current	29 mA
Resolution on analog input	10 bit

8.2.3 Analog Output

Number of programmable analog outputs	2
Terminal number	42, 45[1)]
Current range at analog output	0/4–20 mA
Maximum load to common at analog output	500 Ω
Maximum voltage at analog output	17 V
Accuracy on analog output	Maximum error: 0.4% of full scale
Resolution on analog output	10 bit

1) Terminal 42 and 45 can also be programmed as digital outputs.

8.2.4 Digital Output

Number of digital outputs	2
Terminal number	42, 45[1)]
Voltage level at digital output	17 V
Maximum output current at digital output	20 mA
Maximum load at digital output	1 kΩ

1) Terminals 42 and 45 can also be programmed as analog output.

8.2.5 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

8.2.6 Control Card, 24 V DC Output

Terminal number	12
Maximum load	80 mA

8.2.7 Relay Output

Programmable relay output	2
Relay 01 and 02	01-03 (NC), 01-02 (NO), 04-06 (NC), 04-05 (NO)
Maximum terminal load (AC-1)[1)] on 01-02/04-05 (NO) (Resistive load)	250 V AC, 3 A
Maximum terminal load (AC-15)[1)] on 01-02/04-05 (NO) (Inductive load @ cosφ 0.4)	250 V AC, 0.2 A
Maximum terminal load (DC-1)[1)] on 01-02/04-05 (NO) (Resistive load)	30 V DC, 2 A
Maximum terminal load (DC-13)[1)] on 01-02/04-05 (NO) (Inductive load)	24 V DC, 0.1 A
Maximum terminal load (AC-1)[1)] on 01-03/04-06 (NC) (Resistive load)	250 V AC, 3 A
Maximum terminal load (AC-15)[1)] on 01-03/04-06 (NC) (Inductive load @ cosφ 0.4)	250 V AC, 0.2 A
	30 V DC, 2 A
Maximum terminal load (DC-1)[1)] on 01-03/04-06 (NC) (Resistive load)	Minimum 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 parts 4 and 5.

8

8.2.8 Control Card, 10 V DC Output[1)]

Terminal number	50
Output voltage	10.5 V ±0.5 V
Maximum load	25 mA

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

Surroundings	
Enclosure	IP20
Enclosure kit available	IP21, TYPE 1
Vibration test	1.0 g
Maximum relative humidity	5%-95% (IEC 60721-3-3; Class 3K3 (non-condensing) during operation
Aggressive environment (IEC 60721-3-3), coated (standard)	Class 3C3
Test method according to IEC 60068-2-43 H2S (10 days)	
Ambient temperature	50 °C

Derating for high ambient temperature, see *chapter 8.4 Derating according to Ambient Temperature and Switching Frequency*.

Minimum ambient temperature during full-scale operation	0 °C
Minimum ambient temperature at reduced performance	-20 °C
Temperature during storage/transport	-30 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 8.4 Derating according to Ambient Temperature and Switching Frequency*.	
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 61000-3-12, 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

8.3 Acoustic Noise or Vibration

If the compressor or the equipment driven by the compressor - e.g. a fan - is making noise or vibrations at certain frequencies, configure the following parameters or parameter groups to reduce or eliminate the noise or vibrations:

- Parameter group *4-6* Speed Bypass*
- Set *parameter14-03 Overmodulation* to *[0] Off*
- Switching pattern and switching frequency parameter group *14-0* Inverter Switching*
- *Parameter 1-64 Resonance Dampening*

The acoustic noise from the frequency converter comes from 3 sources:

1. DC intermediate circuit coils
2. Integral fan
3. RFI filter choke

Frame	Level [dBA]
H3	53.8
H4	64
H5	63.7

Table 8.3 Typical Values Measured at a Distance of 1 m from the Unit

8

8.4 Derating according to Ambient Temperature and Switching Frequency

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. If the ambient temperature is higher than 50 °C or the installation by altitude is higher than 1000 m, a larger CDS 803 drive might be needed to run an undersized compressor.
Consult Danfoss for support.

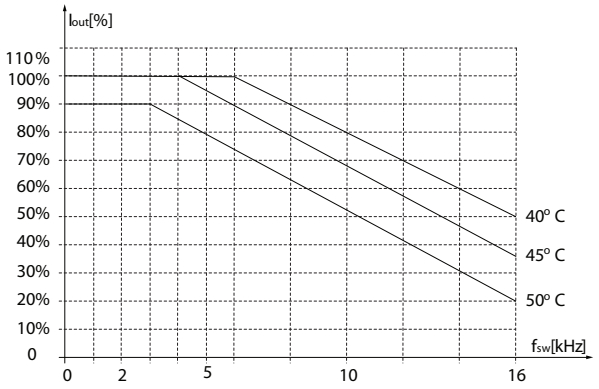

Illustration 8.1 400 V IP20 H3 6.0-7.5 kW

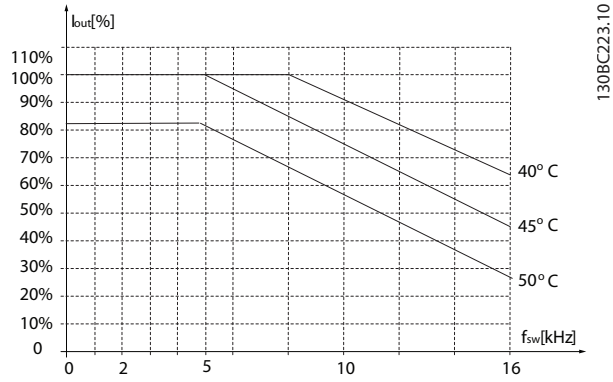

Illustration 8.2 200 V IP20 H4 6.0-7.5 kW

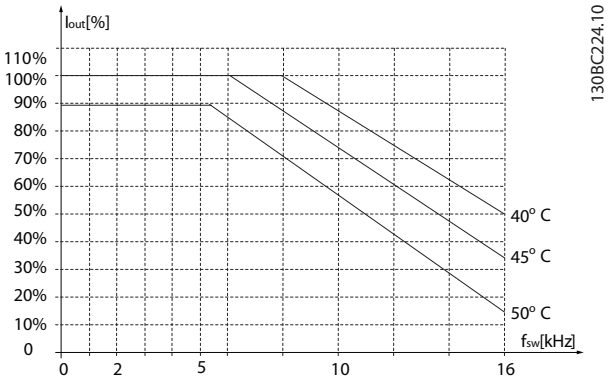

Illustration 8.3 400 V IP20 H4 10 kW

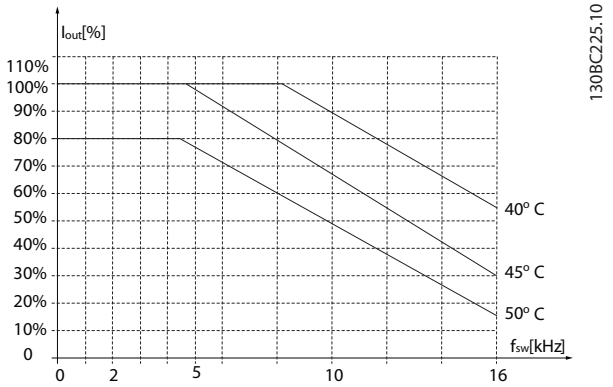

Illustration 8.4 200 V IP20 H5 10 kW

Index

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T

U

V

W

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