Contents

1. How to Read this Design Guide

1.1.1. How to Read this Design Guide

This Design Guide will introduce all aspects of your FC 300.

Available literature for FC 300

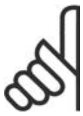
- The VLT® AutomationDrive FC 300 Operating Instructions MG.33.AX.YY provide the neccessary information for getting the drive up and running.
- The VLT® AutomationDrive FC 300 Design Guide MG.33.BX.YY entails all technical information about the drive and customer design and applications.
- The VLT® AutomationDrive FC 300 Programming Guide MG.33.MX.YY provides information on how to programme and includes complete parameter descriptions.
- The VLT® AutomationDrive FC 300 Profibus Operating Instructions MG.33.CX.YY provide the information required for controlling, monitoring and programming the drive via a Profibus fieldbus.
- The VLT® AutomationDrive FC 300 DeviceNet Operating Instructions MG.33.DX.YY provide the information required for controlling, monitoring and programming the drive via a DeviceNet fieldbus.

X = Revision number
YY = Language code

Danfoss Drives technical literature is also available online at www.danfoss.com/BusinessAreas/DrivesSolutions/Documentations/Technical+Documentation.

1.1.2. Symbols

Symbols used in this guide.



NB!
Indicates something to be noted by the reader.

Indicates a general warning.

Indicates a high-voltage warning.

*	Indicates default setting

1

1.1.3. 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
Drive Dependent	D-TYPE
Electro Magnetic Compatibility	EMC
Electronic Thermal Relay	ETR
drive	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	$U_{M,N}$
Parameter	par.
Protective Extra Low Voltage	PELV
Printed Circuit Board	PCB
Rated Inverter Output Current	I_{INV}
Revolutions Per Minute	RPM
Second	s
Torque limit	T_{LIM}
Volts	V

1.1.4. Definitions

Frequency converter:

D-TYPE

Size and type of the connected frequency converter (dependencies).

$I_{VLT,MAX}$

The maximum output current.

$I_{VLT,N}$

The rated output current supplied by the frequency converter.

$U_{VLT, MAX}$

The maximum output voltage.

Input:

Control command

You can start and stop the connected motor by means of LCP and the digital inputs.

Functions are divided into two 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

Motor:

f_{JOG}

The motor frequency when the jog function is activated (via digital terminals).

f_M

The motor frequency.

f_{MAX}

The maximum motor frequency.

f_{MIN}

The minimum motor frequency.

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

I_M
The motor current.

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

M-TYPE
Size and type of the connected motor (dependencies).

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

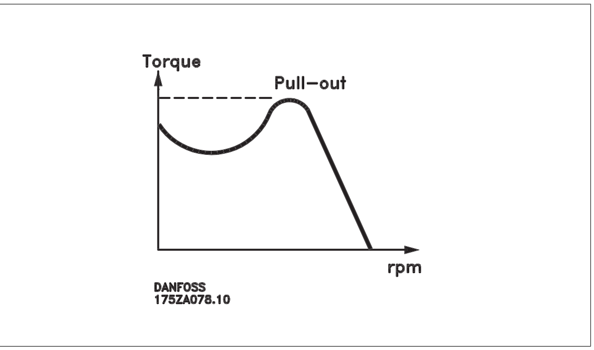
$P_{M,N}$
The rated motor power (nameplate data).

$T_{M,N}$
The rated torque (motor).

U_M
The instantaneous motor voltage.

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

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 this group.

Stop command
See Control commands.

References:

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

Binary Reference
A signal transmitted to the serial communication port.

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

Pulse Reference
A pulse frequency signal transmitted to the digital inputs (terminal 29 or 33).

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

Ref_{MIN}

Determines the relationship between the reference input at 0% value (typically 0V, 0mA, 4mA) and the resulting reference. The minimum reference value set in par. 3-02.

Miscellaneous:

Analog Inputs

The analog inputs are used for controlling various functions of the frequency converter.
There are two types of analog inputs:
Current input, 0-20 mA and 4-20 mA
Voltage input, 0-10 V DC (FC 301)
Voltage input, -10 - +10 V DC (FC 302).

Analog Outputs

The analog outputs can supply a signal of 0-20 mA, 4-20 mA.

Automatic Motor Adaptation, AMA

AMA algorithm determines the electrical parameters for the connected motor at standstill.

Brake Resistor

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

CT Characteristics

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

Digital Inputs

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

Digital Outputs

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

DSP

Digital Signal Processor.

ETR

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

Hiperface®

Hiperface® is a registered trademark by Stegmann.

Initialising

If initialising is carried out (par. 14-22), the frequency converter returns to the default setting.

Intermittent Duty C ycle

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 non-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 metres from the frequency converter, i.e. in a front panel by means of the installation kit option.

lsb

Least significant bit.

msb

Most significant bit.

MCM

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

On-line/Off-line Parameters

Changes to on-line parameters are activated immediately after the data value is changed. Changes to off-line parameters are not activated until you enter [OK] on the LCP.

Process PID

The PID regulator maintains the desired speed, pressure, temperature, etc. by adjusting the output frequency to match the varying load.

Pulse Input/Incremental Encoder

An external, digital pulse transmitter used for feeding back information on motor speed. The encoder is used in applications where great accuracy in speed control is required.

RCD

Residual Current Device.

Set-up
You can save parameter settings in four Set-ups. Change between the four parameter Set-ups and edit one Set-up, while another Set-up is active.

SFAVM
Switching pattern called Stator Flux oriented Asynchronous Vector Modulation (par. 14-00).

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

Smart Logic Control (SLC)
The SLC is a sequence of user defined actions executed when the associated user defined events are evaluated as true by the SLC. (Parameter group 13-xx).

FC Standard Bus
Includes RS 485 bus with FC protocol or MC protocol. See parameter 8-30.

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

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

VT Characteristics
Variable torque characteristics used for pumps and fans.

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

60° AVM
Switching pattern called 60°Asynchronous Vector Modulation (par. 14-00).

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

$$Power\ factor = \frac{\sqrt{3}\ x\ U\ x\ I_1\ cos\varphi}{\sqrt{3}\ x\ U\ x\ I_{RMS}}$$

The power factor for 3-phase control:

$$= \frac{I1\ x\ cos\varphi 1}{I_{RMS}} = \frac{I_1}{I_{RMS}}\ since\ cos\varphi 1 = 1$$

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

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.

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. Safety and Conformity

2.1. Safety Precautions

The voltage of the frequency converter is dangerous whenever connected to mains. Incorrect installation of the motor, frequency converter or fieldbus may cause damage to the equipment, serious personal injury or death. Consequently, the instructions in this manual, as well as national and local rules and safety regulations, must be complied with.

Safety Regulations

1. The mains supply to the frequency converter must be disconnected whenever repair work is to be carried out. Check that the mains supply has been disconnected and that the necessary time has elapsed before removing motor and mains supply plugs.
2. The [OFF] button on the control panel of the frequency converter does not disconnect the mains supply and consequently it must not be used as a safety switch.
3. The equipment must be properly earthed, the user must be protected against supply voltage and the motor must be protected against overload in accordance with applicable national and local regulations.
4. The earth leakage current exceeds 3.5 mA.
5. Protection against motor overload is not included in the factory setting. If this function is desired, set par. *1-90 Motor Thermal Protection* to data value ETR trip 1 [4] or data value ETR warning 1 [3].
6. Do not remove the plugs for the motor 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 motor and mains plugs.
7. Please note that the frequency converter has more voltage sources than L1, L2 and L3, when load sharing (linking of DC intermediate circuit) or external 24 V DC are installed. Check that all voltage sources have been disconnected and that the necessary time has elapsed before commencing repair work.

Warning against unintended start

1. The motor can be brought to a stop by means of digital commands, bus commands, references or a local stop, while the frequency converter is connected to mains. If personal safety considerations (e.g. risk of personal injury caused by contact with moving machine parts following an unintentional start) make it necessary to ensure that no unintended start occurs, these stop functions are not sufficient. In such cases the mains supply must be disconnected or the *Safe Stop* function must be activated.
2. The motor may start while setting the parameters. If this means that personal safety may be compromised (e.g. personal injury caused by contact with moving machine parts), motor starting must be prevented, for instance by use of the *Safe Stop* function or secure disconnection of the motor connection.
3. A motor that has been stopped with the mains supply connected, may start if faults occur in the electronics of the frequency converter, through temporary overload or if a fault in the power supply grid or motor connection is remedied. If unintended start must be prevented for personal safety reasons (e.g. risk of injury caused by contact with moving machine parts), the normal stop functions of the frequency converter are not sufficient. In such cases the mains supply must be disconnected or the *Safe Stop* function must be activated.

NB!
When using the *Safe Stop* function, always follow the instructions in the *Safe Stop* section.

4. Control signals from, or internally within, the frequency converter may in rare cases be activated in error, be delayed or fail to occur entirely. When used in situations where safety is critical, e.g. when controlling the electromagnetic brake function of a hoist application, these control signals must not be relied on exclusively.

Touching the electrical parts may be fatal - even after the equipment has been disconnected from mains.

Also make sure that other voltage inputs have been disconnected, such as external 24 V DC, load sharing (linkage of DC intermediate circuit), as well as the motor connection for kinetic back up.
Systems where frequency converters are installed must, if necessary, be equipped with additional monitoring and protective devices according to the valid safety regulations, e.g law on mechanical tools, regulations for the prevention of accidents etc. Modifications on the frequency converters by means of the operating software are allowed.

Hoisting applications:
FC functions for controlling mechanical rakes cannot be considered as a primary safety circuit. There must always be a redundancy for controlling external brakes.

Protection Mode
Once a hardware limit on motor current or dc-link voltage is exceeded the drive will enter "Protection mode". "Protection mode" means a change of the PWM modulation strategy and a low switching frequency to minimize losses. This continues 10 sec after the last fault and increases the reliability and the robustness of the drive while re-establishing full control of the motor.
In hoist applications "Protection mode" is not usable because the drive will usually not be able to leave this mode again and therefore it will extend the time before activating the brake – which is not recommendable.
The "Protection mode" can be disabled by setting parameter 14-26 "Trip Delay at Inverter Fault" to zero which means that the drive will trip immediately if one of the hardware limits is exceeded.

NB!
It is recommended to disable protection mode in hoisting applications (par. 14-26 = 0)

The DC link capacitors remain charged after power has been disconnected. To avoid electrical shock hazard, disconnect the frequency converter from mains before carrying out maintenance. When using a PM-motor, make sure it is disconnected. Before doing service on the frequency converter wait at least the amount of time indicated below:

380 - 500 V	0.25 - 7.5 kW	4 minutes
	11 - 75 kW	15 minutes
	90 - 200 kW	20 minutes
	250 - 400 kW	40 minutes
525 - 690 V	37 - 250 kW	20 minutes
	315 - 560 kW	30 minutes

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

FC 300

Design Guide

Software version: 4.8x

This Design Guide can be used for all FC 300 frequency converters with software version 4.8x.

The software version number can be seen from parameter 15-43.

2.4.1. CE Conformity and Labelling

What is CE Conformity and Labelling?

The purpose of CE labelling 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 three 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, we provide information on safety aspects relating to the frequency converter. We do this by means of a manufacturer's declaration.

The low-voltage directive (73/23/EEC)

Frequency converters must be CE labelled 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, we specify which standards our products comply with. We offer 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. It must be noted that the responsibility for the final EMC properties of the appliance, system or installation rests with the installer.

2.4.2. What Is Covered

The EU "*Guidelines on the Application of Council Directive 89/336/EEC*" outline three typical situations of using a frequency converter. See below for EMC coverage and CE labelling.

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 labelled 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 labelled 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 labelled 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 e.g. be an air-conditioning system. The complete system must be CE labelled in accordance with the EMC directive. The manufacturer can ensure CE labelling under the EMC directive either by using CE labelled components or by testing the EMC of the system. If he chooses to use only CE labelled components, he does not have to test the entire system.

2.4.3. Danfoss Frequency Converter and CE Labelling

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

However, CE labelling may cover many different specifications. Thus, you have to 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, we guarantee compliance with the low-voltage directive. Danfoss issues a declaration of conformity that confirms our CE labelling 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 gladly provides other types of assistance that can help you obtain the best EMC result.

2.4.4. Compliance with EMC Directive 89/336/EEC

As mentioned, the frequency converter is mostly used by professionals of the trade as a complex component forming part of a larger appliance, system, or installation. It must be noted 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, provided that the EMC-correct instructions for installation are followed, see the section *EMC Immunity*.

2.5.1. Air Humidity

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

A frequency converter contains a large number of mechanical and electronic components. All are to some extent vulnerable to environmental effects.

!	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 IP 55. As an extra protection, coated printet circuit boards can be orded as an option.

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 very dusty environments, use equipment with enclosure rating IP 55 or a cabinet for IP 00/IP 20/TYPE 1 equipment.

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

Such chemical reactions will rapidly affect and damage 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.

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

The frequency converter has been tested according to the procedure based on the shown standards:

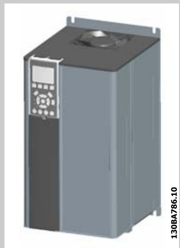
The frequency converter complies with requirements that exist for units mounted on the walls and floors of production premises, as well as in panels bolted to walls or floors.

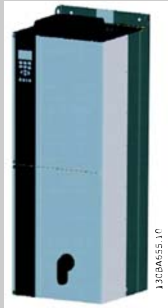
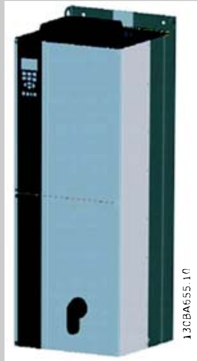
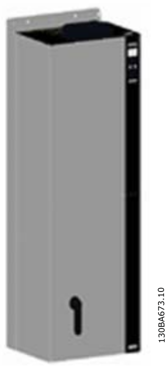
IEC/EN 60068-2-6:	Vibration (sinusoidal) - 1970
IEC/EN 60068-2-64:	Vibration, broad-band random

3. Introduction to FC 300

3.1. Product Overview

Frame size depends on enclosure type, power range and mains voltage

Enclosure type		**A1**	**A2**	**A3**	A5
					
Enclosure	IP	20/21	20/21	20/21	55/66
protection	NEMA	Chassis/Type 1	Chassis/ Type 1	Chassis/ Type 1	Type 12/Type 4X
Rated		0.25 – 1.5 kW (200-240 V)	0.25-3 kW (200–240 V)	3.7 kW (200-240 V)	0.25-3.7 kW (200-240 V)
power		0.37 – 1.5 kW (380-480 V)	0.37-4.0 kW (380-480/ 500V)	5.5-7.5 kW (380-480/ 500 V)	0.37-7.5 kW (380-480/500 V)
			0.75-4 kW (525-600 V)	5.5-7.5 kW (525-600 V)	0.75 -7.5 kW (525-600 V)
Enclosure type		**B1**	**B2**	**B3**	**B4**
					
Enclosure	IP	21/55/66	21/55/66	20	20
protection	NEMA	Type 1/Type 12	Type 1/Type 12	Chassis	Chassis
Rated		5.5-7.5 kW (200-240 V)	11 kW (200-250 V)	5.5-7.5 kW (200-240 V)	11-15 kW (200-240 V)
power		11-15 kW (380-480/ 500V)	18.5-22 kW (380-480/ 500V)	11-15 kW (380-480/500 V)	18.5-30 kW (380-480/ 500 V)
		11-15 kW (525-600 V)	18.5-22 kW (525-600 V)	11-15 kW (525-600 V)	18.5-30 kW (525-600 V)
Enclosure type		**C1**	**C2**	**C3**	**C4**
					
Enclosure	IP	21/55/66	21/55/66	20	20
protection	NEMA	Type 1/Type 12	Type 1/Type 12	Chassis	Chassis
Rated		15-22 kW (200-240 V)	30-37 kW (200-240 V)	18.5-22 kW (200-240 V)	30-37 kW (200-240 V)
power		30-45kW (380-480/ 500V)	55-75 kW (380-480/ 500V)	37-45 kW (380-480/500 V)	55-75 kW (380-480/ 500 V)
		30-45 kW (525-600 V)	55-90 kW (525-600 V)	37-45 kW (525-600 V)	55-90 kW (525-600 V)

Enclosure type		**D1**	**D2**	**D3**	**D4**
					
Enclosure protection	IP	21/54	21/54	00	00
	NEMA	Type 1/ Type 12	Type 1/ Type 12	Chassis	Chassis
Rated power		90-110 kW at 400 V (380-500 V) 37-132 kW at 690 V (525-690 V)	132-200 kW at 400 V (380-500 V) 160-315 kW at 690 V (525-690 V)	90-110 kW at 400 V (380-500 V) 37-132 kW at 690 V (525-690 V)	132-200 kW at 400 V (380-500 V) 160-315 kW at 690 V (525-690 V)
Enclosure type		**E1**	**E2**		
					
Enclosure protection	IP	21/54	00		
	NEMA	Type 1/ Type 12	Chassis		
Rated power		250-400 kW at 400 V (380-500 V) 355-560 kW at 690 V (525-690 V)	250-400 kW at 400 V (380-500 V) 355-560 kW at 690 V (525-690 V)		

3

3.2.1. Control Principle

A frequency converter rectifies AC voltage from mains into DC voltage, after which this DC voltage is converted into a AC current with a variable amplitude and frequency.

The motor is supplied with variable voltage / current and frequency, which enables infinitely variable speed control of three-phased, standard AC motors and permanent magnet synchronous motors.

3.2.2. FC 300 Controls

The frequency converter is capable of controlling either the speed or the torque on the motor shaft. Setting par. 1-00 determines the type of control.

Speed control:

There are two types of speed control:

- Speed open loop control which does not require any feedback from motor (sensorless).
- Speed closed loop control in the form of a PID control that requires a speed feedback to an input. A properly optimised speed closed loop control will have higher accuracy than a speed open loop control.

Selects which input to use as speed PID feedback in par. 7-00.

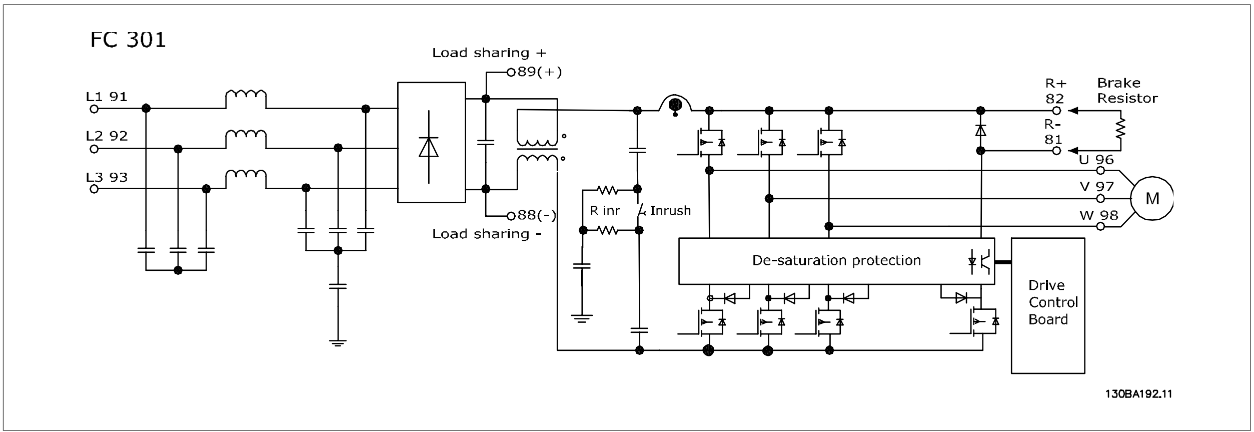
Torque control (FC 302 only):
Torque control is part of the motor control and correct settings of motor parameters are very important. The accuracy and settling time of the torque control are determined from *Flux with motor feedback* (par. 1-01 *Motor Control Principle*).

- Flux with encoder feedback offers superior performance in all four quadrants and at all motor speeds.

Speed / torque reference:
The reference to these controls can either be a single refrence or be the sum of various references including relatively scaled references. The handling of references is explained in detail later in this section.

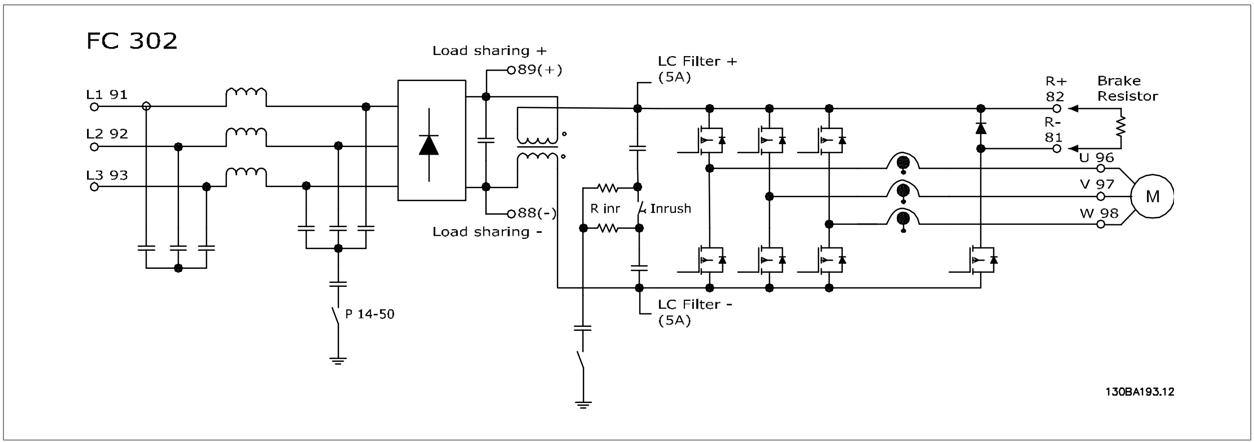
3.2.3. FC 301 vs. FC 302 Control Principle

FC 301 is a general purpose frequency converter for variable speed applications. The control principle is based on Voltage Vector Control (VVC^plus^).
FC 301 can handle asynchronous motors only.
The current sensing principle in FC 301 is based on current measurement in the DC link or motor phase. The ground fault protection on the motor side is solved by a de-saturation circuit in the IGBTs connected to the control board.
Short circuit behaviour on FC 301 depends on the current transducer in the positive DC link and the desaturation protection with feedback from the 3 lower IGBT's and the brake.



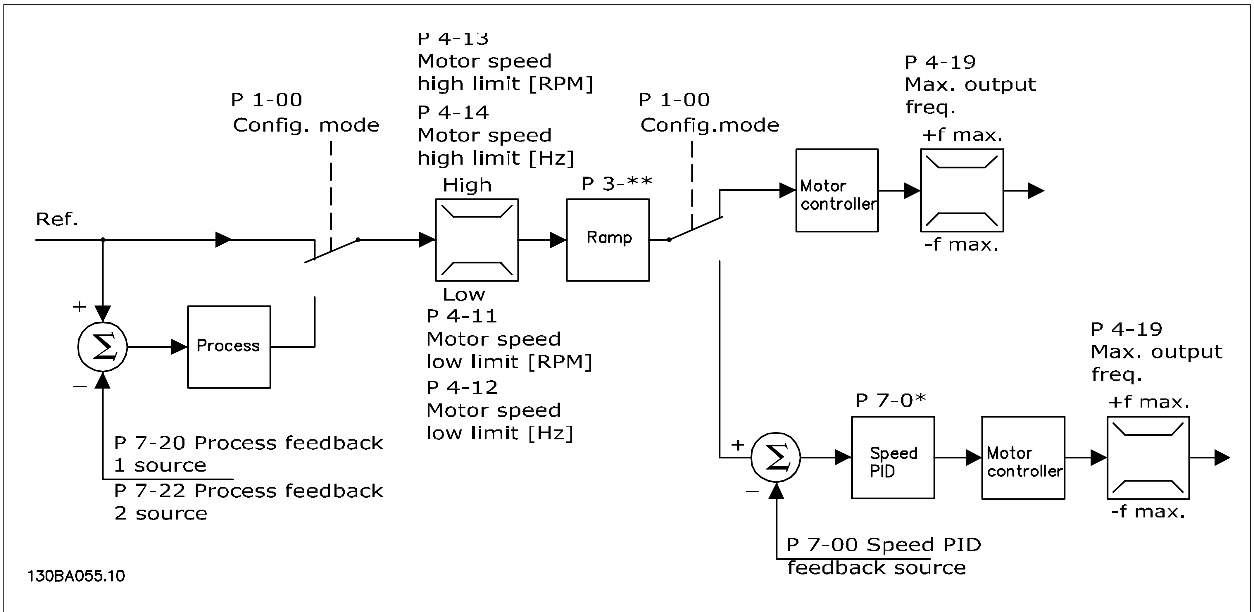
FC 302 is a high performance frequency converter for demanding applications. The frequency converter can handle various kinds of motor control principles such as U/f special motor mode, VVC^plus^ or Flux Vector motor control.

FC 302 is able to handle Permanent Magnet Synchronous Motors (Brushless servo motors) as well as normal squirrel cage asynchronous motors. Short circuit behaviour on FC 302 depends on the 3 current transducers in the motor phases and the desaturation protection with feedback from the brake.



3.2.4. Control Structure in VVCplus

Control structure in VVC^{plus} open loop and closed loop configurations:



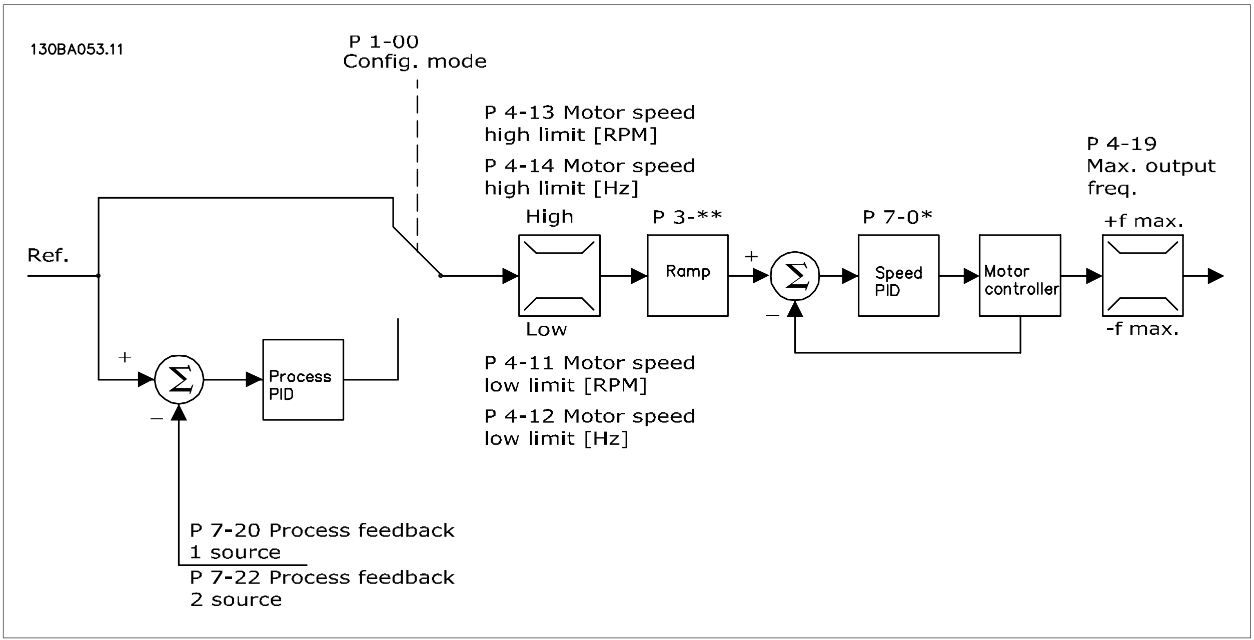
In the configuration shown in the illustration above, par. 1-01 *Motor Control Principle* is set to "VVC^{plus} [1]" and par. 1-00 is set to "Speed open loop [0]". The resulting reference from the reference handling system is received and fed through the ramp limitation and speed limitation before being sent to the motor control. The output of the motor control is then limited by the maximum frequency limit.

If par. 1-00 is set to "Speed closed loop [1]" the resulting reference will be passed from the ramp limitation and speed limitation into a speed PID control. The Speed PID control parameters are located in the par. group 7-0*. The resulting reference from the Speed PID control is sent to the motor control limited by the frequency limit.

Select "Process [3]" in par. 1-00 to use the process PID control for closed loop control of e.g. speed or pressure in the controlled application. The Process PID parameters are located in par. group 7-2* and 7-3*.

3.2.5. Control Structure in Flux Sensorless (FC 302 only)

Control structure in Flux sensorless open loop and closed loop configurations.



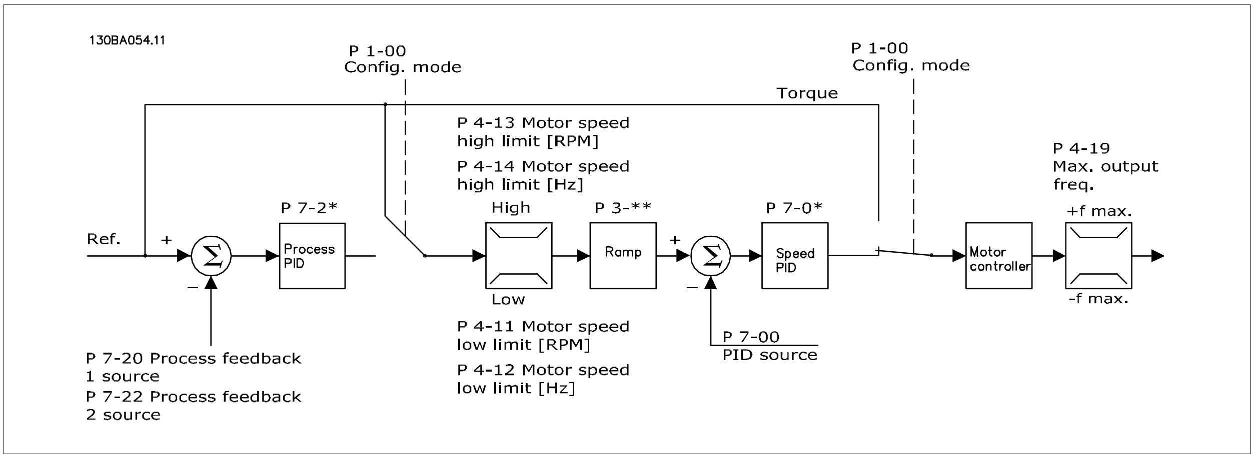
In the shown configuration, par. 1-01 *Motor Control Principle* is set to "Flux sensorless [2]" and par. 1-00 is set to "Speed open loop [0]". The resulting reference from the reference handling system is fed through the ramp and speed limitations as determined by the parameter settings indicated.

An estimated speed feedback is generated to the Speed PID to control the output frequency.
The Speed PID must be set with its P,I, and D parameters (par. group 7-0*).

Select "Process [3]" in par. 1-00 to use the process PID control for closed loop control of i.e. speed or pressure in the controlled application. The Process PID parameters are found in par. group 7-2* and 7-3*.

3.2.6. Control Structure in Flux with Motor Feedback

Control structure in Flux with motor feedback configuration (only available in FC 302):



In the shown configuration, par. 1-01 *Motor Control Principle* is set to "Flux w motor feedb [3]" and par. 1-00 is set to "Speed closed loop [1]".

The motor control in this configuration relies on a feedback signal from an encoder mounted directly on the motor (set in par. 1-02 *Motor Shaft Encoder Source*).

Select "Speed closed loop [1]" in par. 1-00 to use the resulting reference as an input for the Speed PID control. The Speed PID control parameters are located in par. group 7-0*.

Select "Torque [2]" in par. 1-00 to use the resulting reference directly as a torque reference. Torque control can only be selected in the *Flux with motor feedback* (par. 1-01 *Motor Control Principle*) configuration. When this mode has been selected, the reference will use the Nm unit. It requires no torque feedback, since the actual torque is calculated on the basis of the current measurement of the frequency converter.

Select "Process [3]" in par. 1-00 to use the process PID control for closed loop control of e.g. speed or a process variable in the controlled application.

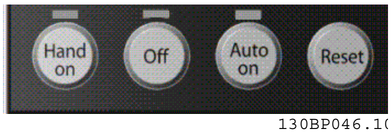
3.2.7. Internal Current Control in VVCplus Mode

The frequency converter features an integral current limit control which is activated when the motor current, and thus the torque, is higher than the torque limits set in par. 4-16, 4-17 and 4-18.
When the frequency converter is at the current limit during motor operation or regenerative operation, the frequency converter will try to get below the preset torque limits as quickly as possible without losing control of the motor.

3.2.8. 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 and digital inputs and serial bus.
If allowed in par. 0-40, 0-41, 0-42, and 0-43, it is possible to start and stop the frequency converter via the LCP using the [Hand ON] and [Off] keys. Alarms can be reset via the [RESET] key. After pressing the [Hand On] key, the frequency converter goes into Hand mode and follows (as default) the Local reference that can be set using arrow key on the LCP.

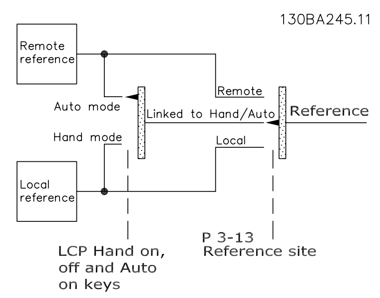
After pressing the [Auto On] key, the frequency converter goes into Auto mode and follows (as default) the Remote reference. In this mode, it is possible to control the frequency converter via the digital inputs and various serial interfaces (RS-485, USB, or an optional fieldbus). See more about starting, stopping, changing ramps and parameter set-ups etc. in par. group 5-1* (digital inputs) or par. group 8-5* (serial communication).

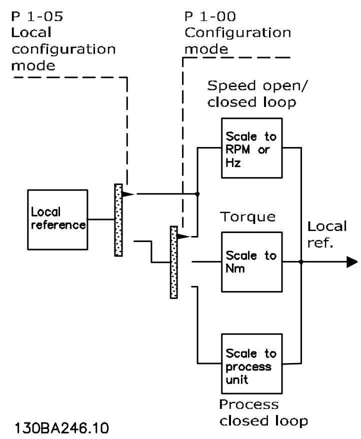


Active Reference and Configuration Mode

The active reference can be either the local reference or the remote reference.

In par. 3-13 *Reference Site* the local reference can be permanently selected by selecting *Local* [2].
To permanently select the remote reference select *Remote* [1]. By selecting *Linked to Hand/Auto* [0] (default) the reference site will depend on which mode is active. (Hand Mode or Auto Mode).





Hand On Auto LCP Keys	Reference Site Par. 3-13	Active Reference
Hand	Linked to Hand / Auto	Local
Hand -> Off	Linked to Hand / Auto	Local
Auto	Linked to Hand / Auto	Remote
Auto -> Off	Linked to Hand / Auto	Remote
All keys	Local	Local
All keys	Remote	Remote

The table shows under which conditions either the Local reference or the Remote reference is active. One of them is always active, but both can not be active at the same time.

Par. 1-00 *Configuration Mode* determines what kind of application control principle (i.e. Speed, Torque or Process Control) is used when the Remote reference is active (see table above for the conditions).

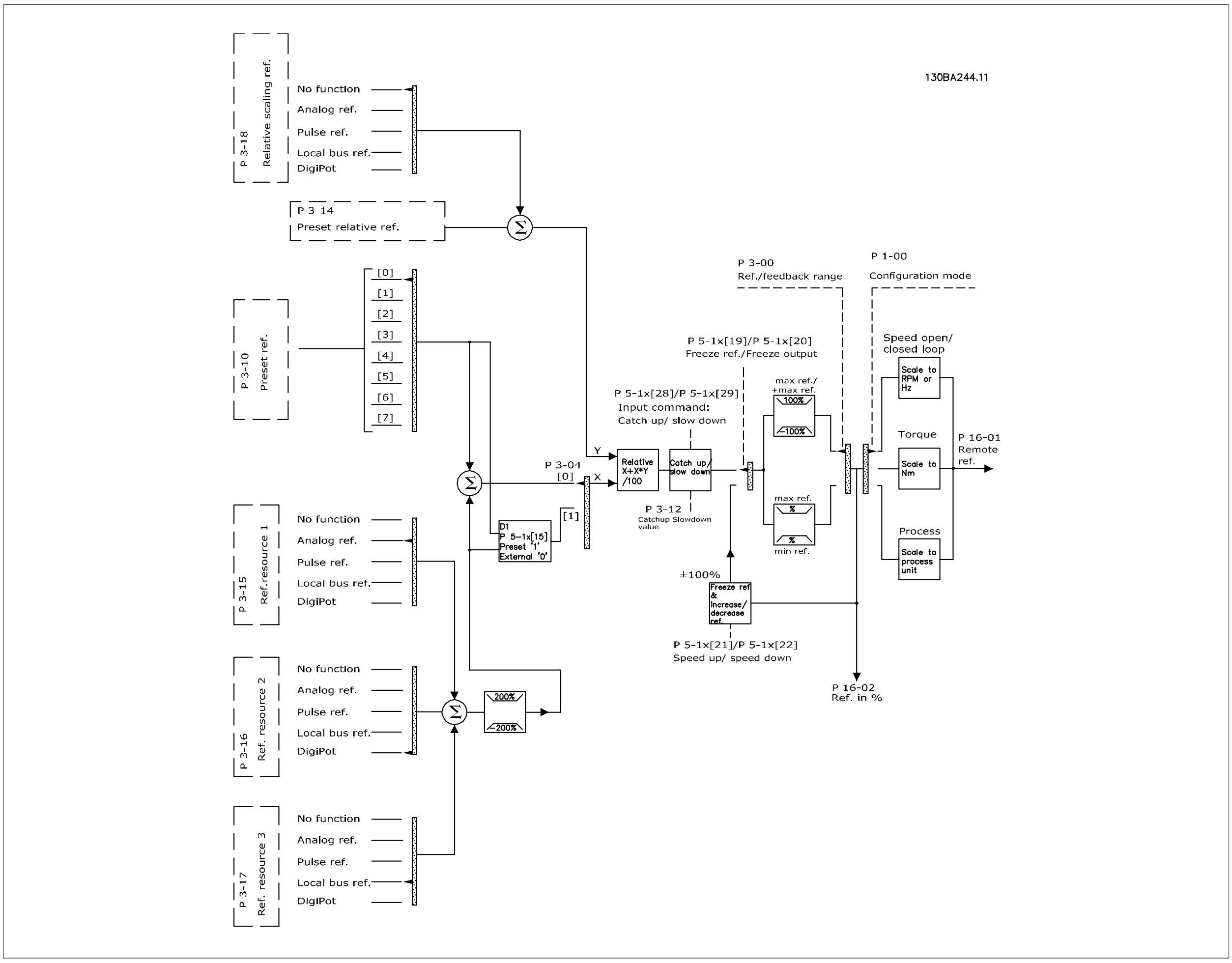
Par. 1-05 *Local Mode Configuration* determines the kind of application control principle that is used when the Local reference is made active.

Reference Handling

Local Reference

Remote Reference

The reference handling system for calculating the Remote reference is shown in the illustration below.



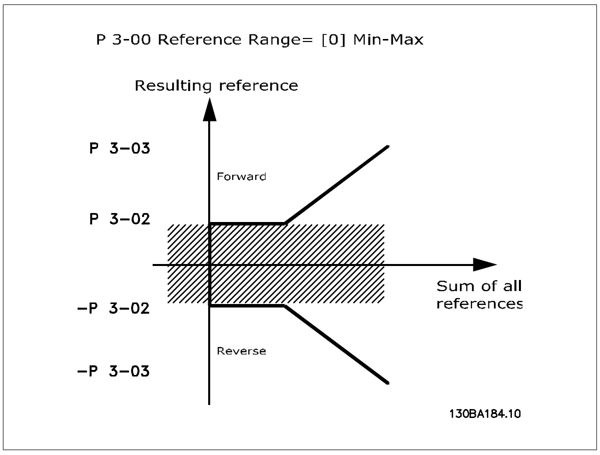
The Remote reference is calculated once every scan interval and initially consists of two parts:

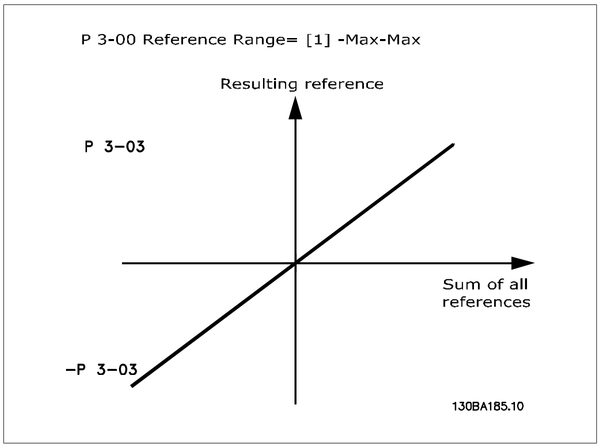
1. X (the external reference) : A sum (see par. 3-04) of up to four externally selected references, comprising any combination (determined by the setting of par. 3-15, 3-16 and 3-17) of a fixed preset reference (par. 3-10), variable analog references, variable digital pulse references, and various serial bus references in whatever unit the frequency converter is controlled ([Hz], [RPM], [Nm] etc.).
2. Y- (the relative reference): A sum of one fixed preset reference (par. 3-14) and one variable analog reference (par. 3-18) in [%].

The two parts are combined in the following calculation: Remote reference = X + X * Y / 100%. The *catch up / slow down* function and the *freeze reference* function can both be activated by digital inputs on the frequency converter. They are described in par. group 5-1*.
The scaling of analog references are described in par. groups 6-1* and 6-2*, and the scaling of digital pulse references are described in par. group 5-5*.
Reference limits and ranges are set in par. group 3-0*.

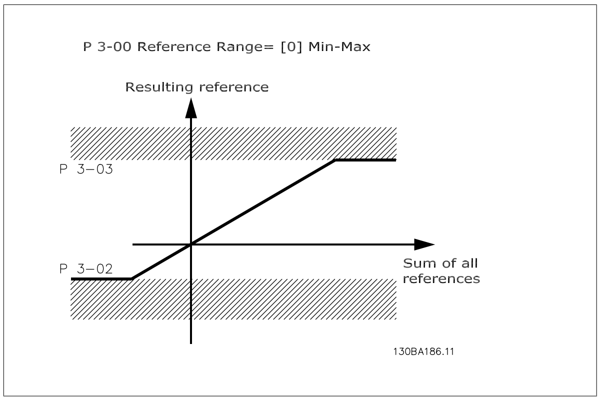
3.2.9. Reference Limits

Par. 3-00 *Reference Range*, 3-02 *Minimum Reference* and 3-03 *Maximum Reference* together define the allowed range of the sum of all references. The sum of all references are clamped when necessary. The relation between the resulting reference (after clamping) and the sum of all references is shown below.





The value of par. 3-02 *Minimum Reference* can not be set to less than 0, unless the par. 1-00 *Configuration Mode* is set to [3] Process. In that case the following relations between the resulting reference (after clamping) and the sum of all references is as shown to the right.



3.2.10. Scaling of Preset References and Bus References

Preset references are scaled according to the following rules:

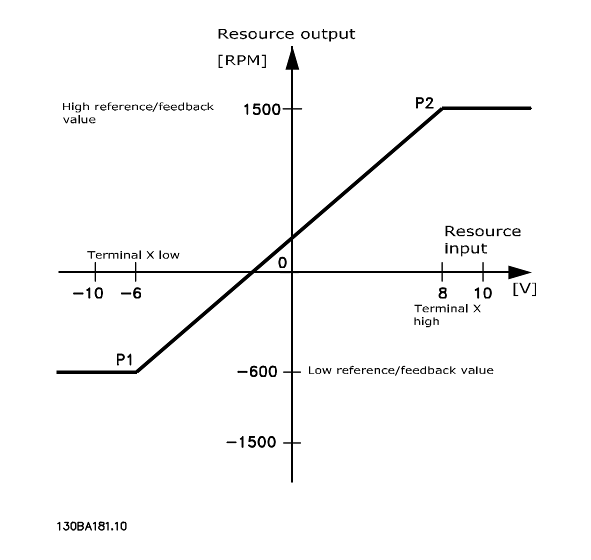
- When par. 3-00 *Reference Range*: [0] Min - Max 0% reference equals 0 [unit] where unit can be any unit e.g. rpm, m/s, bar etc. 100% reference equals the Max (abs (par. 3-03 *Maximum Reference*), abs (par. 3-02 *Minimum Reference*)).
- When par. 3-00 *Reference Range*: [1] -Max - +Max 0% reference equals 0 [unit] -100% reference equals -Max Reference 100% reference equals Max Reference.

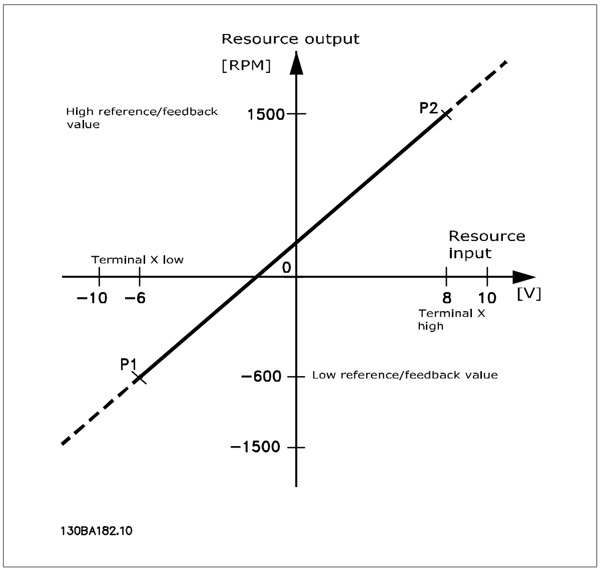
Bus references are scaled according to the following rules:

- When par. 3-00 *Reference Range*: [0] Min - Max. To obtain max resolution on the bus reference the scaling on the bus is: 0% reference equals Min Reference and 100% reference equals Max reference.
- When par. 3-00 *Reference Range*: [1] -Max - +Max -100% reference equals -Max Reference 100% reference equals Max Reference.

3.2.11. Scaling of Analog and Pulse References and Feedback

References and feedback are scaled from analog and pulse inputs in the same way. The only difference is that a reference above or below the specified minimum and maximum "endpoints" (P1 and P2 in the graph below) are clamped whereas a feedback above or below is not.





The endpoints P1 and P2 are defined by the following parameters depending on which analog or pulse input is used

	Analog 53 S201=OFF	Analog 53 S201=ON	Analog 54 S202=OFF	Analog 54 S202=ON	Pulse Input 29	Pulse Input 33
P1 = (Minimum input value, Minimum reference value)						
Minimum reference value	Par. 6-14	Par. 6-14	Par. 6-24	Par. 6-24	Par. 5-52	Par. 5-57
Minimum input value	Par. 6-10 [V]	Par. 6-12 [mA]	Par. 6-20 [V]	Par. 6-22 [mA]	Par. 5-50 [Hz]	Par. 5-55 [Hz]
P2 = (Maximum input value, Maximum reference value)						
Maximum reference value	Par. 6-15	Par. 6-15	Par. 6-25	Par. 6-25	Par. 5-53	Par. 5-58
Maximum input value	Par. 6-11 [V]	Par. 6-13 [mA]	Par. 6-21 [V]	Par. 6-23 [mA]	Par. 5-51 [Hz]	Par. 5-56 [Hz]

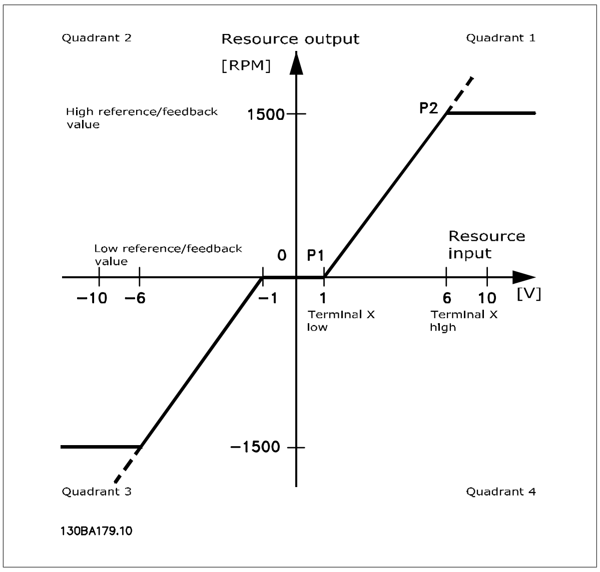
3.2.12. Dead Band Around Zero

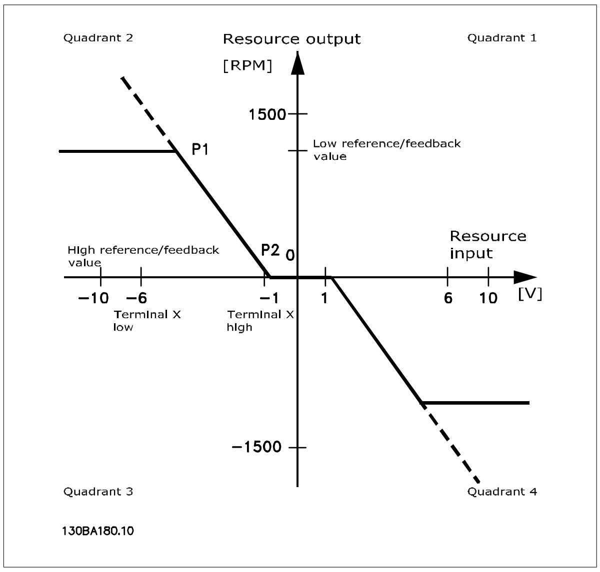
In some cases the reference (in rare cases also the feedback) should have a Dead Band around zero (i.e. to make sure the machine is stopped when the reference is "near zero").

To make the dead band active and to set the amount of dead band, the following settings must be done:

- Either Minimum Reference Value (see table above for relevant parameter) or Maximum Reference Value must be zero. In other words; Either P1 or P2 must be on the X-axis in the graph below.
- And both points defining the scaling graph are in the same quadrant.

The size of the Dead Band is defined by either P1 or P2 as shown in the graph below.

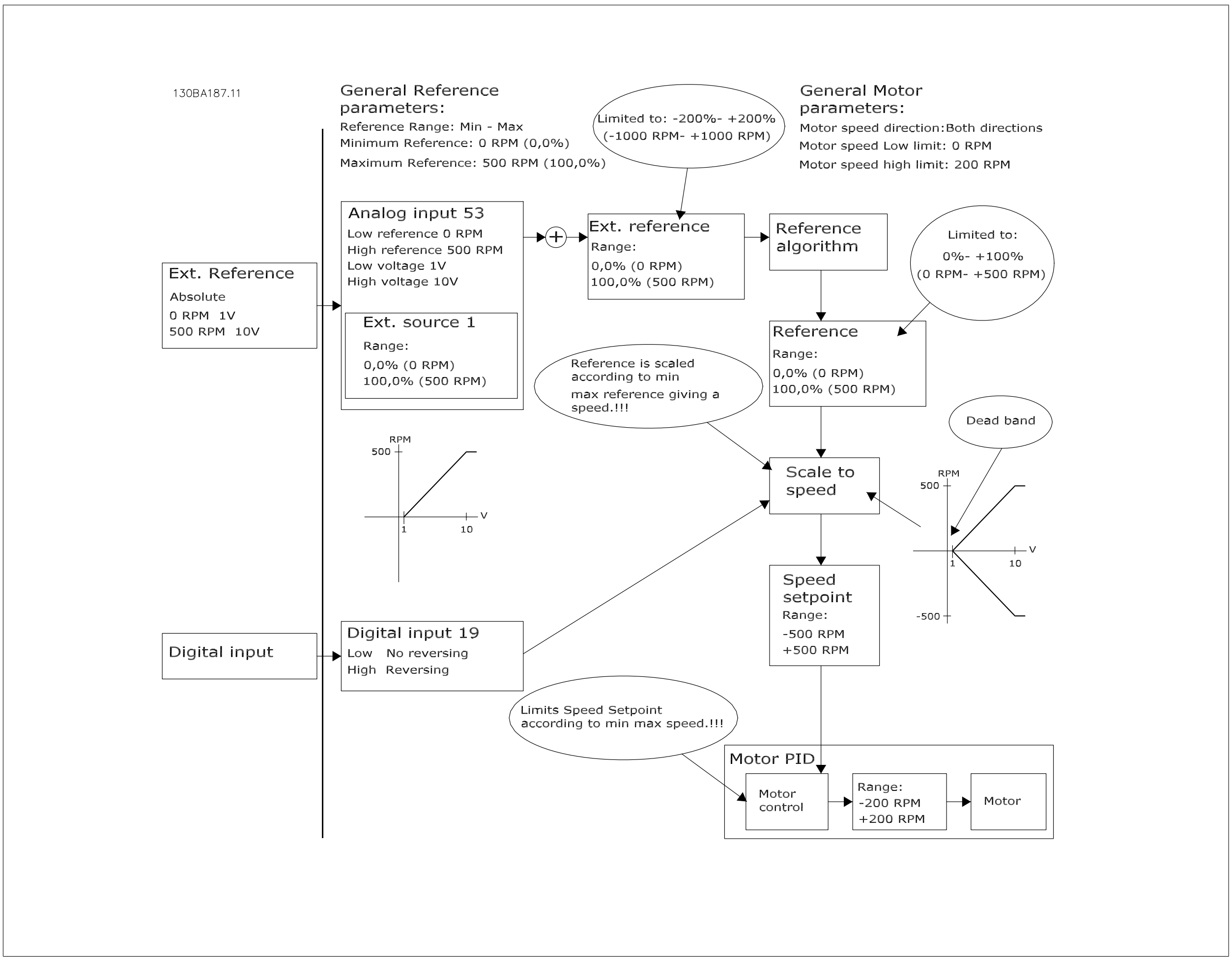




Thus a reference endpoint of P1 = (0 V, 0 RPM) will not result in any dead band, but a reference endpoint of e.g. P1 = (1V, 0 RPM) will result in a -1V to +1V dead band in this case provided that the end point P2 is placed in either Quadrant 1 or Quadrant 4.

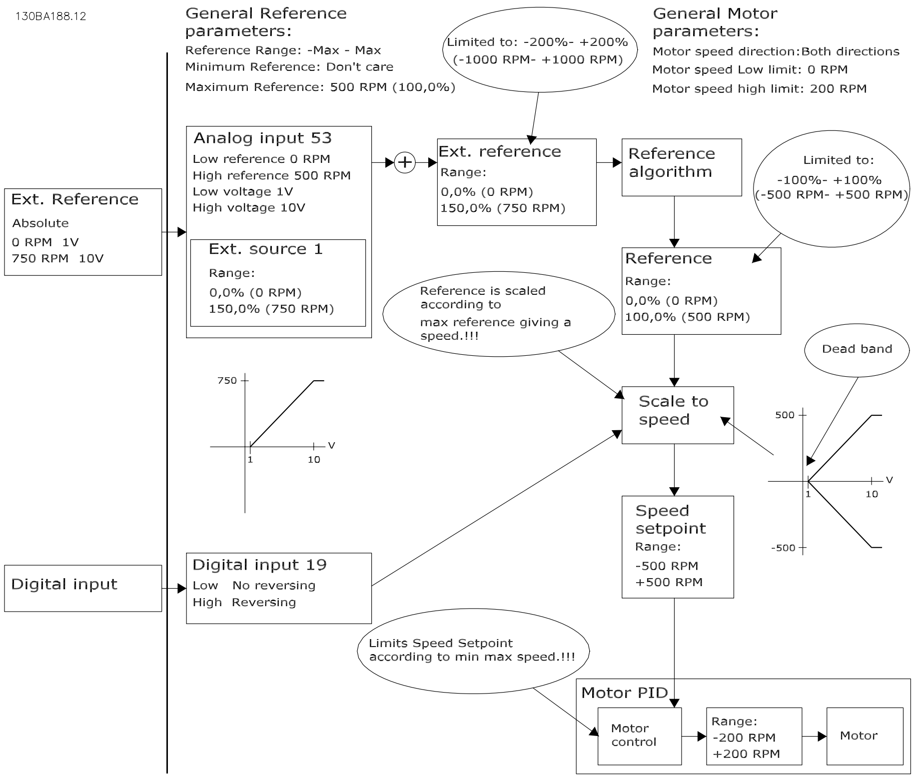
Case 1: Positive Reference with Dead band, Digital input to trigger reverse

This Case shows how Reference input with limits inside Min – Max limits clamps.

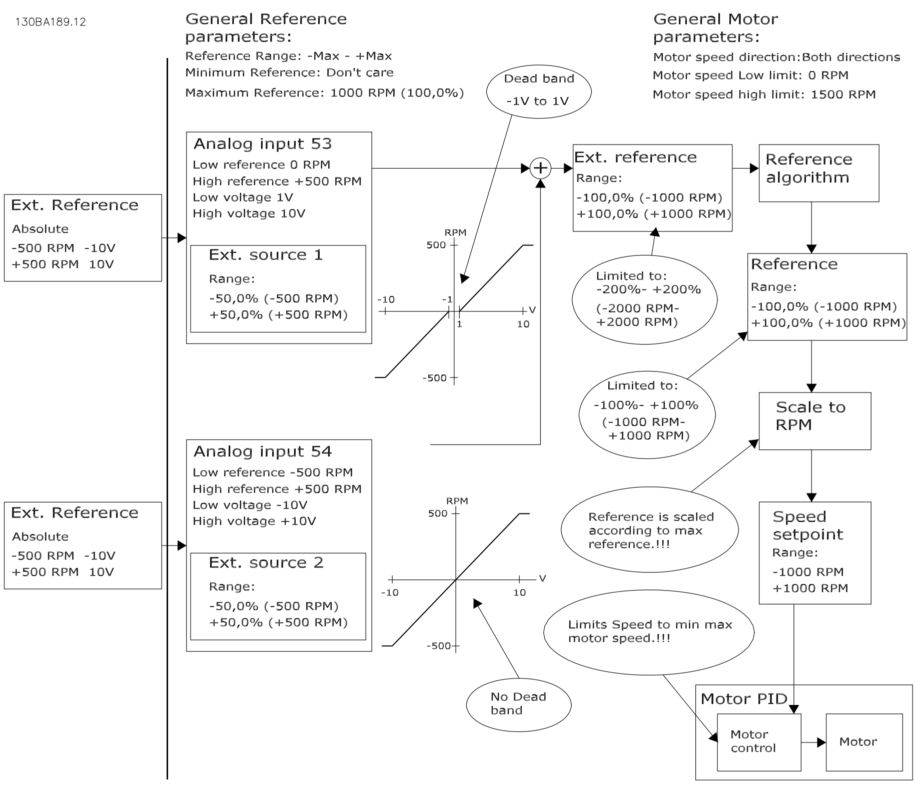


Case 2: Positive Reference with Dead band, Digital input to trigger reverse. Clamping rules.

This Case shows how Reference input with limits outside -Max – +Max limits clamps to the inputs low and high limits before addition to External reference. And how the External reference is clamped to -Max – +Max by the Reference algorithm.



Case 3: Negative to positive reference with dead band, Sign determines the direction, -Max – +Max



3.3.1. Speed PID Control

The table shows the control configurations where the Speed Control is active.

Par. 1-00 Configuration Mode	Par. 1-01 Motor Control Principle			
	U/f	VVCplus	Flux Sensorsless	Flux w/ enc. feedb
[0] Speed open loop	Not Active	Not Active	ACTIVE	N.A.
[1] Speed closed loop	N.A.	ACTIVE	N.A.	ACTIVE
[2] Torque	N.A.	N.A.	N.A.	Not Active
[3] Process		Not Active	ACTIVE	ACTIVE

Note: "N.A." means that the specific mode is not available at all. "Not Active" means that the specific mode is available but the Speed Control is not active in that mode.

Note: The Speed Control PID will work under the default parameter setting, but tuning the parameters is highly recommended to optimize the motor control performance. The two Flux motor control principles are specially dependant on proper tuning to yield their full potential.

The following parameters are relevant for the Speed Control:

Parameter	**Description of function**
Feedback Par. 7-00	Select from which input the Speed PID should get its feedback.
Proportional Gain Par. 7-02	The higher the value - the quicker the control. However, too high value may lead to oscillations.
Integral Time Par. 7-03	Eliminates steady state speed error. Lower value means quick reaction. However, too low value may lead to oscillations.
Differentiation Time Par. 7-04	Provides a gain proportional to the rate of change of the feedback. A setting of zero disables the differentiator.
Differentiator Gain Limit Par. 7-05	If there are quick changes in reference or feedback in a given application - which means that the error changes swiftly - the differentiator may soon become too dominant. This is because it reacts to changes in the error. The quicker the error changes, the stronger the differentiator gain is. The differentiator gain can thus be limited to allow setting of the reasonable differentiation time for slow changes and a suitably quick gain for quick changes.
Lowpass Filter Time Par. 7-06	A low-pass filter that dampens oscillations on the feedback signal and improves steady state performance. However, too large filter time will deteriorate the dynamic performance of the Speed PID control. Practical settings of Par 7-06 taken from the number of pulses per revolution on from encoder (PPR):

Encoder PPR	**Par. 7-06**	
512	10 ms	
1024	5 ms	
2048	2 ms	
4096	1 ms	

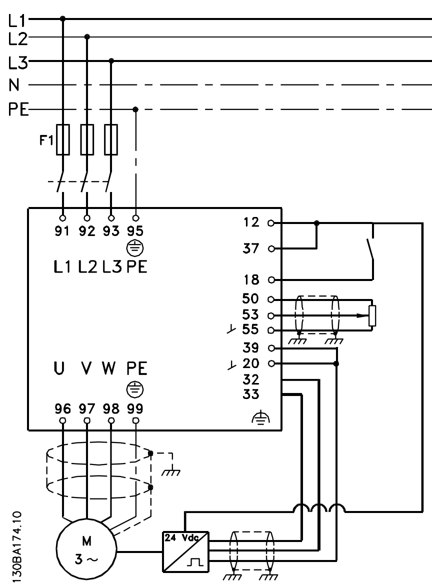
Below is given an example of how to programme the Speed Control:

In this case the Speed PID Control is used to maintain a constant motor speed regardless of the changing load on the motor.

The required motor speed is set via a potentiometer connected to terminal 53. The speed range is 0 - 1500 RPM corresponding to 0 - 10V over the potentiometer.

Starting and stopping is controlled by a switch connected to terminal 18.

The Speed PID monitors the actual RPM of the motor by using a 24V (HTL) incremental encoder as feedback. The feedback sensor is an encoder (1024 pulses per. revolution) connected to terminals 32 and 33.



In the parameter list below it is assumed that all other parameters and switches remain at their default setting.

The following must be programmed in order shown - see explanation of settings in the Programming Guide.

Function	Par. no.	Setting
1) Make sure the motor runs properly. Do the following:		
Set the motor parameters using name plate data	1-2*	As specified by motor name plate
Have the VLT make an Automatic Motor Adaptation	1-29	[1] Enable complete AMA
2) Check the motor is running and the encoder is attached properly. Do the following:		
Press the "Hand On" LCP key. Check that the motor is running and note in which direction it is turning (henceforth referred to as the "positive direction").		Set a **positive** reference.
Go to par. 16-20. Turn the motor slowly in the positive direction. It must be turned so slowly (only a few RPM) that it can be determined if the value in par. 16-20 is increasing or decreasing.	16-20	N.A. (read-only parameter) Note: An increasing value overflows at 65535 and starts again at 0.
If par. 16-20 is decreasing then change the encoder direction in par. 5-71.	5-71	[1] Counter clockwise (if par. 16-20 is decreasing)
3) Make sure the drive limits are set to safe values		
Set acceptable limits for the references.	3-02 3-03	0 RPM (default) 1500 RPM (default)
Check that the ramp settings are within drive capabilities and allowed application operating specifications.	3-41 3-42	default setting default setting
Set acceptable limits for the motor speed and frequency.	4-11 4-13 4-19	0 RPM (default) 1500 RPM (default) 60 Hz (default 132 Hz)
4) Configure the Speed Control and select the Motor Control principle		
Activation of Speed Control	1-00	[1] Speed closed loop
Selection of Motor Control Principle	1-01	[3] Flux w motor feedb
5) Configure and scale the reference to the Speed Control		
Set up Analog Input 53 as a reference Source	3-15	Not necessary (default)
Scale Analog Input 53 0 RPM (0 V) to 1500 RPM (10V)	6-1*	Not necessary (default)
6) Configure the 24V HTL encoder signal as feedback for the Motor Control and the Speed Control		
Set up digital input 32 and 33 as encoder inputs	5-14 5-15	[0] No operation (default)
Choose terminal 32/33 as motor feedback	1-02	Not necessary (default)
Choose terminal 32/33 as Speed PID feedback	7-00	Not necessary (default)
7) Tune the Speed Control PID parameters		
Use the tuning guidelines when relevant or tune manually	7-0*	See the guidelines below
8) Finished!		
Save the parameter setting to the LCP for safe keeping	0-50	[1] All to LCP

3.3.2. Tuning PID Speed Control

The following tuning guidelines are relevant when using one of the Flux motor control principles in applications where the load is mainly inertial (with a low amount of friction).

The value of par. 7-02 Proportional Gain is dependent on the combined inertia of the motor and load, and the selected bandwidth can be calculated using the following formula:

$$Par.\ 7-02 = \frac{Total\ inertia\ [kgm^2]\ x\ Par.\ 1-25}{Par.\ 1-20\ x\ 9550}\ x\ Bandwidth\ [rad/s]$$

Note: Par. 1-20 is the motor power in [kW] (i.e. enter '4' kW instead of '4000' W in the formula). A practical value for the Bandwith is 20 rad/s. Check the result of the par. 7-02 calculation against the following formula (not required if you are using a high resolution feedback such as a SinCos feedback):

$$Par.\ 7-02_{MAXIMUM} = \frac{0.01\ x\ 4\ x\ Encoder\ Resolution\ x\ par.\ 7-06}{2\ x\ \pi}\ x\ Max\ torque\ ripple\ [\%]$$

A good start value for par. 7-06 *Speed Filter Time* is 5 ms (lower encoder resolution calls for a higher filter value). Typically a Max Torque Ripple of 3 % is acceptable. For incremental encoders the Encoder Resolution is found in either par. 5-70 (24V HTL on standard drive) or par. 17-11 (5V TTL on MCB102 Option).

Generally the practical maximum limit of par. 7-02 is determined by the encoder resolution and the feedback filter time but other factors in the application might limit the par. 7-02 *Proportional Gain* to a lower value.

To minimize the overshoot, par. 7-03 *Integral Time* could be set to approx. 2.5 s (varies with the application).

Par. 7-04 *Differential Time* should be set to 0 until everything else is tuned. If necessary finish the tuning by experimenting with small increments of this setting.

3

3.3.3. Process PID Control

The Process PID Control can be used to control application parameters that can be measured by a sensor (i.e. pressure, temperature, flow) and be affected by the connected motor through a pump, fan or otherwise.

The table shows the control configurations where the Process Control is possible. When a Flux Vector motor control principle is used, take care also to tune the Speed Control PID parameters. Refer to the section about the Control Structure to see where the Speed Control is active.

Par. 1-00 Configuration Mode	Par. 1-01 Motor Control Principle			
	U/f	VVC^{plus}	Flux Sensorless	Flux w/ enc. feedb
[3] Process	N.A.	Process	Process & Speed	Process & Speed

Note: The Process Control PID will work under the default parameter setting, but tuning the parameters is highly recommended to optimise the application control performance. The two Flux motor control principles are specially dependant on proper Speed Control PID tuning (prior to tuning the Process Control PID) to yield their full potential.

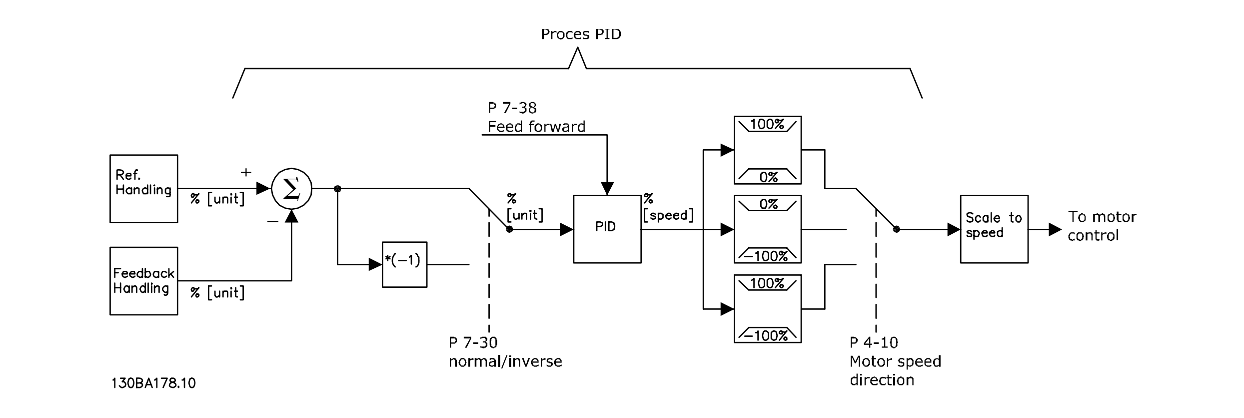


Illustration 3.1: **Process PID Control diagram**

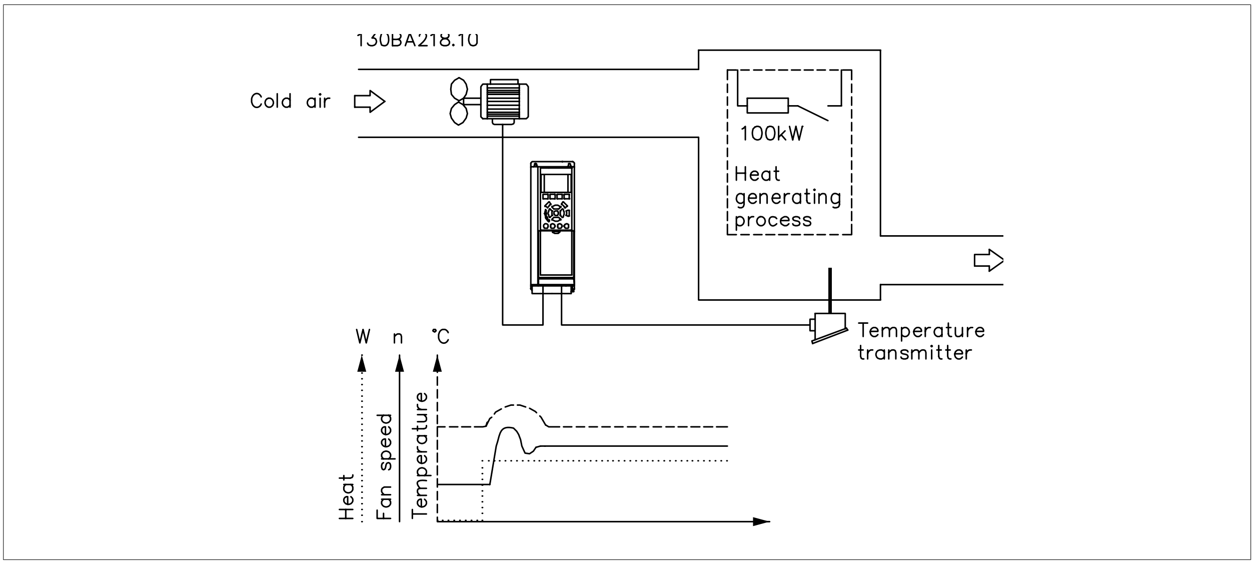
The following parameters are relevant for the Process Control

Parameter	**Description of function**
Feedback 1 Source Par. 7-20	Select from which Source (i.e. analog or pulse input) the Process PID should get its feedback
Feedback 2 Source Par. 7-22	Optional: Determine if (and from where) the Process PID should get an additional feedback signal. If an additional feedback source is selected the two feedback signals will be added together before being used in the Process PID Control.
Normal/inverse control Par. 7-30	Under [0] Normal operation the Process Control will respond with an increase of the motor speed if the feedback is getting lower than the reference. In the same situation, but under [1] Inverse operation, the Process Control will respond with a decreasing motor speed instead.
Anti Windup Par. 7-31	The anti windup function ensures that when either a frequency limit or a torque limit is reached, the integrator will be set to a gain that corresponds to the actual frequency. This avoids integrating on an error that cannot in any case be compensated for by means of a speed change. This function can be disabled by selecting [0] "Off".
Control Start Value Par. 7-32	In some applications, reaching the required speed/set point can take a very long time. In such applications it might be an advantage to set a fixed motor speed from the frequency converter before the process control is activated. This is done by setting a Process PID Start Value (speed) in par. 7-32.
Proportional Gain Par. 7-33	The higher the value - the quicker the control. However, too large value may lead to oscillations.
Integral Time Par. 7-34	Eliminates steady state speed error. Lower value means quick reaction. However, too small value may lead to oscillations.
Differentiation Time Par. 7-35	Provides a gain proportional to the rate of change of the feedback. A setting of zero disables the differentiator.
Differentiator Gain Limit Par. 7-36	If there are quick changes in reference or feedback in a given application - which means that the error changes swiftly - the differentiator may soon become too dominant. This is because it reacts to changes in the error. The quicker the error changes, the stronger the differentiator gain is. The differentiator gain can thus be limited to allow setting of the reasonable differentiation time for slow changes.
Feed Forward Factor Par. 7-38	In application where there is a good (and approximately linear) correlation between the process reference and the motor speed necessary for obtaining that reference, the Feed Forward Factor can be used to achieve better dynamic performance of the Process PID Control.
Lowpass Filter Time Par. 5-54 (Pulse term. 29), Par. 5-59 (Pulse term. 33), Par. 6-16 (Analog term 53), Par. 6-26 (Analog term. 54)	If there are oscillations of the current/voltage feedback signal, these can be dampened by means of a low-pass filter. This time constant represents the speed limit of the ripples occurring on the feedback signal. Example: If the low-pass filter has been set to 0.1s, the limit speed will be 10 RAD/sec. (the reciprocal of 0.1 s), corresponding to (10/(2 x π)) = 1.6 Hz. This means that all currents/voltages that vary by more than 1.6 oscillations per second will be damped by the filter. The control will only be carried out on a feedback signal that varies by a frequency (speed) of less than 1.6 Hz. The low-pass filter improves steady state performance but selecting a too large filter time will deteriorate the dynamic performance of the Process PID Control.

3

3.3.4. Example of Process PID Control

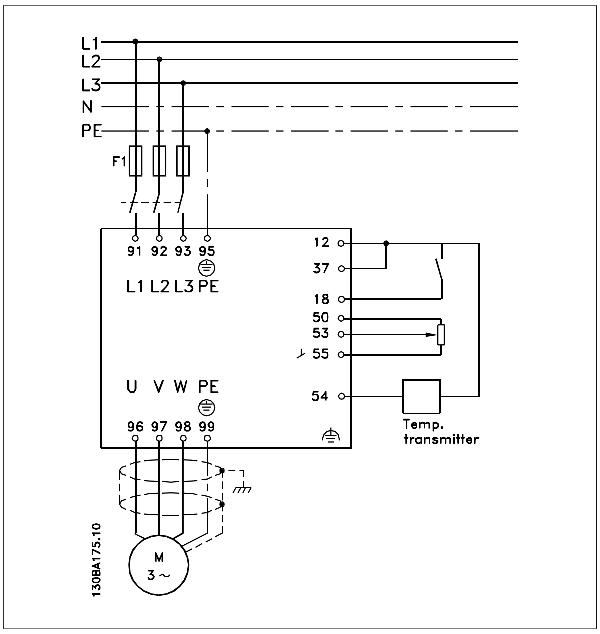
The following is an example of a Process PID Control used in a ventilation system:



In a ventilation system, the temperature is to be settable from - 5 - 35° C with a potentiometer of 0-10 Volt. The set temperature must be kept constant, for which purpose the Process Control is to be used.

The control is of the inverse type, which means that when the temperature increases, the ventilation speed is increased as well, so as to generate more air. When the temperature drops, the speed is reduced. The transmitter used is a temperature sensor with a working range of -10-40° C, 4-20 mA. Min. / Max. speed 300 / 1500 RPM.

NB!
The example shows a two-wire transmitter.



1. Start/Stop via switch connected to terminal 18.
2. Temperature reference via potentiometer (-5-35°C, 0-10 VDC) connected to terminal 53.
3. Temperature feedback via transmitter (-10-40°C, 4-20 mA) connected to terminal 54. Switch S202 set to ON (current input).

Example of Process PID Control set-up

Function	Par. no.	Setting
Initialize the frequency converter	14-22	[2] Initialization - make a power cycling - press reset
1) Set motor parameters:		
Set the motor parameters according to name plate data	1-2*	As stated on motor name plate
Perform a full **A**utomation **M**otor **A**daptation	1-29	[1] Enable complete AMA
2) Check that motor is running in the right direction. When motor is connected to frequency converter with straight forward phase order as U - U; V- V; W - W motor shaft usually turns clockwise seen into shaft end.		
Press "Hand On" LCP key. Check shaft direction by applying a manual reference.		
If motor turns opposite of required direction: 1. Change motor direction in par. 4-10 2. Turn off mains - wait for DC link to discharge - switch two of the motor phases	4-10	Select correct motor shaft direction
Set configuration mode	1-00	[3] Process
Set Local Mode Configuration	1-05	[0] Speed Open Loop
3) Set reference configuration, ie. the range for reference handling. Set scaling of analog input in par. 6-xx		
Set reference/feedback units Set min. reference (10° C) Set max. reference (80° C) If set value is determined from a preset value (array parameter), set other reference sources to No Function	3-01 3-02 3-03 3-10	[60] ° C Unit shown on display -5° C 35° C [0] 35% $Ref = \frac{P3-10(0)}{100} \times ((P3-03) - (p3-02)) = 24,5°\ C$ Par. 3-14 to par. 3-18 [0] = No Function
4) Adjust limits for the frequency converter:		
Set ramp times to an appropriate value as 20 sec.	3-41 3-42	20 sec. 20 sec.
Set min. speed limits Set motor speed max. limit Set max. output frequency	4-11 4-13 4-19	300 RPM 1500 RPM 60 Hz
Set S201 or S202 to wanted analog input function (Voltage (V) or milli-Amps (I)) NOTE! Switches are sensitive - Make a power cycling keeping default setting of V		
5) Scale analog inputs used for reference and feedback		
Set terminal 53 low voltage Set terminal 53 high voltage Set terminal 54 low feedback value Set terminal 54 high feedback value Set feedback source	6-10 6-11 6-24 6-25 7-20	0 V 10 V -5° C 35° C [2] Analog input 54
6) Basic PID settings		
Process PID Normal/Inverse	7-30	[0] Normal
Process PID Anti Wind-up	7-31	[1] On
Process PID start speed	7-37	300 rpm
Save parameters to LCP	0-50	[1] All to LCP

Optimisation of the process regulator

The basic settings have now been made; all that needs to be done is to optimise the proportional gain, the integration time and the differentiation time (par. 7-33, 7-34, 7-35). In most processes, this can be done by following the guidelines given below.

1. Start the motor
2. Set par. 7-33 (*Proportional Gain*) to 0.3 and increase it until the feedback signal again begins to vary continuously. Then reduce the value until the feedback signal has stabilised. Now lower the proportional gain by 40-60%.
3. Set par. 7-34 (Integration Time) to 20 sec. and reduce the value until the feedback signal again begins to vary continuously. Increase the integration time until the feedback signal stabilises, followed by an increase of 15-50%.
4. Only use par. 7-35 for very fast-acting systems only (differentiation time). The typical value is four times the set integration time. The differentiator should only be used when the setting of the proportional gain and the integration time has been fully optimised. Make sure that oscillations on the feedback signal is sufficiently dampened by the lowpass filter on the feedback signal.

NB!
If necessary, start/stop can be activated a number of times in order to provoke a variation of the feedback signal.

3.3.5. Ziegler Nichols Tuning Method

In order to tune the PID controls of the frequency converter, several tuning methods can be used. One approach is to use a technique which was developed in the 1950s but which has stood the test of time and is still used today. This method is known as the Ziegler Nichols tuning method.

NB!
The method described must not be used on applications that could be damaged by the oscillations created by marginally stable control settings.

The criteria for adjusting the parameters are based on evaluating the system at the limit of stability rather than on taking a step response. We increase the proportional gain until we observe continuous oscillations (as measured on the feedback), that is, until the system becomes marginally stable. The corresponding gain *(K_u)* is called the ultimate gain. The period of the oscillation *(P_u)* (called the ultimate period) is determined as shown in Figure 1.

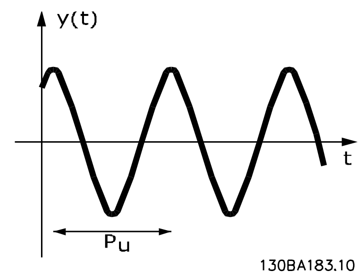


Illustration 3.2: **Figure 1: Marginally stable system**

P_u should be measured when the amplitude of oscillation is quite small. Then we "back off" from this gain again, as shown in Table 1.

K_u is the gain at which the oscillation is obtained.

Type of Control	Proportional Gain	Integral Time	Differentiation Time
PI-control	0.45 * K_u	0.833 * P_u	-
PID tight control	0.6 * K_u	0.5 * P_u	0.125 * P_u
PID some overshoot	0.33 * K_u	0.5 * P_u	0.33 * P_u

Table 1: Ziegler Nichols tuning for regulator, based on a stability boundary.

Experience has shown that the control setting according to Ziegler Nichols rule provides a good closed loop response for many systems. The process operator can do the final tuning of the control iteratively to yield satisfactory control.

Step-by-step Description:

Step 1: Select only Proportional Control, meaning that the Integral time is selected to the maximum value, while the differentiation time is selected to zero.

Step 2: Increase the value of the proportional gain until the point of instability is reached (sustained oscillations) and the critical value of gain, K_u , is reached.

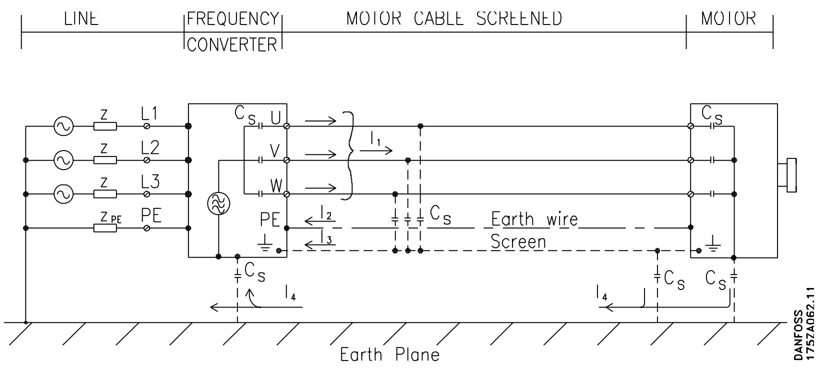
Step 3: Measure the period of oscillation to obtain the critical time constant, P_u .

Step 4: Use the table above to calculate the necessary PID control parameters.

3.4.1. General Aspects of EMC Emissions

Electrical interference is usually conducted at frequences in the range 150 kHz to 30 MHz. Airborne interference from the drive system in the range 30 MHz to 1 GHz is generated from the inverter, motor cable, and the motor.
As shown in the illustration below, capacitive currents in the motor cable coupled with a high dV/dt from the motor voltage generate leakage currents.
The use of a screened motor cable increases the leakage current (see illustration below) because screened cables have higher capacitance to earth than unscreened cables. If the leakage current is not filtered, it will cause greater interference on the mains in the radio frequency range below approx. 5 MHz. Since the leakage current (I_1) is carried back to the unit through the screen (I_3), there will in principle only be a small electro-magnetic field (I_4) from the screened motor cable according to the below figure.

The screen reduces the radiated interference but increases the low-frequency interference on the mains. The motor cable screen must be connected to the frequency converter enclosure as well as on the motor enclosure. This is best done by using integrated screen clamps so as to avoid twisted screen ends (pigtails). These 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 Fieldbus, relay, control cable, signal interface and brake, the screen must be mounted on the enclosure at both ends. In some situations, however, it will be 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, because the screen currents have to be conveyed back to the unit. Moreover, ensure good electrical contact from the mounting plate through the mounting screws to the frequency converter chassis.

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

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

3

3.4.2. EMC test results

The following test results have been obtained using a system with a frequency converter (with options if relevant), a screened control cable, a control box with potentiometer, as well as a motor and motor screened cable.

RFI filter type		Conducted emission			Radiated emission	
		Industrial environment		Housing, trades and light industries	Industrial environment	Housing, trades and light industries
Setup		EN 55011 Class A2	EN 55011 Class A1	EN 55011 Class B	EN 55011 Class A1	EN 55011 Class B
H1						
FC301:	0-3.7 kW 200-240 V	75 m	50 m	10 m	Yes	No
	0-22 kW 380-480 V	75 m	50 m	10 m	Yes	No
FC302:	0-37 kW 200-240 V	150 m	150 m	50 m	Yes	No
	0-75 kW 380-480 V	150 m	150 m	50 m	Yes	No
H2						
FC301/ 302:	0-3.7 kW 200-240 V	5 m	No	No	No	No
	5.5-37 kW 200-240 V	25 m	No	No	No	No
	0-7.5 kW 380-480 V	5 m	No	No	No	No
	11-75 kW 380-480 V	25 m	No	No	No	No
	90-400 kW 380-480 V	50 m	No	No	No	No
	75-500 kW 525-600 V	150 m	No	No	No	No
H3						
FC301:	0-1.5 kW 200-240 V	50 m	25 m	2.5 m	Yes	No
	0-1.5 kW 380-480 V	50 m	25 m	2.5 m	Yes	No
H4						
FC302	90-400 kW 380-480 V	150 m	150 m	No	Yes	No
	75-315 kW 525-600 V	150 m	150 m	No	No	No
Hx						
FC302	0.75-7.5 kW 525-600 V	-	-	-	-	-

Table 3.1: EMC Test Results (Emission, Immunity)

HX, H1, H2 or H3 is defined in the type code pos. 16 - 17 for EMC filters

HX - No EMC filters build in the frequency converter (600 V units only)

H1 - Integrated EMC filter. Fulfil Class A1/B

H2 - No additional EMC filter. Fulfil Class A2

H3 - Integrated EMC filter. Fulfil class A1/B (Enclosure type A1 only)

H4 - Integrated EMC filter. Fulfil class A1

3.4.3. Emission Requirements

According to the EMC product standard for adjustable speed frequency converters EN/IEC61800-3:2004 the EMC requirements depend on the intended use of the frequency converter. Four categories are defined in the EMC product standard. The definitions of the four categories together with the requirements for mains line conducted emissions are given in the table below:

Category	Definition	Conducted emission requirement according to the limits given in EN55011
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 above 1000 V and rated current above 400 A or intended for use in complex systems.	No limit line. An EMC plan should be made.

When the generic emission standards are used the frequency converters are required to comply with the following limits:

Environment	Generic standard	Conducted emission requirement according to the limits given in EN55011
First environment (home and office)	EN/IEC61000-6-3 Emission standard for residential, commercial and light industrial environments.	Class B
Second environment (industrial environment)	EN/IEC61000-6-4 Emission standard for industrial environments.	Class A Group 1

3.4.4. Immunity Requirements

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

In order to document immunity against electrical interference from electrical phenomena, the following immunity tests have been made on a system consisting of a frequency converter (with options if relevant), a screened control cable and a control box with potentiometer, motor cable and motor. The tests were performed in accordance with the following basic standards:

- **EN 61000-4-2 (IEC 61000-4-2):** Electrostatic discharges (ESD): Simulation of electrostatic discharges from human beings.
- **EN 61000-4-3 (IEC 61000-4-3):** Incoming electromagnetic field radiation, amplitude modulated simulation of the effects of radar and radio communication equipment as well as mobile communications equipment.
- **EN 61000-4-4 (IEC 61000-4-4):** Burst transients: Simulation of interference brought about by switching a contactor, relay or similar devices.
- **EN 61000-4-5 (IEC 61000-4-5):** Surge transients: Simulation of transients brought about e.g. by lightning that strikes near installations.
- **EN 61000-4-6 (IEC 61000-4-6):** RF Common mode: Simulation of the effect from radio-transmission equipment joined by connection cables.

See following EMC immunity form.

Voltage range: 200-240 V, 380-480 V

Basic standard	Burst IEC 61000-4-4	Surge IEC 61000-4-5	ESD IEC 61000-4-2	Radiated electromagnetic field IEC 61000-4-3	RF common mode voltage IEC 61000-4-6
Acceptance criterion	B	B	B	A	A
Line	4 kV CM	2 kV/2 Ω DM 4 kV/12 Ω CM	—	—	10 V_{RMS}
Motor	4 kV CM	4 kV/2 Ω[1)]	—	—	10 V_{RMS}
Brake	4 kV CM	4 kV/2 Ω[1)]	—	—	10 V_{RMS}
Load sharing	4 kV CM	4 kV/2 Ω[1)]	—	—	10 V_{RMS}
Control wires	2 kV CM	2 kV/2 Ω[1)]	—	—	10 V_{RMS}
Standard bus	2 kV CM	2 kV/2 Ω[1)]	—	—	10 V_{RMS}
Relay wires	2 kV CM	2 kV/2 Ω[1)]	—	—	10 V_{RMS}
Application and Fieldbus options	2 kV CM	2 kV/2 Ω[1)]	—	—	10 V_{RMS}
LCP cable	2 kV CM	2 kV/2 Ω[1)]	—	—	10 V_{RMS}
External 24 V DC	2 kV CM	0.5 kV/2 Ω DM 1 kV/12 Ω CM	—	—	10 V_{RMS}
Enclosure	—	—	8 kV AD 6 kV CD	10 V/m	—

AD: Air Discharge
CD: Contact Discharge
CM: Common mode
DM: Differential mode
1. Injection on cable shield.

Table 3.2: Immunity

3.5.1. 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 525-600 V units and at grounded Delta leg above 300 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 below, 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 six locations (see illustration):

In order 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) incl. signal isolation of U_{DC}, indicating the intermediate current voltage.
2. Gate drive that runs the IGBTs (trigger transformers/opto-couplers).
3. Current transducers.
4. Opto-coupler, brake module.
5. Internal inrush, RFI, and temperature measurement circuits.
6. Custom relays.

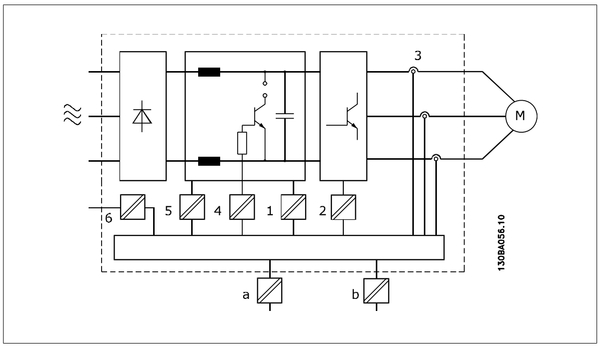


Illustration 3.3: Galvanic isolation

The functional galvanic isolation (a and b on drawing) is for the 24 V back-up option and for the RS 485 standard bus interface.

Installation at high altitude
380 - 500 V: At altitudes above 3 km, please contact Danfoss Drives regarding PELV.
525 - 690 V: At altitudes above 2 km, please contact Danfoss Drives regarding PELV.

3.6.1. Earth Leakage Current

Warning:
Touching the electrical parts may be fatal - even after the equipment has been disconnected from mains.
Also make sure that other voltage inputs have been disconnected, such as load sharing (linkage of DC intermediate circuit), as well as the motor connection for kinetic back-up.
Using VLT AutomationDrive FC 300: wait at least the amount of time indicated in the *Safety Precautions* section.
Shorter time is allowed only if indicated on the nameplate for the specific unit.

Leakage Current
The earth leakage current from the frequency converter exceeds 3.5 mA. To ensure that the earth cable has a good mechanical connection to the earth connection (terminal 95), the cable cross section must be at least 10 mm^2 or 2 rated earth wires terminated separately.
Residual Current Device
This product can cause a d.c. current in the protective conductor. Where a residual current device (RCD) is used for extra protection, only an RCD of Type B (time delayed) shall be used on the supply side of this product. See also RCD Application Note MN.90.GX.02.
Protective earthing of the frequency converter and the use of RCD's must always follow national and local regulations.

3.7. Brake functions in FC 300

Braking function is applied for braking the load on the motor shaft, either as dynamic braking or static braking.

3.7.1. Mechanical Holding Brake

A mechanical holding brake mounted directly on the motor shaft normally performs static braking. In some applications the static holding torque is working as static holding of the motor shaft (usually synchronous permanent motors). A holding brake is either controlled by a PLC or directly by a digital output from the frequency converter (relay or solid state).

NB!
When the holding brake is included in a safety chain:
A frequency converter cannot provide a safe control of a mechanical brake. A redundancy circuitry for the brake control must be included in the total installation.

3.7.2. Dynamic Braking

Dynamic Brake established by:

- Resistor brake: A brake IGBT keep the overvoltage under a certain threshold by directing the brake energy from the motor to the connected brake resistor (par. 2-10 = [1]).
- AC brake: The brake energy is distributed in the motor by changing the loss conditions in the motor. The AC brake function cannot be used in applications with high cycling frequency since this will overheat the motor (par. 2-10 = [2]).
- DC brake: An over-modulated DC current added to the AC current works as an eddy current brake (par. 2-02 ≠ 0 s).

3.7.3. Selection of Brake Resistor

To handle higher demands by generatoric braking a brake resistor is necessary. Using a brake resistor ensures that the energy is absorbed in the brake resistor and not in the frequency converter.

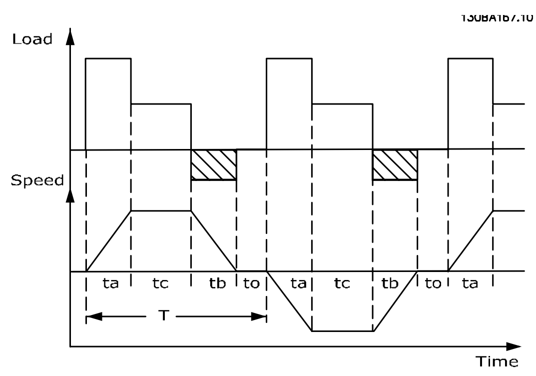
If the amount of kinetic energy transferred to the resistor in each braking period is not known, the average power can be calculated on the basis of the cycle time and braking time also called intermitted duty cycle. The resistor intermittent duty cycle is an indication of the duty cycle at which the resistor is active. The below figure shows a typical braking cycle.

NB!
Motor suppliers often use S5 when stating the permissible load which is an expression of intermittent duty cycle.

The intermittent duty cycle for the resistor is calculated as follows:

Duty cycle = t_b/T

T = cycle time in seconds
t_b is the braking time in seconds (of the cycle time)



	Cycle time (s)	Braking duty cycle at 100% torque	Braking duty cycle at over torque (150/160%)
200-240 V			
PK25-P11K	120	Continuous	40%
P15K-P37K	300	10%	10%
380-500 V			
PK37-P75K	120	Continuous	40%
P90K-P160	600	Continuous	10%
P200	600	40%	10%
P250-P400	600	40%1)	10%2)
525-600 V			
PK75-P75K	120	Continuous	40%
525-690 V			
P110-P315	600	40%	10%
P355-P560	600	40%3)	10%4)

Table 3.3: Braking at high overload torque level

1) 355 kW at 90% torque. At 100% torque the braking duty cycle is 13%. At mains rating 441-500 V 100% torque the braking duty cycle is 17%
400 kW at 80% torque. At 100% torque the braking duty cycle is 8%
2) Based on 300 second cycle:
For 355 kW the torque is 145%
For 400 kW the torque is 130%
3) 500 kW at 80% torque
560 kW at 71% torque
4) Based on 300 second cycle:
For 500 kW the torque is 128%
For 560 kW the torque is 114%
Danfoss offers brake resistors with duty cycle of 5%, 10% and 40%. If a 10% duty cycle is applied, the brake resistors are able to absorb brake power for 10% of the cycle time. The remaining 90% of the cycle time will be used on dissipating excess heat.

The max. permissible load on the brake resistor is stated as a peak power at a given intermittent duty cycle and can be calculated as:

The brake resistance is calculated as shown:

$$R_{br}\,[\Omega] = \frac{U_{dc}^2}{P_{peak}}$$

where

$P_{peak} = P_{motor} \times M_{br} \times \eta_{motor} \times \eta_{VLT}[W]$

As can be seen, the brake resistance depends on the intermediate circuit voltage (U_{dc}).
The FC 301 and FC 302 brake function is settled in 4 areas of mains:

Size	Brake active	Warning before cut out	Cut out (trip)
FC 301 / 302 3 x 200-240 V	390 V (UDC)	405 V	410 V
FC 301 3 x 380-480 V	778 V	810 V	820 V
FC 302 3 x 380-500 V*	810 V/ 795 V	840 V/ 820 V	850 V/ 855 V
FC 302 3 x 525-600 V	943 V	965 V	975 V
FC 302 3 x 525-690 V	1084 V	1109 V	1130 V

* Power size dependent

NB!
Check that the brake resistor can cope with a voltage of 410 V, 820 V, 850 V, 975 V or 1130 V - unless Danfoss brake resistors are used.

Danfoss recommends the brake resistance R_{rec}, i.e. one that guarantees that the frequency converter is able to brake at the highest braking torque ($M_{br(\%)}$) of 160%. The formula can be written as:

$$R_{rec}\,[\Omega] = \frac{U_{dc}^2 \; x \; 100}{P_{motor} \; x \; M_{br\,(\%)} \; x \; \eta_{VLT} \; x \; \eta_{motor}}$$

η_{motor} is typically at 0.90

η_{VLT} is typically at 0.98

For 200 V, 480 V, 500 V and 600 V frequency converters, R_{rec} at 160% braking torque is written as:

$$200V \; : \; R_{rec} = \frac{107780}{P_{motor}}\,[\Omega]$$

$$480V \; : \; R_{rec} = \frac{375300}{P_{motor}}\,[\Omega] \; 1)$$

$$480V \; : \; R_{rec} = \frac{428914}{P_{motor}}\,[\Omega] \; 2)$$

$$500V \; : \; R_{rec} = \frac{464923}{P_{motor}}\,[\Omega]$$

$$600V \; : \; R_{rec} = \frac{630137}{P_{motor}}\,[\Omega]$$

$$690V \; : \; R_{rec} = \frac{832664}{P_{motor}}\,[\Omega]$$

1) For frequency converters ≤ 7.5 kW shaft output

2) For frequency converters 11 - 75 kW shaft output

NB!
The resistor brake circuit resistance selected should not be higher than that recommended by Danfoss. If a brake resistor with a higher ohmic value is selected, the 160% braking torque may not be achieved because there is a risk that the frequency converter cuts out for safety reasons.

NB!
If a short circuit in the brake transistor occurs, power dissipation in the brake resistor is only prevented by using a mains switch or contactor to disconnect the mains for the frequency converter. (The contactor can be controlled by the frequency converter).

NB!
Do not touch the brake resistor as it can get very hot while/after braking.

3.7.4. Control with Brake Function

The brake is to limit the voltage in the intermediate circuit when the motor acts as a generator. This occurs, for example, when the load drives the motor and the power accumulates on the DC link. The brake is built up as a chopper circuit with the connection of an external brake resistor.

Placing the brake resistor externally offers the following advantages:

- The brake resistor can be selected on the basis of the application in question.
- The brake energy can be dissipated outside the control panel, i.e. where the energy can be utilized.
- The electronics of the frequency converter will not be overheated if the brake resistor is overloaded.

The brake is protected against short-circuiting of the brake resistor, and the brake transistor is monitored to ensure that short-circuiting of the transistor is detected. A relay/digital output can be used for protecting the brake resistor against overloading in connection with a fault in the frequency converter. In addition, the brake makes it possible to read out the momentary power and the mean power for the latest 120 seconds. The brake can also monitor the power energizing and make sure it does not exceed a limit selected in par. 2-12. In par. 2-13, select the function to carry out when the power transmitted to the brake resistor exceeds the limit set in par. 2-12.

NB!
Monitoring the brake power is not a safety function; a thermal switch is required for that purpose. The brake resistor circuit is not earth leakage protected.

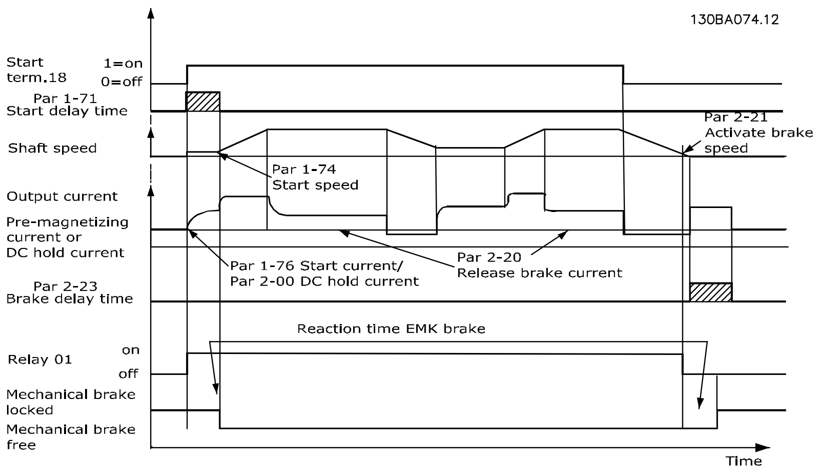
Over voltage control (OVC) (exclusive brake resistor) can be selected as an alternative brake function in par. 2-17. This function is active for all units. The function ensures that a trip can be avoided if the DC link voltage increases. This is done by increasing the output frequency to limit the voltage from the DC link. It is a very useful function, e.g. if the ramp-down time is too short since tripping of the frequency converter is avoided. In this situation the ramp-down time is extended.

3

3.8.1. Mechanical Brake Control

For hoisting applications, it is necessary to be able to control an electro-magnetic brake. For controlling the brake, a relay output (relay1 or relay2) or a programmed digital output (terminal 27 or 29) is required. Normally, this output must be closed for as long as the frequency converter is unable to 'hold' the motor, e.g. because of too big load. In par. 5-40 (Array parameter), par. 5-30, or par. 5-31 (digital output 27 or 29), select *mechanical brake control* [32] for applications with an electro-magnetic brake.

When *mechanical brake control* [32] is selected, the mechanical brake relay stays closed during start until the output current is above the level selected in par. 2-20 *Release Brake Current*. During stop, the mechanical brake will close when the speed is below the level selected in par. 2-21 *Activate Brake Speed [RPM]*. If the frequency converter is brought into an alarm condition, i.e. over-voltage situation, the mechanical brake immediately cuts in. This is also the case during safe stop.



In hoisting/lowering applications, it must be possible to control an electro-mehanical brake.

Step-by-step Description

- To control the mechanical brake any relay output or digital output (terminal 27 or 29) can be used. If necessary use a suitable contactor.
- Ensure that the output is switched off as long as the frequency converter is unable to drive the motor, for example due to the load being too heavy or due to the fact that the motor has not been mounted yet.
- Select *Mechanical brake control* [32] in par. 5-4* (or in par. 5-3*) before connecting the mechanical brake.
- The brake is released when the motor current exceeds the preset value in par. 2-20.
- The brake is engaged when the output frequency is less than the frequency set in par. 2-21 or 2-22 and only if the frequency converter carries out a stop command.

NB!
For vertical lifting or hoisting applications it is strongly recommended to ensure that the load can be stopped in case of an emergency or a malfunction of a single part such as a contactor, etc.
If the frequency converter is in alarm mode or in an over voltage situation, the mechanical brake cuts in.

NB!
For hoisting applications make sure that the torque limits in par. 4-16 and 4-17 are set lower than the current limit in par. 4-18. Also it is recommendable to set par. 14-25, *Trip Delay at Torque Limit* to "0", par. 14-26, *Trip Delay at Inverter Fault* to "0" and par. 14-10, *Mains Failure* to "[3], *Coasting*".

3.8.2. Hoist Mechanical Brake

The VLT Automation Drive FC 300 features a mechanical brake control specifically designed for hoisting applications. The hoist mechanical brake is activated by choice [6] in par. 1-72. The main difference compared to the regular mechanical brake control, where a relay function monitoring the output current is used, is that the hoist mechanical brake function has direct control over the brake relay. This means that instead of setting a current for release of the brake, the torque applied against the closed brake before release is defined. Because the torque is defined directly the setup is more straightforward for hoisting applications.
By using the Proportional Gain Boost (par. 2-28) a quicker control when releasing the brake can be obtained. The hoist mechanical brake strategy is based on a 3-step sequence, where motor control and brake release are synchronized in order to obtain the smoothest possible brake release.

3-step sequence

1. **Pre-magnetize the motor**
   In order to ensure that there is a hold on the motor and to verify that it is mounted correctly, the motor is first pre-magnetized.
2. **Apply torque against the closed brake**
   When the load is held by the mechanical brake, its size cannot be determined, only its direction. The moment the brake opens, the load must be taken over by the motor. To facilitate the takeover, a user defined torque, set in par. 2-26, is applied in hoisting direction. This will be used to initialize the speed controller that will finally take over the load. In order to reduce wear on the gearbox due to backlash, the torque is ramped up.
3. **Release brake**
   When the torque reaches the value set in par. 2-26 *Torque Ref*, the brake is released. The value set in par. 2-25 *Brake Release Time* determines the delay before the load is released. In order to react as quickly as possible on the load-step that follows upon brake release, the speed-PID control can be boosted by increasing the proportional gain.

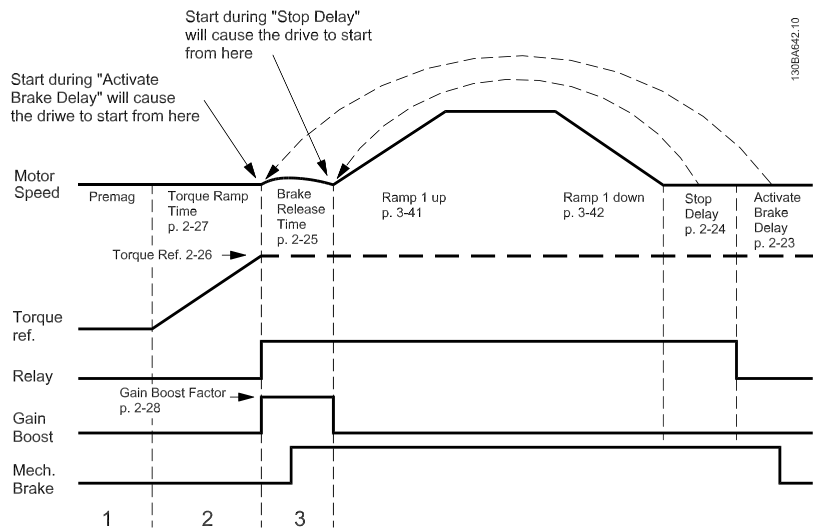


Illustration 3.4: Brake release sequence for hoist mechanical brake control

3.8.3. Brake Resistor Cabling

EMC (twisted cables/shielding)
To reduce the electrical noise from the wires between the brake resistor and the frequency converter, the wires must be twisted.

For enhanced EMC performance a metal screen can be used.

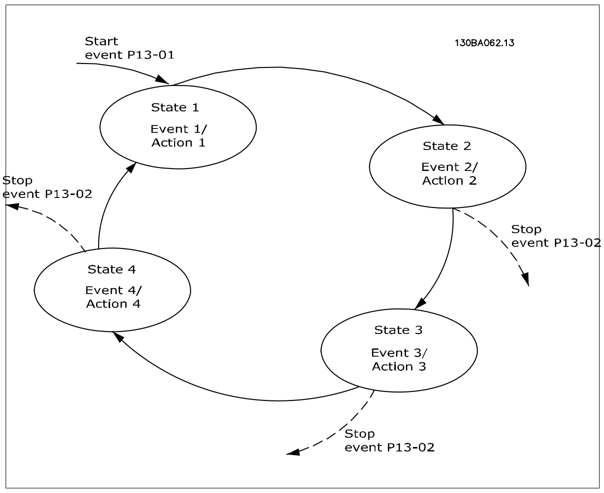
3

3.9.1. Smart Logic Control

The Smart Logic Control (SLC) is essentially a sequence of user defined actions (see par. 13-52) executed by the SLC when the associated user defined *event* (see par. 13-51) is evaluated as TRUE by the SLC.
Events and *actions* are each numbered and are linked in pairs called states. This means that when *event [1]* is fulfilled (attains the value TRUE), *action [1]* is executed. After this, the conditions of *event [2]* will be evaluated and if evaluated TRUE, *action [2]*will be executed and so on. Events and actions are placed in array parameters.

Only one *event* will be evaluated at any time. If an *event* is evaluated as FALSE, nothing happens (in the SLC) during the present scan interval and no other *events* will be evaluated. This means that when the SLC starts, it evaluates *event [1]* (and only *event [1]*) each scan interval. Only when *event [1]* is evaluated TRUE, the SLC executes *action [1]* and starts evaluating *event [2]*.

It is possible to program from 0 to 20 *events* and *actions*. When the last *event / action* has been executed, the sequence starts over again from *event [1] / action [1]*. The illustration shows an example with three *events / actions*.



Short Circuit (Motor Phase – Phase)
The frequency converter is protected against short circuits by means of current measurement in each of the three motor phases or in the DC link. A short circuit between two output phases will cause an overcurrent in the inverter. The inverter will be turned off individually when the short circuit current exceeds the permitted value (Alarm 16 Trip Lock).
To protect the frequency converter against a short circuit at the load sharing and brake outputs please see the design guidelines.

Switching on the Output
Switching on the output between the motor and the frequency converter is fully permitted. You cannot damage the frequency converter in any way by switching on the output. However, fault messages may appear.

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

1. The load drives the motor (at constant output frequency from the frequency converter), ie. the load generates energy.
2. During deceleration ("ramp-down") if the moment of inertia is high, the friction is low and the ramp-down time is too short for the energy to be dissipated as a loss in the frequency converter, the motor and the installation.
3. In-correct slip compensation setting may cause higher DC link voltage.

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

See par. 2-10 and par. 2-17 to select the method used for controlling the intermediate circuit voltage level.

Mains Drop-out

During a mains drop-out, the frequency converter keeps running until the intermediate circuit voltage drops below the minimum stop level, which is typically 15% below the frequency converter's lowest rated supply voltage.

The mains voltage before the drop-out and the motor load determines how long it takes for the inverter to coast.

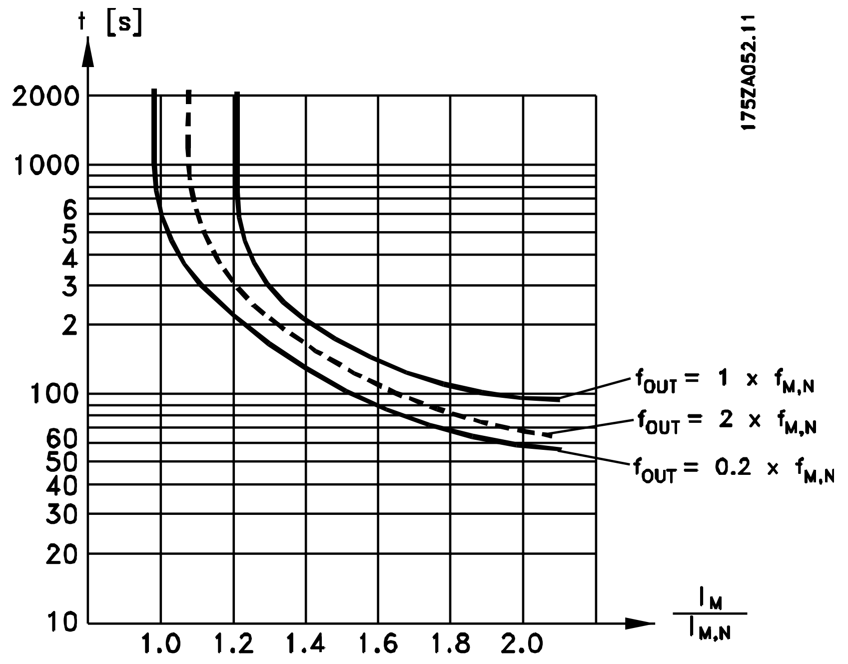
Static Overload in VVCplus mode

When the frequency converter is overloaded (the torque limit in par. 4-16/4-17 is reached), the controls reduces the output frequency to reduce the load. If the overload is excessive, a current may occur that makes the frequency converter cut out after approx. 5-10 s.

Operation within the torque limit is limited in time (0-60 s) in par. 14-25.

3.10.1. Motor Thermal Protection

The motor temperature is calculated on the basis of motor current, output frequency, and time or thermistor. See par. 1-90 in the Programming Guide.



3.11.1. Safe Stop of FC 300

The FC 302, and also the FC301 in A1 enclosure, can perform the safety function *Safe Torque Off* (As defined by IEC 61800-5-2) or *Stop Category 0* (as defined in EN 60204-1).

FC 301 A1 enclosure: When Safe Stop is included in the drive, position 18 of Type Code must be either T or U. If position 18 is B or X, Safe Stop Terminal 37 is not included!

Example:

Type Code for FC 301 A1 with Safe Stop: FC-301PK75T4**Z20**H4**T**GCXXXSXXXXA0BXCXXXXD0

It is designed and approved suitable for the requirements of Safety Category 3 in EN 954-1. This functionality is called Safe Stop. Prior to integration and use of Safe Stop in an installation, a thorough risk analysis on the installation must be carried out in order to determine whether the Safe Stop functionality and safety category are appropriate and sufficient.

Activation and Termination of Safe Stop

The Safe Stop function is activated by switching off the 24Vdcv supply to the Terminal 37. By default the Safe Stop functions is set to an Unintended Restart Prevention behaviour. This means, in order to terminate Safe Stop and resume normal operation, first the 24Vdc must be reapplied to Terminal 37. Subsequently, a reset signal must be given (via Bus, Digital I/O, or [Reset] key).

The Safe Stop function can be set to an Automatic Restart behaviour by setting the value of parameter 5-19 from default value [1] to value [3]. If a MCB112 Option is connected to the drive, then Automatic Restart Behaviour is set by values [7] and [8].
Automatic Restart means that Safe Stop is terminated, and normal operation is resumed, as soon as the 24Vdc are reapplied to Terminal 37, no Reset signal is required.

IMPORTANT! Automatic Restart Behaviour is only allowed in one of the two situations:

1. The Unintended Restart Prevention is implemented by other parts of the Safe Stop installation.
2. A presence in the dangerous zone can be physically excluded when Safe Stop is not activated. In particular, the following paragraphs of standards under the EU Machinery Directive must be observed: 5.2.1, 5.2.2, and 5.2.3. of EN954-1:1996 (or ISO 13849-1:2006), 4.11.3 and 4.11.4 of EN292-2 (ISO 12100-2:2003).

Prüf- und Zertifizierungsstelle
im BG-PRÜFZERT

BGIA
Berufsgenossenschaftliches Institut für Arbeitsschutz
Hauptverband der gewerblichen Berufsgenossenschaften

Translation
In any case, the German original shall prevail.

Type Test Certificate

05 06004
No. of certificate

Name and address of the holder of the certificate: (customer)	Danfoss Drives A/S, Ulnaes 1 DK-6300 Graasten, Dänemark
Name and address of the manufacturer:	Danfoss Drives A/S, Ulnaes 1 DK-6300 Graasten, Dänemark

Ref. of customer:
Ref. of Test and Certification Body: Apf/Köh VE-Nr. 2003 23220
Date of Issue: 13.04.2005

Product designation:	Frequency converter with integrated safety functions
Type:	VLT® Automation Drive FC 302
Intended purpose:	Implementation of safety function „Safe Stop"
Testing based on:	EN 954-1, 1997-03, DKE AK 226.03, 1998-06, EN ISO 13849-2; 2003-12, EN 61800-3, 2001-02, EN 61800-5-1, 2003-09,
Test certificate:	No.: 2003 23220 from 13.04.2005
Remarks:	The presented types of the frequency converter FC 302 meet the requirements laid down in the test bases. With correct wiring a category 3 according to DIN EN 954-1 is reached for the safety function.

The type tested complies with the provisions laid down in the directive 98/37/EC (Machinery).

Further conditions are laid down in the Rules of Procedure for Testing and Certification of April 2004.

Head of certification body
(Prof. Dr. rer. nat. Dietmar Reinert)

Certification officer
(Dipl.-Ing. R. Apfeld)

PZB10E
01.05

Postal adress:
53754 Sankt Augustin

Office:
Alte Heerstraße 111
53757 Sankt Augustin

Phone: 0 22 41/2 31-02
Fax: 0 22 41/2 31-22 34

130BA373.10

3.11.2. Safe Stop Installation (FC 302 and FC 301 - A1 enclosure only)

To carry out an installation of a Category 0 Stop (EN60204) in conformance with Safety Category 3 (EN954-1), follow these instructions:

1. The bridge (jumper) between Terminal 37 and 24 V DC must be removed. Cutting or breaking the jumper is not sufficient. Remove it entirely to avoid short-circuiting. See jumper on illustration.
2. Connect terminal 37 to 24 V DC by a short-circuit protected cable. The 24 V DC voltage supply must be interruptible by an EN954-1 Category 3 circuit interrupt device. If the interrupt device and the frequency converter are placed in the same installation panel, you can use a regular cable instead of a protected one.
3. Unless the FC302 itself has protection class IP54 and higher, it must be placed in an IP 54 enclosure. Consequently, FC301 A1 must always be placed in an IP 54 enclosure.

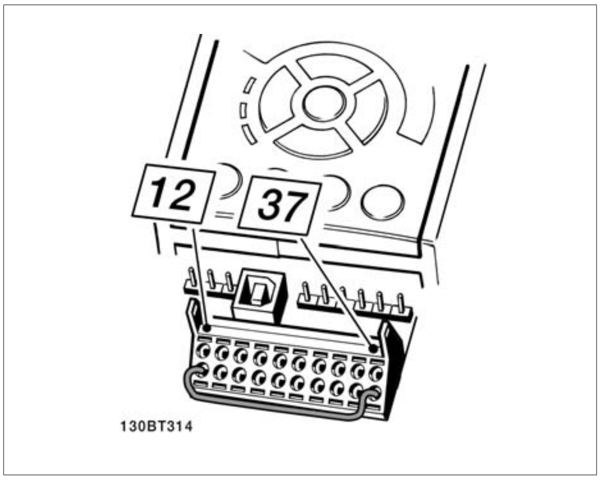


Illustration 3.5: Bridge jumper between terminal 37 and 24 VDC

The illustration below shows a Stopping Category 0 (EN 60204-1) with safety Category 3 (EN 954-1). The circuit interrupt is caused by an opening door contact. The illustration also shows how to connect a non-safety related hardware coast.

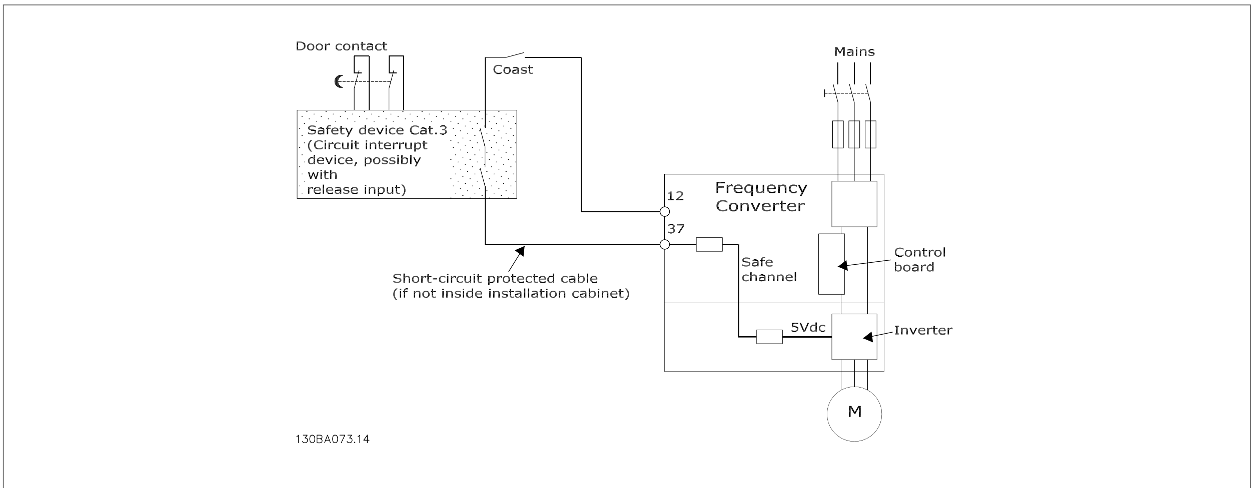


Illustration 3.6: Illustration of the essential aspects of an installation to achieve a Stopping Category 0 (EN 60204-1) with safety Category 3 (EN 954-1).

3.11.3. Installation for Safe Stop in combination with MCB112

If the Ex-certified thermistor module MCB112, which uses Terminal 37 as its safety-related switch-off channel, is connected, then the output X44/11 of MCB112 must be AND-ed with the safety-related sensor (such as emergency stop button, safety-guard switch, etc.) that activates Safe Stop. The AND logic itself must conform to EN 954-1, Safety Category 3. The connection from the output of the safe AND logic to Safe Stop terminal 37 must be short-circuit protected. See figure below:

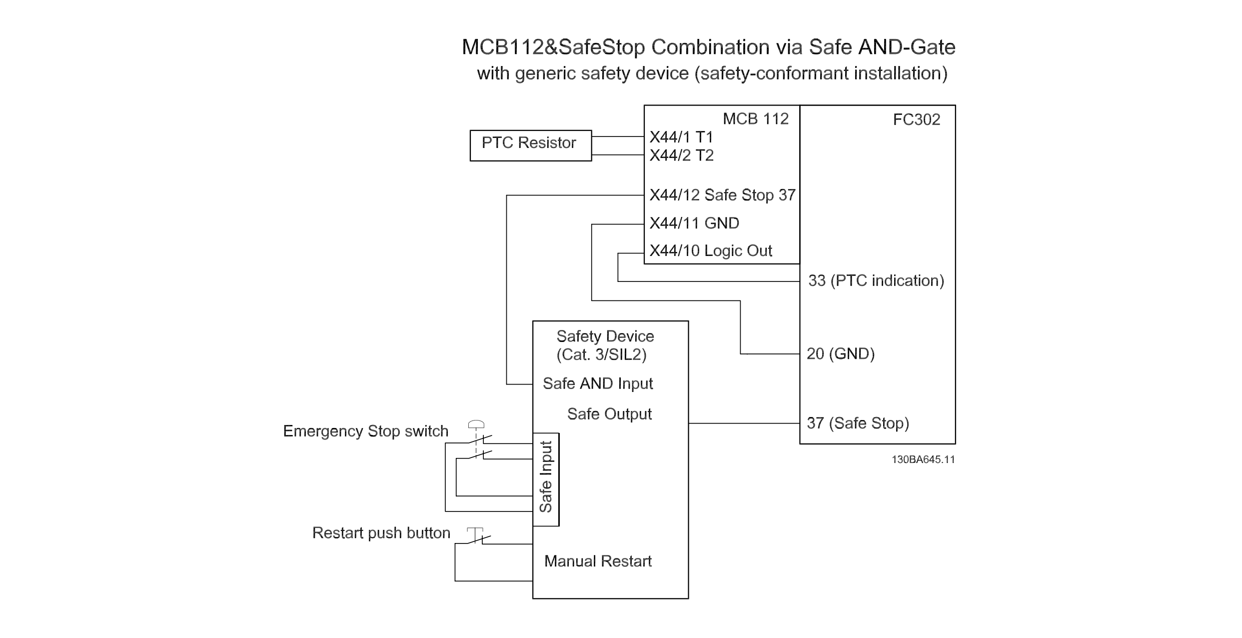


Illustration 3.7: Illustration of the essential aspects for installing a combination of a Safe Stop application and a MCB112 application. The diagram shows a Restart input for the external Safety Device. This means that in this installation parameter 5-19 might be set to value [7] or [8].

Parameter settings for Safe Stop in combination with MCB112

If MCB112 is connected, then additional settings are possible for parameter 5-19: [1] (default) and [3] are still available, but should not be set. They must be set if only Safe Stop is used. If [1] or [3] are chosen and MCB112 is triggered, then the frequency converter will react with an alarm "Dangerous Failure [A72]" and stop the drive safely, without Automatic Restart. [4] and [5] are available then, but should not be used. They must be used if only MCB112 is connected, and no other safety-related sensor. If [4] or [5] are chosen and Safe Stop is activated, then the frequency converter will react with an alarm "Dangerous Failure [A72]" and stop the drive safely, without Automatic Restart.

Choices [6], [7], [8] or [9] must be used for combination of Safe Stop and MCB112. IMPORTANT! Choices [7] or [8] set Safe Stop to Automatic Restart.

This is only allowed in one of the two following situations:

1. The Unintended Restart Prevention is implemented by other parts of the Safe Stop installation.
2. A presence in the dangerous zone can be physically excluded when Safe Stop is not activated. In particular, the following paragraphs of standards under the EU Machinery Directive must be observed: 5.2.1, 5.2.2, and 5.2.3. of EN954-1:1996 (or ISO 13849-1:2006), 4.11.3 and 4.11.4 of EN292-2 (ISO 12100-2:2003).

3.11.4. Safe Stop Commissioning Test

After installation and before first operation, perform a commissioning test of an installation or application making use of FC 300 Safe Stop.
Moreover, perform the test after each modification of the installation or application, which the FC 300 Safe Stop is part of.

NB!
A passed commissioning test is mandatory for fulfilment of Safety Category 3 by such an installation or application.

The commissioning test (select one of cases 1 or 2 as applicable):

Case 1: restart prevention for Safe Stop is required (i.e. Safe Stop only where parameter 5-19 is set to default value [1], or combined Safe Stop and MCB112 where parameter 5-19 is set to [6] or [9]):

1. Remove the 24 V DC voltage supply to terminal 37 by the interrupt device while the motor is driven by the FC 302 (i.e. mains supply is not interrupted). The test step is passed if the motor reacts with a coast and the mechanical brake (if connected) is activated, and if an LCP is mounted, the alarm "Safe Stop [A68]" is displayed.
2. Send Reset signal (via Bus, Digital I/O, or [Reset] key). The test step is passed if the motor remains in the Safe Stop state, and the mechanical brake (if connected) remains activated.

3. Reapply 24 V DC to terminal 37. The test step is passed if the motor remains in the coasted state, and the mechanical brake (if connected) remains activated. Step 1.4: Send Reset signal (via Bus, Digital I/O, or [Reset] key). The test step is passed if the motor becomes operational again.

The commissioning test is passed if all four test steps 1.1, 1.2, 1.3 and 1.4 are passed.

Case 2: Automatic Restart of Safe Stop is wanted and allowed (i.e. Safe Stop only where parameter 5-19 is set to [3], or combined Safe Stop and MCB112 where parameter 5-19 is set to [7] or [8]):

1. Remove the 24 V DC voltage supply to terminal 37 by the interrupt device while the motor is driven by the FC 302 (i.e. mains supply is not interrupted). The test step is passed if the motor reacts with a coast and the mechanical brake (if connected) is activated, and if an LCP is mounted, the warning "Safe Stop [W68]" is displayed.
2. Send Reset signal (via Bus, Digital I/O, or [Reset] key). The test step is passed if the motor remains in the Safe Stop state, and the mechanical brake (if connected) remains activated.
3. Reapply 24 V DC to terminal 37.

The test step is passed if the motor becomes operational again. The commissioning test is passed if all three test steps 2.1, 2.2, and 2.3 are passed.

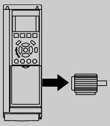
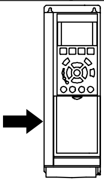
NB!
The Safe Stop function of FC 302 can be used for asynchronous and synchronous motors. It may happen that two faults occur in the frequency converter's power semiconductor. When using synchronous motors this may cause a residual rotation. The rotation can be calculated to Angle=360/(Number of Poles). The application using synchronous motors must take this into consideration and ensure that this is not a safety critical issue. This situation is not relevant for asynchronous motors.

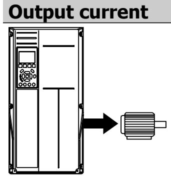
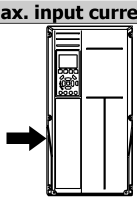
NB!
In order to use the Safe Stop functionality in conformance with the requirements of EN-954-1 Category 3, a number of conditions must be fulfilled by the installation of Safe Stop. Please see section *Safe Stop Installation* for further information.

NB!
The frequency converter does not provide a safety-related protection against unintended or malicious voltage supply to terminal 37 and subsequent reset. Provide this protection via the interrupt device, at the application level, or organisational level.
For more information - see section *Safe Stop Installation*.

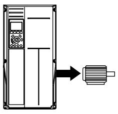
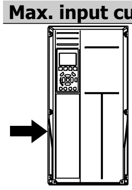
4. FC 300 Selection

4.1. Electrical Data - 200-240 V

Mains Supply 3 x 200 - 240 VAC										
FC 301/FC 302		PK25	PK37	PK55	PK75	P1K1	P1K5	P2K2	P3K0	P3K7
	Typical Shaft Output [kW]	0.25	0.37	0.55	0.75	1.1	1.5	2.2	3	3.7
	Enclosure IP 20/IP 21	A2	A2	A2	A2	A2	A2	A2	A3	A3
	Enclosure IP 20 (FC 301 only)	A1	A1	A1	A1	A1	A1	-	-	-
	Enclosure IP 55, 66	A5	A5	A5	A5	A5	A5	A5	A5	A5
Output current										
	Continuous (3 x 200-240 V) [A]	1.8	2.4	3.5	4.6	6.6	7.5	10.6	12.5	16.7
	Intermittent (3 x 200-240 V) [A]	2.9	3.8	5.6	7.4	10.6	12.0	17.0	20.0	26.7
	Continuous KVA (208 V AC) [KVA]	0.65	0.86	1.26	1.66	2.38	2.70	3.82	4.50	6.00
	Max. cable size (mains, motor, brake) [mm^2 (AWG[2]))]	0.2 - 4 (24 - 10)								
Max. input current										
	Continuous (3 x 200-240 V) [A]	1.6	2.2	3.2	4.1	5.9	6.8	9.5	11.3	15.0
	Intermittent (3 x 200-240 V) [A]	2.6	3.5	5.1	6.6	9.4	10.9	15.2	18.1	24.0
	Max. pre-fuses[1)] [A]	10	10	10	10	20	20	20	32	32
	Environment									
	Estimated power loss at rated max. load [W] [4)]	21	29	42	54	63	82	116	155	185
	Weight, enclosure IP20 [kg]	4.7	4.7	4.8	4.8	4.9	4.9	4.9	6.6	6.6
	A1 (IP20)	2.7	2.7	2.7	2.7	2.7	2.7	-	-	-
	A5 (IP55, 66)	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
	Efficiency [4)]	0.94	0.94	0.95	0.95	0.96	0.96	0.96	0.96	0.96
0.25 - 3.7 kW only available as 160% high overload.										

Mains Supply 3 x 200- 240 VAC							
FC 301/FC 302		P5K5		P7K5		P11K	
High/ Normal Load*		HO	NO	HO	NO	HO	NO
	Typical Shaft Output [kW]	5.5	7.5	7.5	11	11	15
	Enclosure IP20	B3		B3		B4	
	Enclosure IP21	B1		B1		B2	
	Enclosure IP55, 66	B1		B1		B2	
Output current							
	Continuous (3 x 200-240 V) [A]	24.2	30.8	30.8	46.2	46.2	59.4
	Intermittent (60 sec overload) (3 x 200-240 V) [A]	38.7	33.9	49.3	50.8	73.9	65.3
	Continuous KVA (208 V AC) [KVA]	8.7	11.1	11.1	16.6	16.6	21.4
Max. input current							
	Continuous (3 x 200-240 V) [A]	22	28	28	42	42	54
	Intermittent (60 sec overload) (3 x 200-240 V) [A]	35.2	30.8	44.8	46.2	67.2	59.4
	Max. cable size [mm^2 (AWG)] [2)]	16 (6)		16 (6)		35 (2)	
	Max. pre-fuses [A] [1]	63		63		80	
	Estimated power loss at rated max. load [W] [4)]	239	310	371	514	463	602
	Weight, enclosure IP21, IP 55, 66 [kg]	23		23		27	
	Efficiency[4)]	0.964		0.959		0.964	
* High overload = 160% torque during 60 s, Normal overload = 110% torque during 60 s							

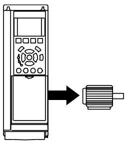
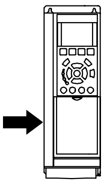
Mains Supply 3 x 200- 240 VAC

FC 301/FC 302		P15K		P18K5		P22K		P30K		P37K	
High/ Normal Load*		HO	NO	HO	NO	HO	NO	HO	NO	HO	NO
	Typical Shaft Output [kW]	15	18.5	18.5	22	22	30	30	37	37	45
	Enclosure IP20	B4		C3		C3		C4		C4	
	Enclosure IP21	C1		C1		C1		C2		C2	
	Enclosure IP55, 66	C1		C1		C1		C2		C2	
Output current											
	Continuous (3 x 200-240 V) [A]	59.4	74.8	74.8	88	88	115	115	143	143	170
	Intermittent (60 sec overload) (3 x 200-240 V) [A]	89.1	82.3	112	96.8	132	127	173	157	215	187
	Continuous KVA (208 V AC) [KVA]	21.4	26.9	26.9	31.7	31.7	41.4	41.4	51.5	51.5	61.2
Max. input current											
	Continuous (3 x 200-240 V) [A]	54	68	68	80	80	104	104	130	130	154
	Intermittent (60 sec overload) (3 x 200-240 V) [A]	81	74.8	102	88	120	114	156	143	195	169
	Max. cable size, IP20 [mm^2 (AWG)] [2)]	35 (2)		90 (3/0)		90 (3/0)		120 (4/0)		120 (4/0)	
	Max. cable size, IP 21/55/66 [mm^2 (AWG)] [2)]	90 (3/0)		90 (3/0)		90 (3/0)		120 (4/0)		120 (4/0)	
	Max. pre-fuses [A] [1]	125		125		160		200		250	
	Estimated power loss at rated max. load [W] [4)]	624	737	740	845	874	1140	1143	1353	1400	1636
	Weight, enclosure IP21, IP 55, 66 [kg]	45		45		45		65		65	
	Efficiency[4)]	0.96		0.97		0.97		0.97		0.97	

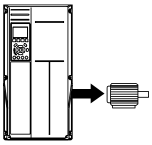
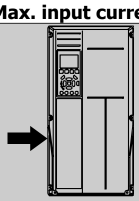
* High overload = 160% torque during 60 s, Normal overload = 110% torque during 60 s

4.2. Electrical Data - 380-500 V

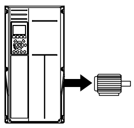
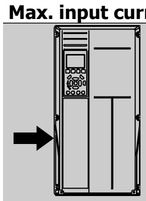
Mains Supply 3 x 380 - 500 VAC (FC 302), 3 x 380 - 480 VAC (FC 301)

		PK 37	PK 55	PK75	P1K1	P1K5	P2K2	P3K0	P4K0	P5K5	P7K5
FC 301/FC 302 Typical Shaft Output [kW]		0.37	0.55	0.75	1.1	1.5	2.2	3	4	5.5	7.5
Enclosure IP20/IP21		A2	A2	A2	A2	A2	A2	A2	A2	A3	A3
Enclosure IP20 (FC 301 only)		A1	A1	A1	A1	A1					
Enclosure IP55, 66		A5	A5	A5	A5	A5	A5	A5	A5	A5	A5
Output current **High overload 160% for 1 minute**											
	Shaft output [kW]	0.37	0.55	0.75	1.1	1.5	2.2	3	4	5.5	7.5
	Continuous (3 x 380-440 V) [A]	1.3	1.8	2.4	3	4.1	5.6	7.2	10	13	16
	Intermittent (3 x 380-440 V) [A]	2.1	2.9	3.8	4.8	6.6	9.0	11.5	16	20.8	25.6
	Continuous (3 x 441-500 V) [A]	1.2	1.6	2.1	2.7	3.4	4.8	6.3	8.2	11	14.5
	Intermittent (3 x 441-500 V) [A]	1.9	2.6	3.4	4.3	5.4	7.7	10.1	13.1	17.6	23.2
	Continuous KVA (400 V AC) [KVA]	0.9	1.3	1.7	2.1	2.8	3.9	5.0	6.9	9.0	11.0
	Continuous KVA (460 V AC) [KVA]	0.9	1.3	1.7	2.4	2.7	3.8	5.0	6.5	8.8	11.6
	Max. cable size (mains, motor, brake) [AWG] [2] [mm^2]	24 - 10 AWG 0.2 - 4 mm^2							24 - 10 AWG 0.2 - 4 mm^2		
Max. input current											
	Continuous (3 x 380-440 V) [A]	1.2	1.6	2.2	2.7	3.7	5.0	6.5	9.0	11.7	14.4
	Intermittent (3 x 380-440 V) [A]	1.9	2.6	3.5	4.3	5.9	8.0	10.4	14.4	18.7	23.0
	Continuous (3 x 441-500 V) [A]	1.0	1.4	1.9	2.7	3.1	4.3	5.7	7.4	9.9	13.0
	Intermittent (3 x 441-500 V) [A]	1.6	2.2	3.0	4.3	5.0	6.9	9.1	11.8	15.8	20.8
	Max. pre-fuses[1][A]	10	10	10	10	10	20	20	20	32	32
	Environment										
	Estimated power loss at rated max. load [W] [4]	35	42	46	58	62	88	116	124	187	255
	Weight, enclosure IP20	4.7	4.7	4.8	4.8	4.9	4.9	4.9	4.9	6.6	6.6
	Enclosure IP55, 66	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	14.2	14.2
	Efficiency [4]	0.93	0.95	0.96	0.96	0.97	0.97	0.97	0.97	0.97	0.97

0.37 - 7.5 kW only available as 160% high overload.

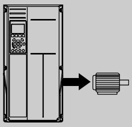
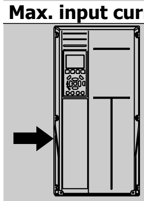
Mains Supply 3 x 380 - 500 VAC (FC 302), 3 x 380 - 480 VAC (FC 301)									
FC 301/FC 302		P11K		P15K		P18K		P22K	
High/ Normal Load*		HO	NO	HO	NO	HO	NO	HO	NO
	Typical Shaft output [kW]	11	15	15	18.5	18.5	22.0	22.0	30.0
	Enclosure IP20	B3		B3		B4		B4	
	Enclosure IP21	B1		B1		B2		B2	
	Enclosure IP55, 66	B1		B1		B2		B2	
Output current									
	Continuous (3 x 380-440 V) [A]	24	32	32	37.5	37.5	44	44	61
	Intermittent (60 sec over-load) (3 x 380-440 V) [A]	38.4	35.2	51.2	41.3	60	48.4	70.4	67.1
	Continuous (3 x 441-500 V) [A]	21	27	27	34	34	40	40	52
	Intermittent (60 sec over-load) (3 x 441-500 V) [A]	33.6	29.7	43.2	37.4	54.4	44	64	57.2
	Continuous KVA (400 V AC) [KVA]	16.6	22.2	22.2	26	26	30.5	30.5	42.3
	Continuous KVA (460 V AC) [KVA]		21.5		27.1		31.9		41.4
Max. input current									
	Continuous (3 x 380-440 V) [A]	22	29	29	34	34	40	40	55
	Intermittent (60 sec over-load) (3 x 380-440 V) [A]	35.2	31.9	46.4	37.4	54.4	44	64	60.5
	Continuous (3 x 441-500 V) [A]	19	25	25	31	31	36	36	47
	Intermittent (60 sec over-load) (3 x 441-500 V) [A]	30.4	27.5	40	34.1	49.6	39.6	57.6	51.7
	Max. cable size [mm^2 / AWG] 2)	16/6		16/6		35/2		35/2	
	Max. pre-fuses [A] 1	63		63		63		80	
	Estimated power loss at rated max. load [W] 4)	291	392	379	465	444	525	547	739
	Weight, enclosure IP20	12		12		23.5		23.5	
	Weight, enclosure IP21, IP 55, 66 [kg]	23		23		27		27	
	Efficiency4)	0.98		0.98		0.98		0.98	
* High overload = 160% torque during 60 s, Normal overload = 110% torque during 60 s									

Mains Supply 3 x 380 - 500 VAC (FC 302), 3 x 380 - 480 VAC (FC 301)

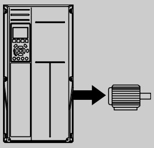
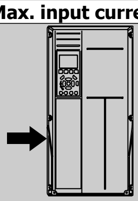
FC 301/FC 302		P30K		P37K		P45K		P55K		P75K	
High/ Normal Load*		HO	NO	HO	NO	HO	NO	HO	NO	HO	NO
	Typical Shaft output [kW]	30	37	37	45	45	55	55	75	75	90
	Enclosure IP20	B4		C3		C3		C4		C4	
	Enclosure IP21	C1		C1		C1		C2		C2	
	Enclosure IP55, 66	C1		C1		C1		C2		C2	
Output current											
	Continuous (3 x 380-440 V) [A]	61	73	73	90	90	106	106	147	147	177
	Intermittent (60 sec overload) (3 x 380-440 V) [A]	91.5	80.3	110	99	135	117	159	162	221	195
	Continuous (3 x 441-500 V) [A]	52	65	65	80	80	105	105	130	130	160
	Intermittent (60 sec overload) (3 x 441-500 V) [A]	78	71.5	97.5	88	120	116	158	143	195	176
	Continuous KVA (400 V AC) [KVA]	42.3	50.6	50.6	62.4	62.4	73.4	73.4	102	102	123
	Continuous KVA (460 V AC) [KVA]		51.8		63.7		83.7		104		128
Max. input current											
	Continuous (3 x 380-440 V) [A]	55	66	66	82	82	96	96	133	133	161
	Intermittent (60 sec overload) (3 x 380-440 V) [A]	82.5	72.6	99	90.2	123	106	144	146	200	177
	Continuous (3 x 441-500 V) [A]	47	59	59	73	73	95	95	118	118	145
	Intermittent (60 sec overload) (3 x 441-500 V) [A]	70.5	64.9	88.5	80.3	110	105	143	130	177	160
	Max. cable size IP20, mains and motor [mm^2 (AWG[2]))]	35 (2)		50 (1)		50 (1)		95 (4/0)		150 (300mcm)	
	Max. cable size IP20, load share and brake [mm^2 (AWG[2]))]	35 (2)		50 (1)		50 (1)		95 (4/0)		95 (4/0)	
	Max. cable size, IP21/55/66 [mm^2 (AWG[2]))]	90 (3/0)		90 (3/0)		90 (3/0)		120 (4/0)		120 (4/0)	
	Max. pre-fuses [A] [1]	100		125		160		250		250	
	Estimated power loss at rated max. load [W] [4)]	570	698	697	843	891	1083	1022	1384	1232	1474
	Weight, enclosure IP21, IP 55, 66 [kg]	45		45		45		65		65	
	Efficiency[4)]	0.98		0.98		0.98		0.98		0.99	

* High overload = 160% torque during 60 s, Normal overload = 110% torque during 60 s

4

Mains Supply 3 x 380 - 500 VAC											
FC 302		P90K		P110		P132		P160		P200	
High/ Normal Load*		HO	NO	HO	NO	HO	NO	HO	NO	HO	NO
	Typical Shaft output at 400 V [kW]	90	110	110	132	132	160	160	200	200	250
	Typical Shaft output at 460 V [HP]	125	150	150	200	200	250	250	300	300	350
	Typical Shaft output at 500 V [kW]	110	132	132	160	160	200	200	250	250	315
	Enclosure IP21, 54	D1		D1		D2		D2		D2	
	Enclosure IP00	D3		D3		D4		D4		D4	
Output current											
	Continuous (at 400 V) [A]	177	212	212	260	260	315	315	395	395	480
	Intermittent (60 sec overload) (at 400 V) [A]	266	233	318	286	390	347	473	435	593	528
	Continuous (at 460/ 500 V) [A]	160	190	190	240	240	302	302	361	361	443
	Intermittent (60 sec overload) (at 460/ 500 V) [A]	240	209	285	264	360	332	453	397	542	487
	Continuous KVA (at 400 V) [KVA]	123	147	147	180	180	218	218	274	274	333
	Continuous KVA (at 460 V) [KVA]	127	151	151	191	191	241	241	288	288	353
	Continuous KVA (at 500 V) [KVA]	139	165	165	208	208	262	262	313	313	384
Max. input current											
	Continuous (at 400 V) [A]	171	204	204	251	251	304	304	381	381	463
	Continuous (at 460/ 500 V) [A]	154	183	183	231	231	291	291	348	348	427
	Max. cable size [mm²] (AWG2))]	2 x 70 (2 x 2/0)				2 x 185 (2 x 350 mcm)					
	Max. pre-fuses [A] 1	300		350		400		500		600	
	Estimated power loss at rated max. load [W] 4)	2641	3234	2995	3782	3425	4213	3910	5119	4625	5893
	Weight, enclosure IP21, IP 54 [kg]	96		104		125		136		151	
	Weight, enclosure IP00 [kg]	82		91		112		123		138	
	Efficiency4)	0.97		0.97		0.97		0.98		0.98	

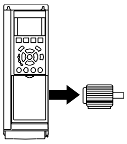
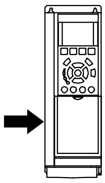
* High overload = 160% torque during 60 s, Normal overload = 110% torque during 60 s

Mains Supply 3 x 380 - 500 VAC									
FC 302		P250		P315		P355		P400	
High/ Normal Load*		HO	NO	HO	NO	HO	NO	HO	NO
	Typical Shaft output at 400 V [kW]	250	315	315	355	355	400	400	450
	Typical Shaft output at 460 V [HP]	350	450	450	500	500	600	550	600
	Typical Shaft output at 500 V [kW]	315	355	355	400	400	500	500	530
	Enclosure IP21, 54	E1		E1		E1		E1	
	Enclosure IP00	E2		E2		E2		E2	
Output current									
	Continuous (at 400 V) [A]	480	600	600	658	658	745	695	800
	Intermittent (60 sec overload) (at 400 V) [A]	720	660	900	724	987	820	1043	880
	Continuous (at 460/ 500 V) [A]	443	540	540	590	590	678	678	730
	Intermittent (60 sec overload) (at 460/ 500 V) [A]	665	594	810	649	885	746	1017	803
	Continuous KVA (at 400 V) [KVA]	333	416	416	456	456	516	482	554
	Continuous KVA (at 460 V) [KVA]	353	430	430	470	470	540	540	582
	Continuous KVA (at 500 V) [KVA]	384	468	468	511	511	587	587	632
Max. input current									
	Continuous (at 400 V) [A]	472	590	590	647	647	733	684	787
	Continuous (at 460/ 500 V) [A]	436	531	531	580	580	667	667	718
	Max. cable size, mains, motor & load share [mm^2 (AWG[2])]	4x240 (4x500 mcm)							
	Max. cable size, brake [mm^2 (AWG[2])]	2 x 185 (2 x 350 mcm)							
	Max. pre-fuses [A] [1]	700		900		900		900	
	Estimated power loss at rated max. load [W] [4]	6005	7630	6960	7701	7691	8879	7964	9428
	Weight, enclosure IP21, IP 54 [kg]	263		270		272		313	
	Weight, enclosure IP00 [kg]	221		234		236		277	
	Efficiency[4]	0.98		0.98		0.98		0.98	

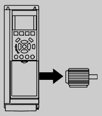
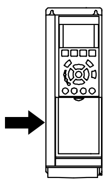
* High overload = 160% torque during 60 s, Normal overload = 110% torque during 60 s

4.3. Electrical Data - 525-690 V

Mains Supply 3 x 525 - 600 VAC (FC 302 only)

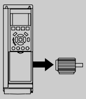
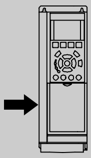
FC 302		PK75	P1K1	P1K5	P2K2	P3K0	P4K0	P5K5	P7K5
	Typical Shaft Output [kW]	0.75	1.1	1.5	2.2	3	4	5.5	7.5
	Enclosure IP20, 21	A2	A2	A2	A2	A2	A2	A3	A3
	Enclosure IP55	A5	A5	A5	A5	A5	A5	A5	A5
Output current									
	Continuous (3 x 525-550 V) [A]	1.8	2.6	2.9	4.1	5.2	6.4	9.5	11.5
	Intermittent (3 x 525-550 V) [A]	2.9	4.2	4.6	6.6	8.3	10.2	15.2	18.4
	Continuous (3 x 551-600 V) [A]	1.7	2.4	2.7	3.9	4.9	6.1	9.0	11.0
	Intermittent (3 x 551-600 V) [A]	2.7	3.8	4.3	6.2	7.8	9.8	14.4	17.6
	Continuous kVA (525 V AC) [kVA]	1.7	2.5	2.8	3.9	5.0	6.1	9.0	11.0
	Continuous kVA (575 V AC) [kVA]	1.7	2.4	2.7	3.9	4.9	6.1	9.0	11.0
	Max. cable size (mains, motor, brake) [AWG] 2) [mm^2]	24 - 10 AWG 0.2 - 4 mm^2					24 - 10 AWG 0.2 - 4 mm^2		
Max. input current									
	Continuous (3 x 525-600 V) [A]	1.7	2.4	2.7	4.1	5.2	5.8	8.6	10.4
	Intermittent (3 x 525-600 V) [A]	2.7	3.8	4.3	6.6	8.3	9.3	13.8	16.6
	Max. pre-fuses1) [A]	10	10	10	20	20	20	32	32
	Environment								
	Estimated power loss at rated max. load [W] 4)	35	50	65	92	122	145	195	261
	Weight, enclosure IP20 [kg]	6.5	6.5	6.5	6.5	6.5	6.5	6.6	6.6
	Weight, enclosure IP55 [kg]	13.5	13.5	13.5	13.5	13.5	13.5	14.2	14.2
	Efficiency 4)	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97

Mains Supply 3 x 525 - 600 VAC

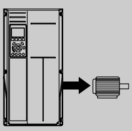
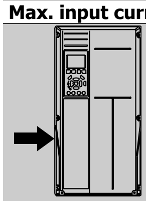
FC 302	P11K		P15K		P18K5		P22K		P30K	
High/ Normal Load*	HO	NO	HO	NO	HO	NO	HO	NO	HO	NO
Typical Shaft Output [kW]	11	15	15	18.5	18.5	22	22	30	30	37
Enclosure IP 21, 55, 66	B1		B1		B2		B2		C1	
Enclosure IP20	B3		B3		B4		B4		B4	
Output current										
 Continuous (3 x 525-550 V) [A]	19	23	23	28	28	36	36	43	43	54
Intermittent (3 x 525-550 V) [A]	30	25	37	31	45	40	58	47	65	59
Continuous (3 x 525-600 V) [A]	18	22	22	27	27	34	34	41	41	52
Intermittent (3 x 525-600 V) [A]	29	24	35	30	43	37	54	45	62	57
Continuous kVA (550 V AC) [kVA]	18.1	21.9	21.9	26.7	26.7	34.3	34.3	41.0	41.0	51.4
Continuous kVA (575 V AC) [kVA]	17.9	21.9	21.9	26.9	26.9	33.9	33.9	40.8	40.8	51.8
Max. cable size IP20 (mains, motor, load share and brake) [AWG] [2] [mm^2]	16(6)				35(2)					
Max. cable size IP21, 55, 66 (mains, motor, load share and brake) [AWG] [2] [mm^2]	16(6)				35(2)				90 (3/0)	
Max. input current										
 Continuous at 550 V [A]	17.2	20.9	20.9	25.4	25.4	32.7	32.7	39	39	49
Intermittent at 550 V [A]	28	23	33	28	41	36	52	43	59	54
Continuous at 575 V [A]	16	20	20	24	24	31	31	37	37	47
Intermittent at 575 V [A]	26	22	32	27	39	34	50	41	56	52
Max. pre-fuses[1] [A]	63		63		63		80		100	
Environment										
Estimated power loss at rated max. load [W] [4]		225		285		329		700		700
Weight, enclosure IP21, 55 [kg]	23		23		27		27		27	
Weight, enclosure IP20 [kg]	12		12		23.5		23.5		23.5	
Efficiency [4]	0.98		0.98		0.98		0.98		0.98	

4

Mains Supply 3 x 525 - 600 VAC

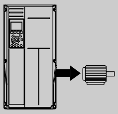
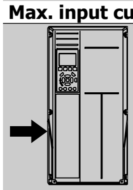
FC 302	P37K		P45K		P55K		P75K	
High/ Normal Load*	HO	NO	HO	NO	HO	NO	HO	NO
Typical Shaft Output [kW]	37	45	45	55	55	75	75	90
Enclosure IP21, 55, 66	C1	C1	C1		C2		C2	
Enclosure IP20	C3	C3	C3		C4		C4	
Output current 								
Continuous (3 x 525-550 V) [A]	54	65	65	87	87	105	105	137
Intermittent (3 x 525-550 V) [A]	81	72	98	96	131	116	158	151
Continuous (3 x 525-600 V) [A]	52	62	62	83	83	100	100	131
Intermittent (3 x 525-600 V) [A]	78	68	93	91	125	110	150	144
Continuous kVA (550 V AC) [kVA]	51.4	61.9	61.9	82.9	82.9	100.0	100.0	130.5
Continuous kVA (575 V AC) [kVA]	51.8	61.7	61.7	82.7	82.7	99.6	99.6	130.5
Max. cable size IP20 (mains, motor) [AWG] 2) [mm²]	50 (1)				95 (4/0)		150 (300mcm)	
Max. cable size IP20 (load share, brake) [AWG] 2) [mm²]	50 (1)				95 (4/0)			
Max. cable size IP21, 55, 66 (mains, motor, load share and brake) [AWG] 2) [mm²]	90 (3/0)				120 (4/0)			
Max. input current 								
Continuous at 550 V [A]	49	59	59	78.9	78.9	95.3	95.3	124.3
Intermittent at 550 V [A]	74	65	89	87	118	105	143	137
Continuous at 575 V [A]	47	56	56	75	75	91	91	119
Intermittent at 575 V [A]	70	62	85	83	113	100	137	131
Max. pre-fuses1) [A]	125		160		250		250	
Environment								
Estimated power loss at rated max. load [W] 4)		850		1100		1400		1500
Weight, enclosure IP20 [kg]	35		35		50		50	
Weight, enclosure IP21, 55 [kg]	45		45		65		65	
Efficiency 4)	0.98		0.98		0.98		0.98	

Mains Supply 3 x 525- 690 VAC

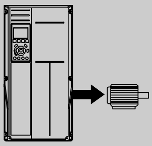
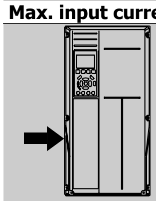
FC 302	P37K		P45K		P55K		P75K		P90K	
High/ Normal Load*	HO	NO	HO	NO	HO	NO	HO	NO	HO	NO
Typical Shaft output at 690 V [kW]	37	45	45	55	55	75	75	90	90	110
Enclosure IP21, 54	D1		D1		D1		D1		D1	
Enclosure IP00	D3		D3		D3		D3		D3	
Output current 										
Continuous (at 690 V) [A]	46	54	54	73	73	86	86	108	108	131
Intermittent (60 sec overload) (at 690 V) [A]	74	59	86	80	117	95	129	119	162	144
Continuous KVA (at 690 V) [KVA]	55	65	65	87	87	103	103	129	129	157
Max. input current 										
Continuous (at 690 V) [A]	50	58	58	77	77	87	87	109	109	128
Max. cable size [mm² (AWG)]	2x70 (2x2/0)									
Max. pre-fuses [A] 1	80		90		125		150		175	
Estimated power loss at rated max. load [W] 4)	1355	1458	1459	1717	1721	1913	1913	2262	2264	2662
Weight, enclosure IP21, IP 54 [kg]	96		96		96		96		96	
Weight, enclosure IP00 [kg]	82		82		82		82		82	
Efficiency4)	0.97		0.97		0.98		0.98		0.98	

* High overload = 160% torque during 60 s, Normal overload = 110% torque during 60 s

Mains Supply 3 x 525- 690 VAC

FC 302	P110		P132		P160		P200		P250		P315	
High/ Normal Load*	HO	NO	HO	NO	HO	NO	HO	NO	HO	NO	HO	NO
Typical Shaft output at 550 V [kW]	90	110	110	132	132	160	160	200	200	250	250	315
Typical Shaft output at 575 V [HP]	125	150	150	200	200	250	250	300	300	350	350	400
Typical Shaft output at 690 V [kW]	110	132	132	160	160	200	200	250	250	315	315	400
Enclosure IP21, 54	D1		D1		D2		D2		D2		D2	
Enclosure IP00	D3		D3		D4		D4		D4		D4	
Output current 												
Continuous (at 550 V) [A]	137	162	162	201	201	253	253	303	303	360	360	418
Intermittent (60 sec overload) (at 550 V) [A]	206	178	243	221	302	278	380	333	455	396	540	460
Continuous (at 575/ 690 V) [A]	131	155	155	192	192	242	242	290	290	344	344	400
Intermittent (60 sec overload) (at 575/ 690 V) [A]	197	171	233	211	288	266	363	319	435	378	516	440
Continuous KVA (at 550 V) [KVA]	131	154	154	191	191	241	241	289	289	343	343	398
Continuous KVA (at 575 V) [KVA]	130	154	154	191	191	241	241	289	289	343	343	398
Continuous KVA (at 690 V) [KVA]	157	185	185	229	229	289	289	347	347	411	411	478
Max. input current 												
Continuous (at 550 V) [A]	130	158	158	198	198	245	245	299	299	355	355	408
Continuous (at 575 V) [A]	124	151	151	189	189	234	234	286	286	339	339	390
Continuous (at 690 V) [A]	128	155	155	197	197	240	240	296	296	352	352	400
Max. cable size [mm^2 (AWG)]	2 x 70 (2 x 2/0)				2 x 185 (2 x 350 mcm)							
Max. pre-fuses [A] [1]	315		350		350		400		500		550	
Estimated power loss at rated max. load [W] [4)]	2664	3114	2953	3612	3451	4292	4275	5156	4875	5821	5185	6149
Weight, enclosure IP21, IP 54 [kg]	96		104		125		136		151		165	
Weight, enclosure IP00 [kg]	82		91		112		123		138		151	
Efficiency[4)]	0.98		0.98		0.98		0.98		0.98		0.98	

* High overload = 160% torque during 60 s, Normal overload = 110% torque during 60 s

Mains Supply 3 x 525- 690 VAC									
FC 302		P355		P400		P500		P560	
High/ Normal Load*		HO	NO	HO	NO	HO	NO	HO	NO
	Typical Shaft output at 550 V [kW]	315	355	315	400	400	450	450	500
	Typical Shaft output at 575 V [HP]	400	450	400	500	500	600	600	650
	Typical Shaft output at 690 V [kW]	355	450	400	500	500	560	560	630
	Enclosure IP21, 54	E1		E1		E1		E1	
	Enclosure IP00	E2		E2		E2		E2	
Output current									
	Continuous (at 550 V) [A]	395	470	429	523	523	596	596	630
	Intermittent (60 sec over-load) (at 550 V) [A]	593	517	644	575	785	656	894	693
	Continuous (at 575/ 690 V) [A]	380	450	410	500	500	570	570	630
	Intermittent (60 sec over-load) (at 575/ 690 V) [A]	570	495	615	550	750	627	855	693
	Continuous KVA (at 550 V) [KVA]	376	448	409	498	498	568	568	600
	Continuous KVA (at 575 V) [KVA]	378	448	408	498	498	568	568	627
	Continuous KVA (at 690 V) [KVA]	454	538	490	598	598	681	681	753
Max. input current									
	Continuous (at 550 V) [A]	381	453	413	504	504	574	574	607
	Continuous (at 575 V) [A]	366	434	395	482	482	549	549	607
	Continuous (at 690 V) [A]	366	434	395	482	482	549	549	607
	Max. cable size, mains motor and load share [mm² (AWG)]	4x240 (4x500 mcm)							
	Max. cable size, brake [mm² (AWG)]	2 x 185 (2 x 350 mcm)							
	Max. pre-fuses [A] [1]	700		700		900		900	
	Estimated power loss at rated max. load [W] [4)]	5383	6449	5818	7249	7671	8727	8715	9673
	Weight, enclosure IP21, IP 54 [kg]	263		263		272		313	
	Weight, enclosure IP00 [kg]	221		221		236		277	
	Efficiency[4)]	0.98		0.98		0.98		0.98	
* High overload = 160% torque during 60 s, Normal overload = 110% torque during 60 s									

1) For type of fuse see section *Fuses.*

2) American Wire Gauge.

3) Measured using 5 m screened motor cables at rated load and rated frequency.

4) The typical power loss is at nominal load conditions and expected to be within +/-15% (tolerence relates to variety in voltage and cable conditions).
Values are based on a typical motor efficiency (eff2/eff3 border line). Motors with lower efficiency will also add to the power loss in the frequency converter and opposite.
If the switching frequency is increased compared to the default setting, the power losses may rise significantly.
LCP and typical control card power consumptions are included. Further options and customer load may add up to 30W to the losses. (Though typical only 4W extra for a fully loaded control card, or options for slot A or slot B, each).
Although measurements are made with state of the art equipment, some measurement inaccuracy must be allowed for (+/-5%).

4.4. General Specifications

Mains supply (L1, L2, L3):

Supply voltage	200-240 V ±10%
Supply voltage	FC 301: 380-480 V / FC 302: 380-500 V ±10%
Supply voltage	FC 302: 525-690 V ±10%
Supply frequency	50/60 Hz
Max. imbalance temporary between mains phases	3.0 % of rated supply voltage
True Power Factor (λ)	≥ 0.9 nominal at rated load
Displacement Power Factor (cos ϕ)	near unity (> 0.98)
Switching on input supply L1, L2, L3 (power-ups) ≤ 7.5 kW	maximum 2 times/min.
Switching on input supply L1, L2, L3 (power-ups) 11-75 kW	maximum 1 time/min.
Switching on input supply L1, L2, L3 (power-ups) ≥ 90 kW	maximum 1 time/2 min.
Environment according to EN60664-1	overvoltage category III/pollution degree 2

The unit is suitable for use on a circuit capable of delivering not more than 100.000 RMS symmetrical Amperes, 240/500/600/ 690 V maximum.

Motor output (U, V, W):

Output voltage	0 - 100% of supply voltage
Output frequency (0.25-75 kW)	FC 301: 0.2 - 1000 Hz / FC 302: 0 - 1000 Hz
Output frequency (90-560 kW)	0 - 800* Hz
Output frequency in Flux Mode (FC 302 only)	0 - 300 Hz
Switching on output	Unlimited
Ramp times	0.01 - 3600 sec.

Voltage and power dependent

Torque characteristics:

Starting torque (Constant torque)	maximum 160% for 60 sec.*
Starting torque	maximum 180% up to 0.5 sec.*
Overload torque (Constant torque)	maximum 160% for 60 sec.*
Starting torque (Variable torque)	maximum 110% for 60 sec.*
Overload torque (Variable torque)	maximum 110% for 60 sec.

**Percentage relates to the nominal torque.*

Cable lengths and cross sections for control cables*:

Max. motor cable length, screened	FC 301: 50 m / FC 301 (A1-encl.): 25 m/ FC 302: 150 m
Max. motor cable length, unscreened	FC 301: 75 m / FC 301 (A1-encl.): 50 m/ FC 302: 300 m
Maximum cross section to control terminals, flexible/ rigid wire without cable end sleeves	1.5 mm^2/16 AWG
Maximum cross section to control terminals, flexible wire with cable end sleeves	1 mm^2/18 AWG
Maximum cross section to control terminals, flexible wire with cable end sleeves with collar	0.5 mm^2/20 AWG
Minimum cross section to control terminals	0.25 mm^2/ 24 AWG

** Power cables, see tables in section "Electrical Data" of the Design Guide*

Protection and Features:

- Electronic thermal motor protection against overload.
- Temperature monitoring of the heatsink ensures that the frequency converter trips if the temperature reaches a predefined level. An overload temperature cannot be reset until the temperature of the heatsink is below the values stated in the tables on the following pages (Guideline - these temperatures may vary for different power sizes, enclosures etc.).
- The frequency converter is protected against short-circuits on motor terminals U, V, W.
- If 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 if the intermediate circuit voltage is too low or too high.

- The frequency converter constantly checks for critical levels of internal temperature, load current, high voltage on the intermediate circuit and low motor speeds. As a response to a critical level, the frequency converter can adjust the switching frequency and/ or change the switching pattern in order to ensure the performance of the drive.

Digital inputs:

Programmable digital inputs	FC 301: 4 (5) / FC 302: 4 (6)
Terminal number	18, 19, 27[1)], 29[4)], 32, 33,
Logic	PNP or NPN
Voltage level	0 - 24 V DC
Voltage level, logic'0' PNP	< 5 V DC
Voltage level, logic'1' PNP	> 10 V DC
Voltage level, logic '0' NPN[2)]	> 19 V DC
Voltage level, logic '1' NPN[2)]	< 14 V DC
Maximum voltage on input	28 V DC
Pulse frequency range	0 - 110 kHz
(Duty cycle) Min. pulse width	4.5 ms
Input resistance, R_i	approx. 4 kΩ

Safe stop Terminal 37[3)] (Terminal 37 is fixed PNP logic):

Voltage level	0 - 24 V DC
Voltage level, logic'0' PNP	< 4 V DC
Voltage level, logic'1' PNP	>20 V DC
Nominal input current at 24 V	50 mA rms
Nominal input current at 20 V	60 mA rms
Input capacitance	400 nF

All digital inputs are galvanically isolated from the supply voltage (PELV) and other high-voltage terminals.

1) Terminals 27 and 29 can also be programmed as output.

2) Except safe stop input Terminal 37.

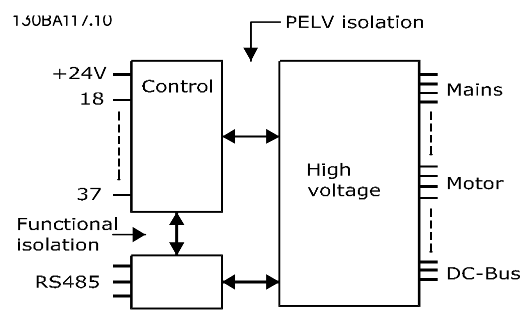
3) Terminal 37 is only available in FC 302 and FC 301 A1 with Safe Stop. It can only be used as safe stop input. Terminal 37 is suitable for category 3 installations according to EN 954-1 (safe stop according to category 0 EN 60204-1) as required by the EU Machinery Directive 98/37/EC. Terminal 37 and the Safe Stop function are designed in conformance with EN 60204-1, EN 50178, EN 61800-2, EN 61800-3, and EN 954-1. For correct and safe use of the Safe Stop function follow the related information and instructions in the Design Guide.

4) FC 302 only.

Analog inputs:

Number of analog inputs	2
Terminal number	53, 54
Modes	Voltage or current
Mode select	Switch S201 and switch S202
Voltage mode	Switch S201/switch S202 = OFF (U)
Voltage level	FC 301: 0 to + 10/ FC 302: -10 to +10 V (scaleable)
Input resistance, R_i	approx. 10 kΩ
Max. voltage	± 20 V
Current mode	Switch S201/switch S202 = ON (I)
Current level	0/4 to 20 mA (scaleable)
Input resistance, R_i	approx. 200 Ω
Max. current	30 mA
Resolution for analog inputs	10 bit (+ sign)
Accuracy of analog inputs	Max. error 0.5% of full scale
Bandwidth	FC 301: 20 Hz/ FC 302: 100 Hz

The analog inputs are galvanically isolated from the supply voltage (PELV) and other high-voltage terminals.



4

Pulse/encoder inputs:

Programmable pulse/encoder inputs	2/1
Terminal number pulse/encoder	29 1), 33 2) / 32 3), 33 3)
Max. frequency at terminal 29, 32, 33	110 kHz (Push-pull driven)
Max. frequency at terminal 29, 32, 33	5 kHz (open collector)
Min. frequency at terminal 29, 32, 33	4 Hz
Voltage level	see section on Digital input
Maximum voltage on input	28 V DC
Input resistance, R_i	approx. 4 kΩ
Pulse input accuracy (0.1 - 1 kHz)	Max. error: 0.1% of full scale
Encoder input accuracy (1 - 110 kHz)	Max. error: 0.05 % of full scale

The pulse and encoder inputs (terminals 29, 32, 33) are galvanically isolated from the supply voltage (PELV) and other high-voltage terminals.

1) FC 302 only

2) Pulse inputs are 29 and 33

3) Encoder inputs: 32 = A, and 33 = B

Analog output:

Number of programmable analog outputs	1
Terminal number	42
Current range at analog output	0/4 - 20 mA
Max. load GND - analog output	500 Ω
Accuracy on analog output	Max. error: 0.5 % of full scale
Resolution on analog output	12 bit

The analogue output is galvanically isolated from the supply voltage (PELV) and other high-voltage terminals.

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

The RS 485 serial communication circuit is functionally separated from other central circuits and galvanically isolated from the supply voltage (PELV).

Digital output:

Programmable digital/pulse outputs	2
Terminal number	27, 29 1)
Voltage level at digital/frequency output	0 - 24 V
Max. output current (sink or source)	40 mA
Max. load at frequency output	1 kΩ
Max. capacitive load at frequency output	10 nF
Minimum output frequency at frequency output	0 Hz
Maximum output frequency at frequency output	32 kHz
Accuracy of frequency output	Max. error: 0.1 % of full scale
Resolution of frequency outputs	12 bit

1) Terminal 27 and 29 can also be programmed as input.

The digital output is galvanically isolated from the supply voltage (PELV) and other high-voltage terminals.

Control card, 24 V DC output:	
Terminal number	12, 13
Output voltage	24 V +1, -3 V
Max. load	FC 301: 130 mA/ FC 302: 200 mA

The 24 V DC supply is galvanically isolated from the supply voltage (PELV), but has the same potential as the analog and digital inputs and outputs.

4

Relay outputs:	
Programmable relay outputs	FC 301 ≤ 7.5 kW: 1 / FC 302 all kW: 2
Relay 01 Terminal number	1-3 (break), 1-2 (make)
Max. terminal load (AC-1)[1] on 1-3 (NC), 1-2 (NO) (Resistive load)	240 V AC, 2 A
Max. terminal load (AC-15)[1] (Inductive load @ cosφ 0.4)	240 V AC, 0.2 A
Max. terminal load (DC-1)[1] on 1-2 (NO), 1-3 (NC) (Resistive load)	60 V DC, 1A
Max. terminal load (DC-13)[1] (Inductive load)	24 V DC, 0.1A
Relay 02 (FC 302 only) Terminal number	4-6 (break), 4-5 (make)
Max. terminal load (AC-1)[1] on 4-5 (NO) (Resistive load) [2] [3]	400 V AC, 2 A
Max. terminal load (AC-15)[1] on 4-5 (NO) (Inductive load @ cosφ 0.4)	240 V AC, 0.2 A
Max. terminal load (DC-1)[1] on 4-5 (NO) (Resistive load)	80 V DC, 2 A
Max. terminal load (DC-13)[1] on 4-5 (NO) (Inductive load)	24 V DC, 0.1A
Max. terminal load (AC-1)[1] on 4-6 (NC) (Resistive load)	240 V AC, 2 A
Max. terminal load (AC-15)[1] on 4-6 (NC) (Inductive load @ cosφ 0.4)	240 V AC, 0.2A
Max. terminal load (DC-1)[1] on 4-6 (NC) (Resistive load)	50 V DC, 2 A
Max. terminal load (DC-13)[1] on 4-6 (NC) (Inductive load)	24 V DC, 0.1 A
Min. terminal load on 1-3 (NC), 1-2 (NO), 4-6 (NC), 4-5 (NO)	24 V DC 10 mA, 24 V AC 20 mA
Environment according to EN 60664-1	overvoltage category III/pollution degree 2

1) IEC 60947 part 4 and 5

The relay contacts are galvanically isolated from the rest of the circuit by reinforced isolation (PELV).

2) Overvoltage category II

3) UL applications 300 V AC 2A

Control card, 10 V DC output:	
Terminal number	50
Output voltage	10.5 V ±0.5 V
Max. load	15 mA

The 10 V DC supply is galvanically isolated from the supply voltage (PELV) and other high-voltage terminals.

Control characteristics:	
Resolution of output frequency at 0 - 1000 Hz	+/- 0.003 Hz
Repeat accuracy of *Precise start/stop* (terminals 18, 19)	≤± 0.1 msec
System response time (terminals 18, 19, 27, 29, 32, 33)	≤ 2 ms
Speed control range (open loop)	1:100 of synchronous speed
Speed control range (closed loop)	1:1000 of synchronous speed
Speed accuracy (open loop)	30 - 4000 rpm: error ±8 rpm
Speed accuracy (closed loop), depending on resolution of feedback device	0 - 6000 rpm: error ±0.15 rpm

All control characteristics are based on a 4-pole asynchronous motor

Control card performance:	
Scan interval	FC 301: 5 ms / FC 302: 1 ms

Surroundings:	
Enclosure ≤ 7.5 kW	IP 20, IP 55
Enclosure 11-75 kW	IP 21, IP 55
Enclosure ≥ 90 kW	IP 00, IP 21, IP 54

Enclosure kit available ≤ 7.5 kW	IP21/TYPE 1/IP 4X top
Vibration test < 90 kW	1.0 g RMS
Vibration test ≥ 90 kW	0.7 g
Max. relative humidity	5% - 93%(IEC 60 721-3-3; Class 3K3 (non-condensing) during operation
Aggressive environment (IEC 60068-2-43) H_2S test	class Kd
Test method according to IEC 60068-2-43 H2S (10 days)	
Ambient temperature < 90 kW	Max. 50 °C (24-hour average maximum 45 °C)
Ambient temperature ≥ 90 kW	Max. 45 °C (24-hour average maximum 40 °C)

Derating for high ambient temperature, see section on special conditions

Minimum ambient temperature during full-scale operation	0 °C
Minimum ambient temperature at reduced performance	- 10 °C
Temperature during storage/transport	-25 - +65/70 °C
Maximum altitude above sea level	1000 m

Derating for high altitude, see section on special conditions

EMC standards, Emission	EN 61800-3, EN 61000-6-3/4, EN 55011
EMC standards, Immunity	EN 61800-3, EN 61000-6-1/2, EN 61000-4-2, EN 61000-4-3, EN 61000-4-4, EN 61000-4-5, EN 61000-4-6

See section on special conditions

Control card, USB serial communication:

USB standard	1.1 (Full speed)
USB plug	USB type B "device" plug

Connection to PC is carried out via a standard host/device USB cable.
The USB connection is galvanically isolated from the supply voltage (PELV) and other high-voltage terminals.
The USB ground connection is not galvanically isolated from protection earth. Use only an isolated laptop as PC connection to the USB connector on the frequency converter.

4.5.1. Efficiency

Efficiency of the frequency converter (η_{VLT})

The load on the frequency converter has little effect on its efficiency. In general, the efficiency is the same at the rated motor frequency $f_{M,N}$, even if the motor supplies 100% of the rated shaft torque or only 75%, i.e. in case of part loads.

This also means that the efficiency of the frequency converter does not change even if other U/f characteristics are chosen.
However, the U/f characteristics influence the efficiency of the motor.

The efficiency declines a little when the switching frequency is set to a value of above 5 kHz. The efficiency will also be slightly reduced if the mains voltage is 500 V, or if the motor cable is longer than 30 m.

Efficiency of the motor (η_{MOTOR})

The efficiency of a motor connected to the frequency converter depends on magnetising level. In general, the efficiency is just as good as with mains operation. The efficiency of the motor depends on the type of motor.

In the range of 75-100% of the rated torque, the efficiency of the motor is practically constant, both when it is controlled by the frequency converter and when it runs directly on mains.

In small motors, the influence from the U/f characteristic on efficiency is marginal. However, in motors from 11 kW and up, the advantages are significant.

In general, the switching frequency does not affect the efficiency of small motors. Motors from 11 kW and up have their efficiency improved (1-2%). This is because the sine shape of the motor current is almost perfect at high switching frequency.

Efficiency of the system (η_{SYSTEM})

To calculate the system efficiency, the efficiency of the frequency converter (η_{VLT}) is multiplied by the efficiency of the motor (η_{MOTOR}):

$\eta_{SYSTEM} = \eta_{VLT} \times \eta_{MOTOR}$

4.6.1. Acoustic Noise

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

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

The typical values measured at a distance of 1 m from the unit:

Enclosure	At reduced fan speed (50%) [dBA] ***	Full fan speed [dBA]
A1	51	60
A2	51	60
A3	51	60
A5	54	63
B1	61	67
B2	58	70
C1	52	62
C2	55	65
D1+D3	74	76
D2+D4	73	74
E1/E2 *	73	74
E1/E2 **	82	83

* 315 kW, 380-480 VAC and 355 kW, 525-600 VAC only!
** Remaining E1+E2 power sizes.
*** For D and E sizes, reduced fan speed is at 87%, measured at 200 V.

4.7.1. du/dt conditions

When a transistor in the inverter bridge switches, the voltage across the motor increases by a du/dt ratio depending on:

- the motor cable (type, cross-section, length screened or unscreened)
- inductance

The natural induction causes an overshoot U_{PEAK} in the motor voltage before it stabilises itself at a level depending on the voltage in the intermediate circuit. The rise time and the peak voltage U_{PEAK} affect the service life of the motor. If the peak voltage is too high, especially motors without phase coil insulation are affected. If the motor cable is short (a few metres), the rise time and peak voltage are lower.
If the motor cable is long (100 m), the rise time and peak voltage are higher.

In motors without phase insulation paper or other insulation reinforcement suitable for operation with voltage supply (such as a frequency converter), fit a du/dt filter or a sine-wave filter on the output of the frequency converter.

Peak voltage on the motor terminals is caused by the switching of the IGBTs. The FC 300 complies with the demands of IEC 60034-25 regarding motors designed to be controlled by frequency converters. The FC 300 also complies with IEC 60034-17 regarding Norm motors controlled by frequency converters
Measured values from lab tests:

Cable length	1.5 kW, 400 V		4.0 kW, 400 V		7.5 kW, 400 V	
	U_{peak}[V]	du/dt V/μs	U_{peak}[V]	du/dt V/μs	U_{peak}[V]	du/dt V/μs
5	690	1329	890	4156	739	8035
50	985	985	180	2564	1040	4548
150[1)]	1045	947	1190	1770	1030	2828

1) FC 302 only

4

4.8. Special Conditions

4.8.1. Purpose of derating

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

4.8.2. Derating for Ambient Temperature

The average temperature ($T_{AMB, AVG}$) measured over 24 hours must be at least 5 °C lower than the maximum allowed ambient temperature ($T_{AMB,MAX}$).

If the frequency converter is operated at high ambient temperatures, the continuous output current should be decreased.

The derating depends on the switching pattern, which can be set to 60 PWM or SFAVM in par. 14-00.

A enclosures

60 PWM - Pulse Width Modulation

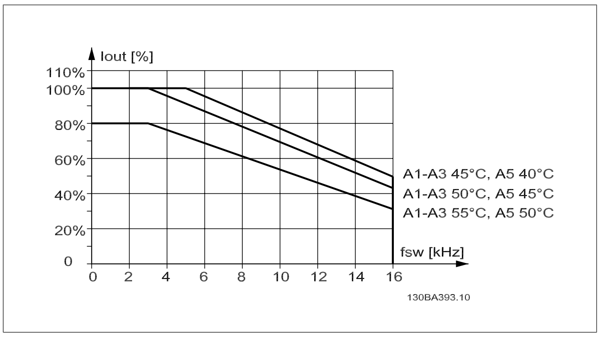


Illustration 4.1: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure A, using 60 PWM

SFAVM - Stator Frequency Asyncron Vector Modulation

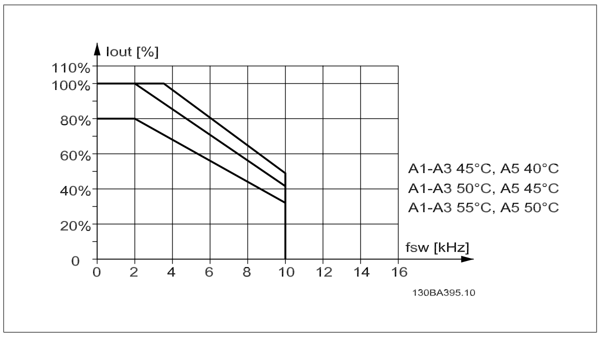


Illustration 4.2: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure A, using SFAVM

When using only 10 m motor cable or less in frame size A, less derating is necessary. This is due to the fact that the length of the motor cable has a relatively high impact on the recommended derating.

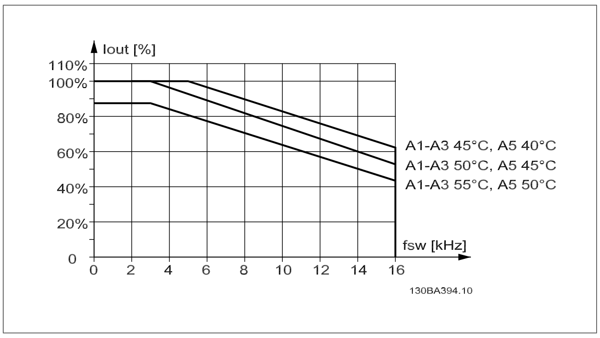


Illustration 4.3: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure A, using 60 PWM and maximum 10 m motor cable

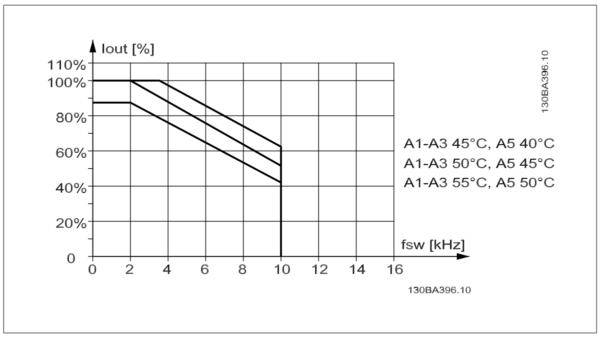


Illustration 4.4: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure A, using SFAVM and maximum 10 m motor cable

B enclosures

For the B and C enclosures the derating also depends on the overload mode selected in par. 1-04

60 PWM - Pulse Width Modulation

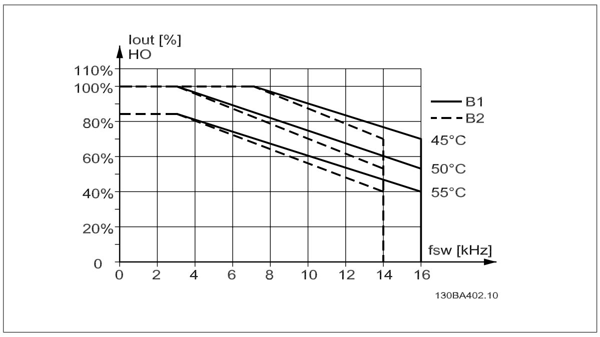


Illustration 4.5: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure B, using 60 PWM in High torque mode (160% over torque)

SFAVM - Stator Frequency Asyncron Vector Modulation

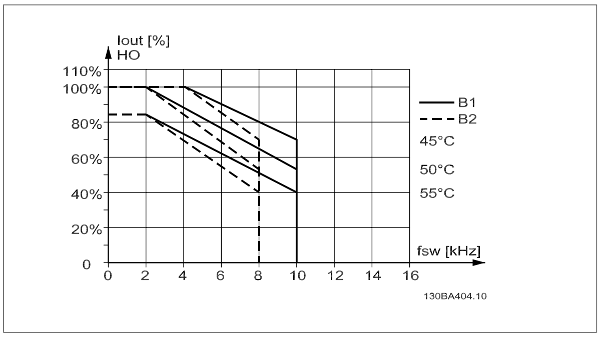


Illustration 4.6: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure B, using SFAVM in High torque mode (160% over torque)

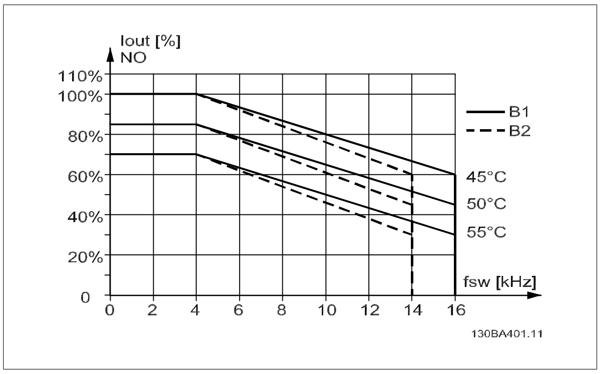


Illustration 4.7: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure B, using 60 PWM in Normal torque mode (110% over torque)

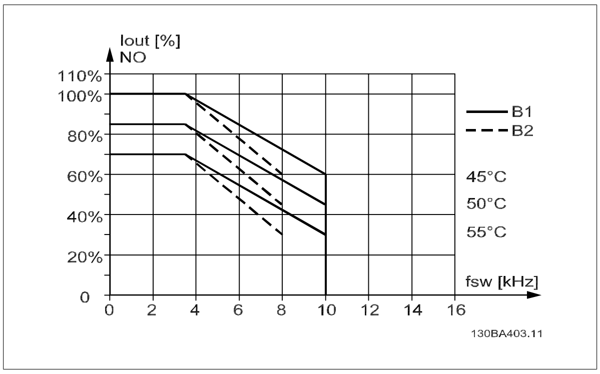


Illustration 4.8: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure B, using SFAVM in Normal torque mode (110% over torque)

C enclosures

60 PWM - Pulse Width Modulation

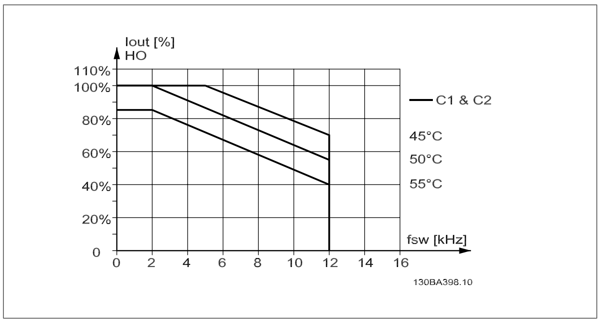


Illustration 4.9: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure C, using 60 PWM in High torque mode (160% over torque)

SFAVM - Stator Frequency Asyncron Vector Modulation

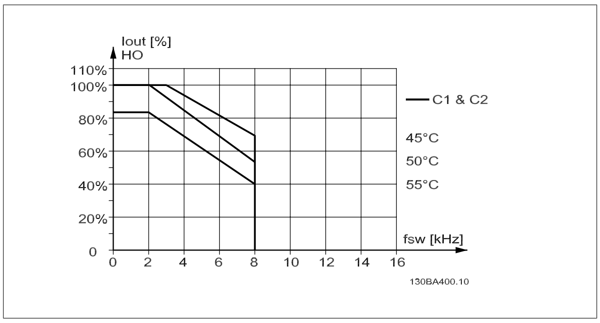


Illustration 4.10: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure C, using SFAVM in High torque mode (160% over torque)

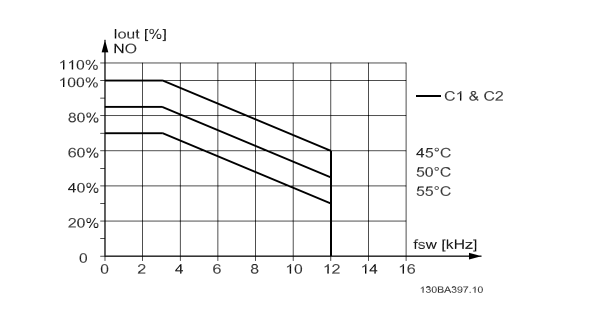


Illustration 4.11: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure C, using 60 PWM in Normal torque mode (110% over torque)

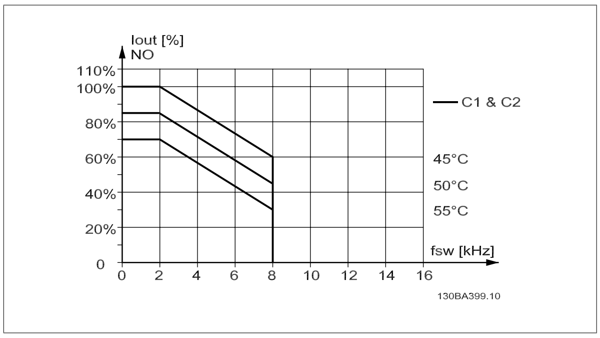


Illustration 4.12: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure C, using SFAVM in Normal torque mode (110% over torque)

D enclosures

60 PWM - Pulse Width Modulation, 380 - 500 V

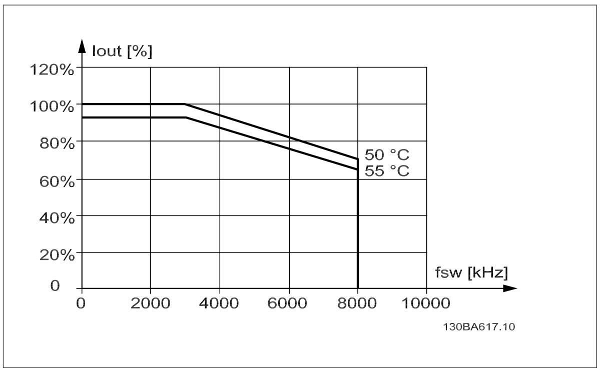


Illustration 4.13: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure D at 500 V, using 60 PWM in High torque mode (160% over torque)

SFAVM - Stator Frequency Asyncron Vector Modulation, 380 - 500 V

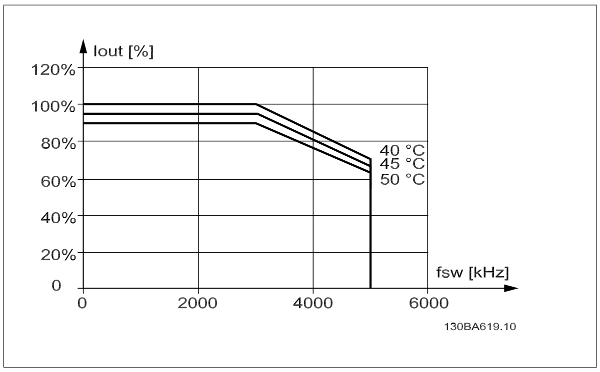


Illustration 4.14: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure D at 500 V, using SFAVM in High torque mode (160% over torque)

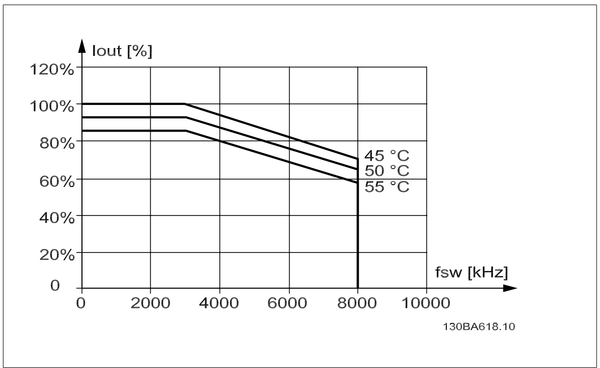


Illustration 4.15: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure D at 500 V, using 60 PWM in Normal torque mode (110% over torque)

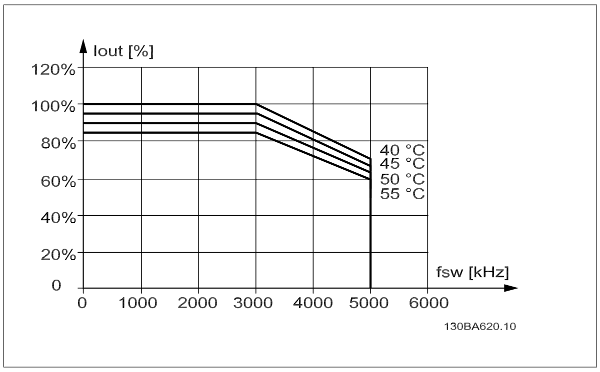


Illustration 4.16: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure D at 500 V, using SFAVM in Normal torque mode (110% over torque)

60 PWM - Pulse Width Modulation, 525 - 690 V (except P315)

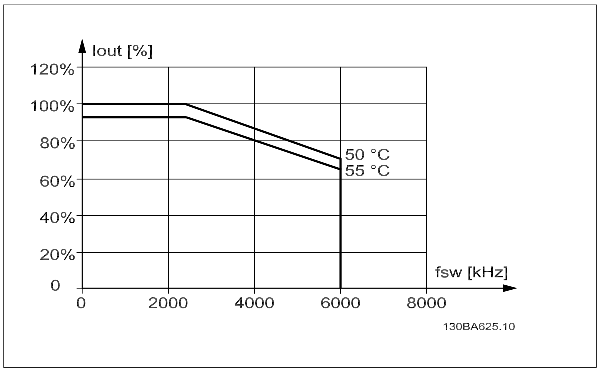


Illustration 4.17: Derating of I_{out} for different $T_{AMB,\ MAX}$ for enclosure D at 690 V, using 60 PWM in High torque mode (160% over torque). Note: *not* valid for P315.

SFAVM - Stator Frequency Asyncron Vector Modulation, 525 - 690 V (except P315)

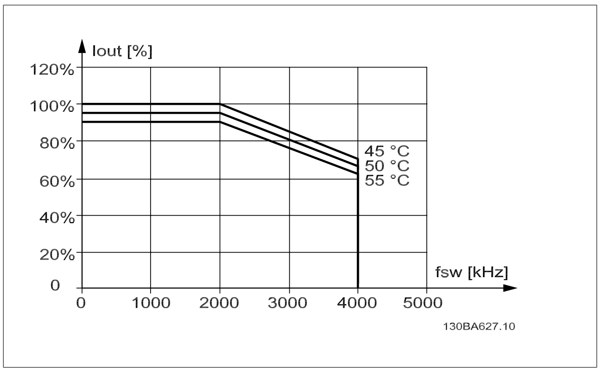


Illustration 4.18: Derating of I_{out} for different $T_{AMB,\ MAX}$ for enclosure D at 690 V, using SFAVM in High torque mode (160% over torque). Note: *not* valid for P315.

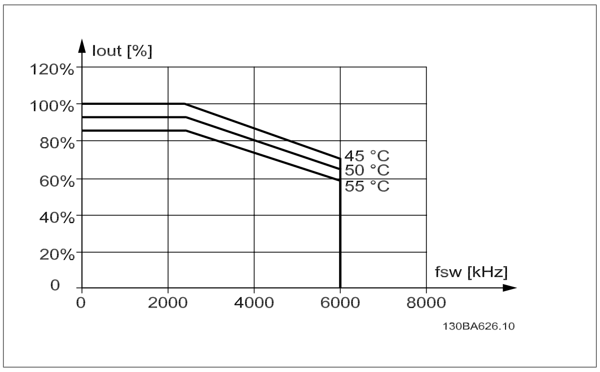


Illustration 4.19: Derating of I_{out} for different $T_{AMB,\ MAX}$ for enclosure D at 690 V, using 60 PWM in Normal torque mode (110% over torque). Note: *not* valid for P315.

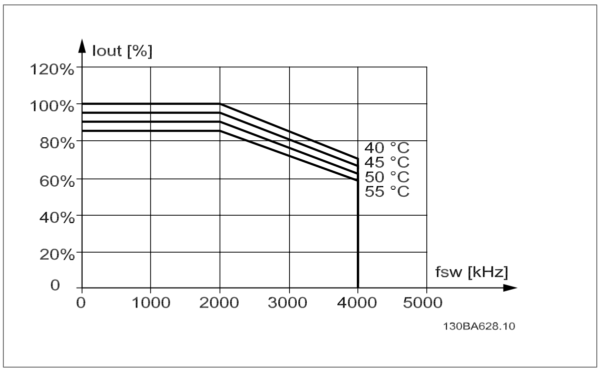


Illustration 4.20: Derating of I_{out} for different $T_{AMB,\ MAX}$ for enclosure D at 690 V, using SFAVM in Normal torque mode (110% over torque). Note: *not* valid for P315.

60 PWM - Pulse Width Modulation, 525 - 690 V, P315

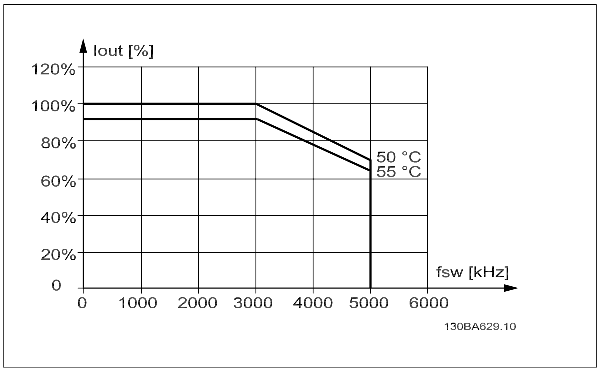


Illustration 4.21: Derating of I_{out} for different $T_{AMB,\ MAX}$ for enclosure D at 690 V, using 60 PWM in High torque mode (160% over torque). Note: P315 *only*.

SFAVM - Stator Frequency Asyncron Vector Modulation, 525 - 690 V, P315

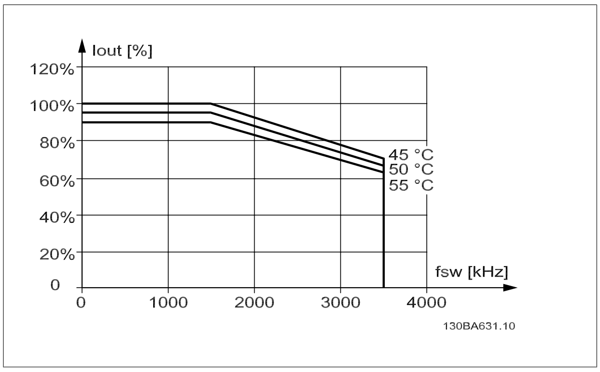


Illustration 4.22: Derating of I_{out} for different $T_{AMB,\ MAX}$ for enclosure D at 690 V, using SFAVM in High torque mode (160% over torque). Note: P315 *only*.

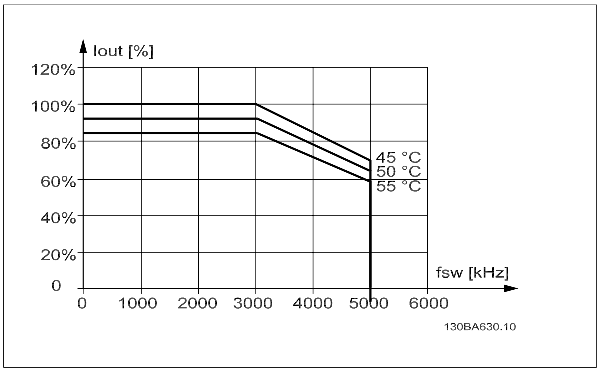


Illustration 4.23: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure D at 690 V, using 60 PWM in Normal torque mode (110% over torque). Note: P315 *only*.

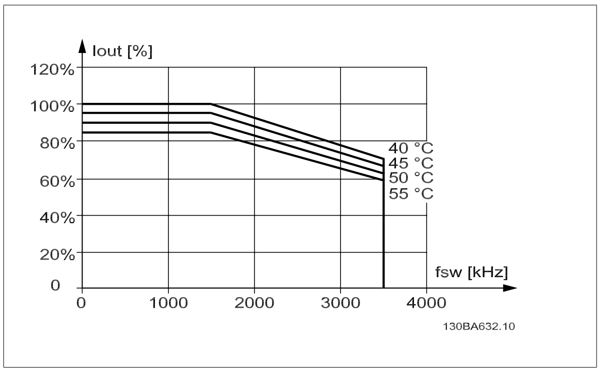


Illustration 4.24: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure D at 690 V, using SFAVM in Normal torque mode (110% over torque). Note: P315 *only*.

E enclosures

60 PWM - Pulse Width Modulation, 380 - 500 V

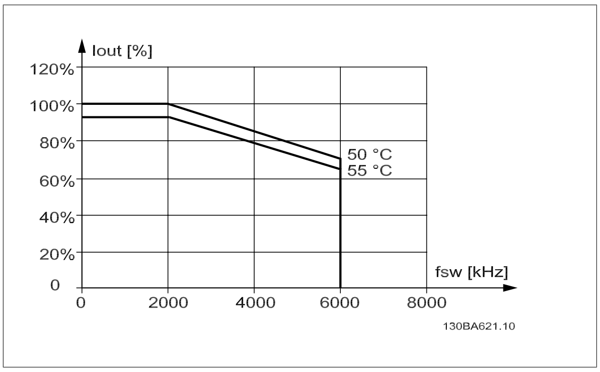


Illustration 4.25: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure E at 500 V, using 60 PWM in High torque mode (160% over torque)

SFAVM - Stator Frequency Asyncron Vector Modulation, 380 - 500 V

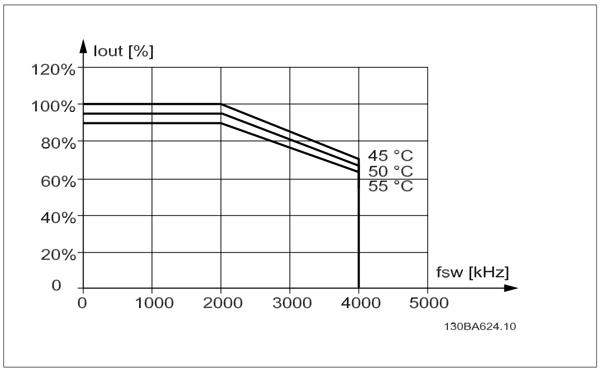


Illustration 4.26: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure E at 500 V, using SFAVM in High torque mode (160% over torque).

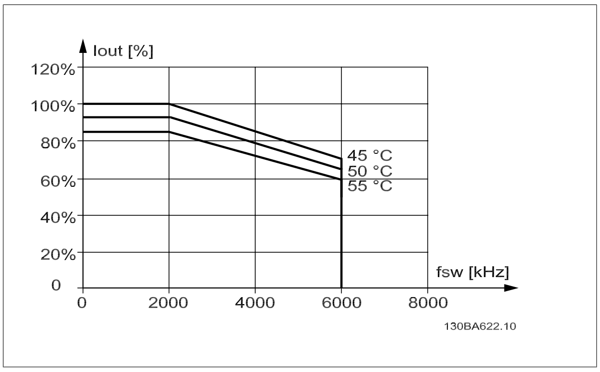


Illustration 4.27: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure E at 500 V, using 60 PWM in Normal torque mode (110% over torque)

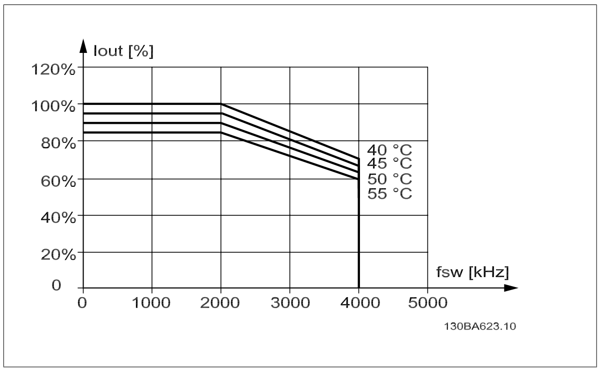


Illustration 4.28: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure E at 500 V, using SFAVM in Normal torque mode (110% over torque)

60 PWM - Pulse Width Modulation, 525 - 690 V

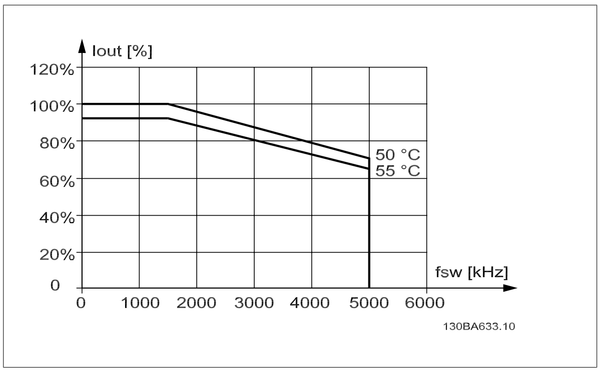


Illustration 4.29: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure E at 690 V, using 60 PWM in High torque mode (160% over torque).

SFAVM - Stator Frequency Asyncron Vector Modulation, 525 - 690 V

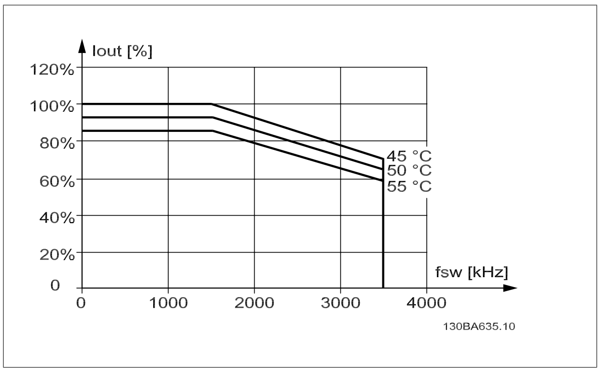


Illustration 4.30: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure E at 690 V, using SFAVM in High torque mode (160% over torque).

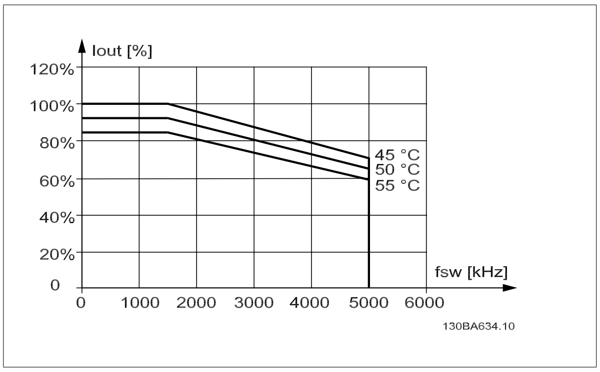


Illustration 4.31: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure E at 690 V, using 60 PWM in Normal torque mode (110% over torque).

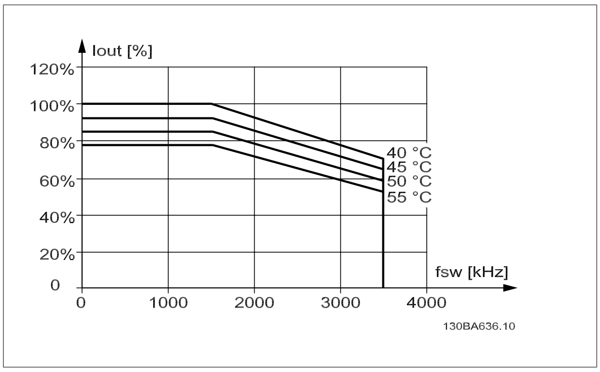


Illustration 4.32: Derating of I_{out} for different $T_{AMB, MAX}$ for enclosure E at 690 V, using SFAVM in Normal torque mode (110% over torque).

4.8.3. Derating for Low Air Pressure

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

Below 1000 m altitude no derating is necessary but above 1000 m the ambient temperature (T_{AMB}) or max. output current (I_{out}) should be derated in accordance with the shown diagram.

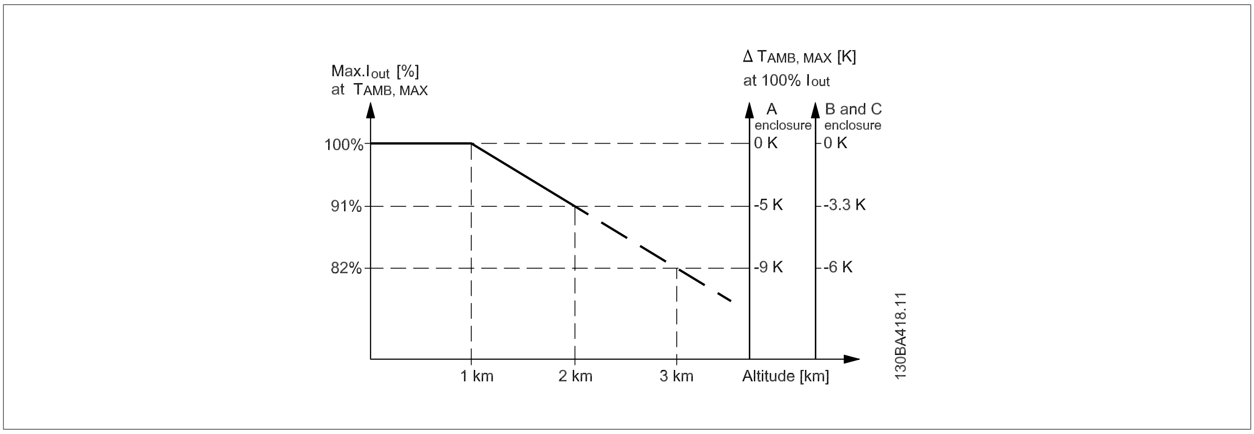


Illustration 4.33: Derating of output current versus altitude at $T_{AMB, MAX}$. By altitudes above 2 km, please contact Danfoss Drives regarding PELV.

An alternative is to lower the ambient temperature at high altitudes and thereby ensure 100% output current at high altitudes. As an example of how to read the graph, the situation at 2 km is elaborated. At a temperature of 45° C ($T_{AMB, MAX}$ - 3.3 K), 91% of the rated output current is available. At a temperature of 41.7° C, 100% of the rated output current is available.

4.8.4. Derating for Running at Low Speed

When a motor is connected to a frequency converter, it is necessary to check that the cooling of the motor is adequate.
A problem may occur at low RPM values in constant torque applications. The motor fan may not be able to supply the required volume of air for cooling and this limits the torque that can be supported. Therefore, if the motor is to be run continuously at an RPM value lower than half of the rated value, the motor must be supplied with additional air-cooling (or a motor designed for this type of operation may be used).

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

4.8.5. Derating for Installing Long Motor Cables or Cables with Larger Cross-Section

The maximum cable length for FC 301 is 75 m unscreened and 50 m screened cable. For FC302 it is 300 m unscreened and 150 m screened

The frequency converter has been designed to work using a motor cable with a rated cross-section. If a cable with a larger cross-section is used, reduce the output current by 5% for every step the cross-section is increased.
(Increased cable cross-section leads to increased capacity to earth, and thus an increased earth leakage current).

4.8.6. Automatic adaptations to ensure performance

The frequency converter constantly checks for critical levels of internal temperature, load current, high voltage on the intermediate circuit and low motor speeds. As a response to a critical level, the frequency converter can adjust the switching frequency and/ or change the switching pattern in order to ensure the performance of the drive.

5

5. How to Order

5.1.1. Drive Configurator

It is possible to design an FC 300 frequency converter according to the application requirements by using the ordering number system.

For the FC 300 Series, you can order standard drives and drives with integral options by sending a type code string describing the product to the local Danfoss sales office, i.e.:

FC-312PK75T5E20H1BGCXXXSXXXXA0BXCXXXXD0

The meaning of the characters in the string can be located in the pages containing the ordering numbers in the chapter *How to Select Your VLT*. In the example above, a Profibus DP V1 and a 24 V back-up option is included in the drive.

Ordering numbers for FC 300 standard variants can also be located in the chapter *FC 300 Selection*.

From the Internet based Drive Configurator, you can configure the right drive for the right application and generate the type code string. The Drive Configurator will automatically generate an eight-digit sales number to be delivered to your local sales office.
Furthermore, you can establish a project list with several products and send it to a Danfoss sales representative.

The Drive Configurator can be found on the global Internet site: www.danfoss.com/drives.

Drives will automatically be delivered with a language package relevant to the region from which it is ordered. Four regional language packages cover the following languages:
Language package 1
English, German, French, Danish, Dutch, Spanish, Swedish, Italian and Finnish.
Language package 2
English, German, Chinese, Korean, Japanese, Thai, Traditional Chinese and Bahasa Indonesian.
Language package 3
English, German, Slovenian, Bulgarian, Serbian, Romanian, Hungarian, Czech and Russian.
Language package 4
English, German, Spanish, English US, Greek, Brazilian Portuguese, Turkish and Polish.
To order drives with a different language package, please contact your local sales office.

5

5.1.2. Ordering Form Type Code

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
F	C	-		0		P				T					H						X	X	S	X	X	X	X	A		B		C					D	

130BA052.14

Product groups	1-3	
VLT series	4-6	
Power rating	8-10	
Phases	11	
Mains Voltage	12	
Enclosure	13-15	
Enclosure type		
Enclosure class		
Control supply voltage		
Hardware configuration		
RFI filter	16-17	
Brake	18	
Display (LCP)	19	
Coating PCB	20	
Mains option	21	
Adaptation A	22	
Adaptation B	23	
Software release	24-27	
Software language	28	
A options	29-30	
B options	31-32	
C0 options, MCO	33-34	
C1 options	**35**	
C option software	**36-37**	
D options	**38-39**	

Description	Pos	Possible choice
Product group	1-3	FC 30x
Drive series	4-6	FC 301 FC 302
Power rating	8-10	0.25-560 kW
Phases	11	Three phases (T)
Mains voltage	11-12	T 2: 200-240 V AC T 4: 380-480 V AC T 5: 380-500 V AC T 6: 525-600 V AC T 7: 525-690 V AC
Enclosure	13-15	E00: IP00/ Chassis C00: IP00/ Chassis Corrosion resistant E0D: IP00/ Chassis, D enclosure C0D: IP00/ Chassis Corrosion resistant, D enclosure E20: IP20 E2D: IP 21/NEMA Type 1, D1 enclosure E54: IP 54/NEMA Type 12 E55: IP 55/NEMA Type 12 E5D: IP00/ Chassis, D enclosure P20: IP20 (with back plate) P21: IP21/ NEMA Type 1 (with back plate) P55: IP55/ NEMA Type 12 (with back plate) Z20: IP 20[1)] E66: IP 66
RFI filter	16-17	H1: RFI filter class A1/B1 H2: No RFI filter, observes class A2 H3: RFI filter class A1/B1[1)] H4: RFI filter class A1[2)] H6: RFI filter Maritime use[1)] HX: No filter (600 V only)
Brake	18	B: Brake chopper included X: No brake chopper included T: Safe Stop No brake[1)] U: Safe stop brake chopper[1)]
Display	19	G: Graphical Local Control Panel (LCP) N: Numerical Local Control Panel (LCP) X: No Local Control Panel
Coating PCB	20	C: Coated PCB X. No coated PCB
Mains option	21	X: No mains option 1: Mains disconnect 3: Mains disconnect and Fuse[3)] 5: Mains disconnect, Fuse and Load sharing[3, 4)] 7: Fuse[3)] 8: Mains disconnect and Load sharing[4)] A: Fuse and Load sharing [3, 4)] D: Load sharing [4)]
Adaptation	22	Reserved
Adaptation	23	Reserved
Software release	24-27	Actual software
Software language	28	

Description	Pos	Possible choice
A options	29-30	AX: No A option A0: MCA 101 Profibus DP V1 (standard) A1: MCA 101 Profibus DP V1 (with top-entry) A4: MCA 104 DeviceNet (standard) A4: MCA 104 DeviceNet (with top-entry) A6: MCA 105 CANOpen (standard) A6: MCA 105 CANOpen (with top-entry) AN: MCA 121 Ethernet IP AT: MCA 113 Profibus converter VLT3000 AY: MCA 123 Ethernet PowerLink
B options	31-32	BX: No option BK: MCB 101 General purpose I/O option BR: MCB 102 Encoder option BU: MCB 103 Resolver option BP: MCB 105 Relay option BZ: MCB 108 Safety PLC Interface B2: MCB 112 PTC Thermistor Card
C0 options	33-34	CX: No option C4: MCO 305, Programmable Motion Controller.
C1 options	35	X: No option R: MCB 113 Ext. Relay Card
C option software	36-37	XX: Standard controller 10: MCO 350 Synchronizing control 11: MCO 351 Positioning control 12: MCO 352 Center winder
D options	38-39	DX: No option D0: DC back-up D0: MCB 107 Ext. 24 V back-up

1): FC 301/ A1 enclosure only

2): Power sizes ≥ 90 kW only

3) US Market only

4): Power sizes ≥ 11 kW only

Not all choices/options are available for each FC 301/FC 302 variant. To verify if the appropriate version is available, please consult the Drive Configurator on the Internet.

5

5.2.1. Ordering Numbers: Options and Accessories

Type	Description	Ordering no.	
Miscellaneous hardware			
DC link connector	Terminal block for DC link connection on frame size A2/A3	130B1064	
IP 21/4X top/TYPE 1 kit	Enclosure, frame size A1: IP21/IP 4X Top/TYPE 1	130B1121	
IP 21/4X top/TYPE 1 kit	Enclosure, frame size A2: IP21/IP 4X Top/TYPE 1	130B1122	
IP 21/4X top/TYPE 1 kit	Enclosure, frame size A3: IP21/IP 4X Top/TYPE 1	130B1123	
MCF 101 IP21 Kit	IP21/NEMA 1 enclosure Top Cover A2	130B1132	
MCF 101 IP21 Kit	IP21/NEMA 1 enclosure Top Cover A3	130B1133	
MCF 108 Backplate	A5 IP55/ NEMA 12	130B1098	
MCF 108 Backplate	B1 IP21/ IP55/ NEMA 12	130B3383	
MCF 108 Backplate	B2 IP21/ IP55/ NEMA 12	130B3397	
MCF 108 Backplate	C1 IP21/ IP55/ NEMA 12	130B3910	
MCF 108 Backplate	C2 IP21/ IP55/ NEMA 12	130B3911	
MCF 108 Backplate	A5 IP66/ NEMA 4x Stainless steel	130B3242	
MCF 108 Backplate	B1 IP66/ NEMA 4x Stainless steel	130B3434	
MCF 108 Backplate	B2 IP66/ NEMA 4x Stainless steel	130B3465	
MCF 108 Backplate	C1 IP66/ NEMA 4x Stainless steel	130B3468	
MCF 108 Backplate	C2 IP66/ NEMA 4x Stainless steel	130B3491	
Profibus D-Sub 9	D-Sub connector kit for IP20, frame sizes A1, A2 and A3	130B1112	
Profibus screen plate	Profibus screen plate kit for IP20, frame sizes A1, A2 and A3	130B0524	
Terminal blocks	Screw terminal blocks for replacing spring loaded terminals 1 pc 10 pin 1 pc 6 pin and 1 pc 3 pin connectors	130B1116	
USB Cable Extension for A5/ B1		130B1155	
USB Cable Extension for B2/ C1/ C2		130B1156	
Footmount frame for flat pack resistors, frame size A2		175U0085	
Footmount frame for flat pack resistors, frame size A3		175U0088	
Footmount frame for 2 flat pack resistors, frame size A2		175U0087	
Footmount frame for 2 flat pack resistors, frame size A3		175U0086	
LCP			
LCP 101	Numerical Local Control Panel (NLCP)	130B1124	
LCP 102	Graphical Local Control Panel (GLCP)	130B1107	
LCP cable	Separate LCP cable, 3 m	175Z0929	
LCP kit, IP21	Panel mounting kit including graphical LCP, fasteners, 3 m cable and gasket	130B1113	
LCP kit, IP21	Panel mounting kit including numerical LCP, fasteners and gasket	130B1114	
LCP kit, IP21	Panel mounting kit for all LCPs including fasteners, 3 m cable and gasket	130B1117	
Options for Slot A		**Uncoated**	**Coated**
MCA 101	Profibus option DP V0/V1	130B1100	130B1200
MCA 104	DeviceNet option	130B1102	130B1202
MCA 105	CANopen	130B1103	130B1205
MCA 113	Profibus VLT3000 protocol converter	130B1245	
Options for Slot B			
MCB 101	General purpose Input Output option	130B1125	130B1212
MCB 102	Encoder option	130B1115	130B1203
MCB 103	Resolver option	130B1127	130B1227
MCB 105	Relay option	130B1110	130B1210
MCB 108	Safety PLC interface (DC/DC Converter)	130B1120	130B1220
MCB 112	ATEX PTC Thermistor Card		130B1137
Options for Slot C			
MCO 305	Programmable Motion Controller	130B1134	130B1234
MCO 350	Synchronizing controller	130B1152	130B1252
MCO 351	Positioning controller	130B1153	120B1253
MCO 352	Center Winder Controller	130B1165	130B1166
Mounting kit for frame size A2 and A3		130B7530	-
Mounting kit for frame size A5		130B7532	-
Mounting kit for frame size B and C		130B7533	-
Option for Slot D			
MCB 107	24 V DC back-up	130B1108	130B1208
External Options			
Ethernet IP	Ethernet master	175N2584	-
PC Software			
MCT 10	MCT 10 set-up software - 1 user	130B1000	
MCT 10	MCT 10 set-up software - 5 users	130B1001	
MCT 10	MCT 10 set-up software - 10 users	130B1002	
MCT 10	MCT 10 set-up software - 25 users	130B1003	
MCT 10	MCT 10 set-up software - 50 users	130B1004	
MCT 10	MCT 10 set-up software - 100 users	130B1005	
MCT 10	MCT 10 set-up software - unlimited users	130B1006	

Options can be ordered as factory built-in options, see ordering information. For information on fieldbus and application option combatibility with older software versions, please contact your Danfoss supplier.

Type	Description	Ordering no.	
Spare Parts			
Control board FC 302	Coated version	-	130B1109
Control board FC 301	Coated version	-	130B1126
Fan A2	Fan, frame size A2	130B1009	-
Fan A3	Fan, frame size A3	130B1010	-
Fan option C		130B7534	-
Backplate A5	Backplate A5 enclosures for	130B1098	
Connectors FC 300 Profibus	10 pieces Profibus connectors	130B1075	
Connectors FC 300 DeviceNet	10 pieces DeviceNet connectors	130B1074	
Connectors FC 302 10 pole	10 pieces 10 pole spring loaded connectors	130B1073	
Connectors FC 301 8 pole	10 pieces 8 pole spring loaded connectors	130B1072	
Connectors FC 300 5 pole	10 pieces 5 pole spring loaded connectors	130B1071	
Connectors FC 300 RS485	10 pieces 3 pole spring loaded connectors for RS 485	130B1070	
Connectors FC 300 3 pole	10 pieces 3 pole connectors for relay 01	130B1069	
Connectors FC 302 3 pole	10 pieces 3 pole connectors for relay 02	130B1068	
Connectors FC 300 Mains	10 pieces mains connectors IP20/21	130B1067	
Connectors FC 300 Mains	10 pieces mains connctors IP 55	130B1066	
Connectors FC 300 Motor	10 pieces motor connectors	130B1065	
Connectors FC 300 Brake DC bus	10 pieces brake/load sharing connectors	130B1073	
Accessory bag A1	Accessory bag, frame size A1	130B1021	
Accessory bag A5	Accessory bag, frame size A5 (IP55)	130B1023	
Accessory bag A2	Accessory bag, frame size A2/A3	130B1022	
Accessory bag B1	Accessory bag, frame size B1	130B2060	
Accessory bag B2	Accessory bag, frame size B2	130B2061	
Accessory bag MCO 305		130B7535	

5

Ordering Numbers: Brake Resistors
Mains 200-240 V

			FC 301/302										Max. torque load [%][b]	
			Selected resistor											
			Standard IP 20							Aluminium Housed (Flatpack) IP65				
				Duty Cycle 10%			Duty Cycle 40%							
FC 301/ FC 302	P_{motor}	R_{min}	$R_{br,nom}$ [c]	R_{rec}	$P_{br\ max}$	Order no.	R_{rec}	$P_{br\ max}$	Order no.	R_{rec} per item	Duty cycle	Order no.	FC 301	FC 302
	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[Ω]	[kW]	175Uxxxx	[Ω]	%	175Uxxxx		
PK25	0.25	420	466.7	425	0.095	1841	425	0.430	1941	430Ω/100W	40	1002	145	160
PK37	0.37	284	315.3	310	0.250	1842	310	0.800	1942	330Ω/100W	27	1003	145	160
PK37	0.37	284	315.3	310	0.250	1842	310	0.800	1942	310Ω/200W	55	0984	145	160
PK55	0.55	190	211.0	210	0.285	1843	210	1.350	1943	220Ω/100W	20	1004	145	160
PK55	0.55	190	211.0	210	0.285	1843	210	1.350	1943	210Ω/200W	37	0987	145	160
PK75	0.75	139	154.0	145	0.065	1820	145	0.260	1920	150Ω/100W	14	1005	145	160
PK75	0.75	139	154.0	-	-	-	-	-	-	150Ω/200W	27	0989	145	160
P1K1	1.1	90	104.4	90	0.095	1821	90	0.430	1921	100Ω/100W	10	1006	145	160
P1K1	1.1	90	104.4	-	-	-	-	-	-	100Ω/200W	19	0991	145	160
P1K5	1.5	65	75.7	65	0.250	1822	65	0.800	1922	72Ω/200W	14	0992	145	160
P2K2	2.2	46	51.0	50	0.285	1823	50	1.00	1923	50Ω/200W	10	0993	145	160
P3K0	3	33	37.0	35	0.430	1824	35	1.35	1924	35Ω/200W	7	0994	145	160
P3K0	3	33	37.0	-	-	-	-	-	-	72Ω/200W	14	2X0992[a]	145	160
P3K7	3.7	25	29.6	25	0.800	1825	25	3.00	1925	60Ω/200W	11	2X0996[a]	145	160
P5K5	5.5	18	19.7	20	1	1826	20	3.5	1926	-	-	-	158	158
P7K5	7.5	13	14.3	15	2	1827	15	5	1927	-	-	-	153	153
P11K	11	9	9.6	10	2.8	1828	10	9	1928	-	-	-	154	154
P15K	15	6.3	7.0	7	4	1829	7	10	1929	-	-	-	150	150
P18K	18.5	5.3	5.7	6	4.8	1830	6	12.7	1930	-	-	-	150	150
P22K	22	4.2	5.0	4.7	6	1954	4.7	-	-	-	-	-	150	150
P30K	30	2.9	3.7	3.3	8	1955	3.3	-	-	-	-	-	150	150
P37K	37	2.4	3.0	2.7	10	1956	2.7	-	-	-	-	-	150	150

[a] Order two pieces, resistors must be connected in parallel.
[b] Max. load with the resistor in Danfoss standard program.
[c] $R_{br,nom}$ is the nominal (recommended) resistor value that ensures a brake power on motor shaft of 145% / 160% for 1 minute.

5

Ordering Numbers: Brake Resistors
Mains 380-500 V / 380-480 V

			FC 301/302											
			Selected resistor											
			Standard IP 20							Aluminium Housed (Flatpack) IP65			Max. torque load [%][b]	
			Duty Cycle 10%				Duty Cycle 40%							
FC 301/ FC 302	P_{motor}	R_{min}	$R_{br,nom}$ [c]	R_{rec}	$P_{br\ max}$	Order no.	R_{rec}	$P_{br\ max}$	Order no.	R_{rec} per item	Duty cycle	Order no.	FC 301	FC 302
	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[Ω]	[kW]	175Uxxxx	[Ω]	%	175Uxxxx		
PK37	0.37	620	1360.2	620	0.065	1840	830	0.450	1976	830Ω/100W	20	1000	137	160
PK55	0.55	620	915.0	620	0.065	1840	830	0.450	1976	830Ω/100W	20	1000	137	160
PK75	0.75	601	667.6	620	0.065	1840	620	0.260	1940	620Ω/100W	14	1001	137	160
PK75	0.75	601	667.6	-	-	-	-	-	-	620Ω/200W	40	0982	137	160
P1K1	1.1	408	452.8	425	0.095	1841	425	0.430	1941	430Ω/100W	8	1002	137	160
P1K1	1.1	408	452.8	-	-	-	-	-	-	430Ω/200W	20	0983	137	160
P1K5	1.5	297	330.4	310	0.250	1842	310	0.800	1942	310Ω/200W	16	0984	137	160
P2K2	2.2	200	222.6	210	0.285	1843	210	1.35	1943	210Ω/200W	9	0987	137	160
P3K0	3	145	161.4	150	0.430	1844	150	2.00	1944	150Ω/200W	5.5	0989	137	160
P3K0	3	145	161.4	-	-	-	-	-	-	300Ω/200W	12	2X0985[a]	137	160
P4K0	4	108	119.6	110	0.600	1845	110	2.40	1945	240Ω/200W	11	2X0986[a]	137	160
P5K5	5.5	77	86.0	80	0.850	1846	80	3.00	1946	160Ω/200W	6.5	2X0988[a]	137	160
P7K5	7.5	56	62.4	65	1.0	1847	65	4.50	1947	130Ω/200W	4	2X0990[a]	137	160
P11K	11	38	42.1	40	1.8	1848	40	5.00	1948	80Ω/240W	9	2X0090[a]	137	160
P15K	15	27	30.5	30	2.8	1849	30	9.30	1949	72Ω/240W	6	2X0091[a]	137	160
P18K	18.5	22	24.5	25	3.5	1850	25	12.70	1950					160
P22K	22	18	20.3	20	4.0	1851	20	13.00	1951					160
P30K	30	13.5	14.9	15	5.0	1852	15	16	1952					160
P37K	37	108	12.0	12	6.0	1853	12	19	1953					150
P45K	45	9.8	10.5	9.8	15	2008	9.8	38	2007					150
P55K	55	7.3	8.6	7.3	13	0069	7.3	38	0068					150
P75K	75	5.7	6.2	6.0	15	0067	6.0	45	0066					150
P90K	90	3.4	5.2	3.8	22	1960	3.8	75	0072					150
P110	110	2.9	4.2	3.2	27	1961	3.2	90	0073					150
P132	132	2.3	-	2.6	32	1962	-	-	-					150
P160	160	1.9	-	2.1	39	1963	-	-	-					150
P200	200	1.65	-	1.65	56	2x1061	-	-	-					150
P250	250	1.3	-	1.3	72	2x1062	1.3	-	2x1062					150
P315	315	1.3	-	1.3	-	2x1062	1.3	-	2x1062					150
P355	355	1.3	-	1.3	-	2x1062	1.3	-	2x1062					145
P400	400	1.3	-	1.3	-	2x1062	1.3	-	2x1062					130

[a] Order two pieces, resistors must be connected in parallel.
[b] Max. load with the resistor in Danfoss standard program.
[c] $R_{br,nom}$ is the nominal (recommended) resistor value that ensures a brake power on motor shaft of 137% / 160% for 1 minute.

5

5.2.2. Ordering Numbers: Harmonic Filters

Harmonic filters are used to reduce mains harmonics.

- AHF 010: 10% current distortion
- AHF 005: 5% current distortion

380-415V, 50Hz

$I_{AHF,N}$	Typical Motor Used [kW]	Danfoss ordering number		Frequency converter size
		AHF 005	AHF 010	
10 A	1.1 - 4	175G6600	175G6622	P1K1, P4K0
19 A	5.5 - 7.5	175G6601	175G6623	P5K5 - P7K5
26 A	11	175G6602	175G6624	P11K
35 A	15 - 18.5	175G6603	175G6625	P15K - P18K
43 A	22	175G6604	175G6626	P22K
72 A	30 - 37	175G6605	175G6627	P30K - P37K
101A	45 - 55	175G6606	175G6628	P45K - P55K
144 A	75	175G6607	175G6629	P75K
180 A	90	175G6608	175G6630	P90K
217 A	110	175G6609	175G6631	P110
289 A	132 - 160	175G6610	175G6632	P132 - P160
324 A		175G6611	175G6633	
370 A	200	175G6688	175G6691	P200
434 A	250	2x 175G6609	2x 175G6631	P250
578 A	315	2x 175G6610	2x 175G6632	P315
613 A	350	175G6610 + 175G6611	175G6632 + 175G6633	P350

440-480V, 60Hz

$I_{AHF,N}$	Typical Motor Used [HP]	Danfoss ordering number		Frequency converter size
		AHF 005	AHF 010	
19 A	7.5 - 15	175G6612	175G6634	P7K5 - P11K
26 A	20	175G6613	175G6635	P15K
35 A	25 - 30	175G6614	175G6636	P18K, P22K
43 A	40	175G6615	175G6637	P30K
72 A	50 - 60	175G6616	175G6638	P30K - P37K
101A	75	175G6617	175G6639	P45K - P55K
144 A	100 - 125	175G6618	175G6640	P75K - P90K
180 A	150	175G6619	175G6641	P110
217 A	200	175G6620	175G6642	P132
289 A	250	175G6621	175G6643	P160
324 A	300	175G6689	175G6692	P200
370 A	350	175G6690	175G6693	P250
506 A	450	175G6620 + 175G6621	175G6642 + 175G6643	P315
578 A	500	2x 175G6621	2x 175G6643	P355

Matching the frequency converter and filter is pre-calculated based on 400V/480V and on a typical motor load (4 pole) and 110 % torque.

500-525V, 50Hz

$I_{AHF,N}$	Typical Motor Used [kW]	Danfoss ordering number		Frequency converter size
		AHF 005	AHF 010	
10 A	1.1 - 5.5	175G6644	175G6656	P4K0 - P5K5
19 A	7.5 - 11	175G6645	175G6657	P7K5

690V, 50Hz

$I_{AHF,N}$	Typical Motor Used [kW]	Danfoss ordering number		Frequency converter size
		AHF 005	AHF 010	
144 A	110, 132	130B2333	130B2298	P110
180 A	160	130B2334	130B2299	P132
217 A	200	130B2335	130B2300	P160
289 A	250	130B2331+2333	130B2301	P200
324 A	315	130B2333+2334	130B2302	P250
370 A	400	130B2334+2335	130B2304	P315

5.2.3. Ordering Numbers:Sine Wave Filter Modules, 200-500 VAC

Mains supply 3 x 200 to 500 V

Frequency converter size			Minimum switching frequency	Maximum output frequency	Part No. IP20	Part No. IP00	Rated filter current at 50Hz
200-240V	**380-440V**	**440-500V**					
PK25	PK37	PK37	5 kHz	120 Hz	130B2439	130B2404	2.5 A
PK37	PK55	PK55	5 kHz	120 Hz	130B2439	130B2404	2.5 A
	PK75	PK75	5 kHz	120 Hz	130B2439	130B2404	2.5 A
PK55	P1K1	P1K1	5 kHz	120 Hz	130B2441	130B2406	4.5 A
	P1K5	P1K5	5 kHz	120 Hz	130B2441	130B2406	4.5 A
PK75	P2K2	P2K2	5 kHz	120 Hz	130B2443	130B2408	8 A
P1K1	P3K0	P3K0	5 kHz	120 Hz	130B2443	130B2408	8 A
P1K5			5 kHz	120 Hz	130B2443	130B2408	8 A
	P4K0	P4K0	5 kHz	120 Hz	130B2444	130B2409	10 A
P2K2	P5K5	P5K5	5 kHz	120 Hz	130B2446	130B2411	17 A
P3K0	P7K5	P7K5	5 kHz	120 Hz	130B2446	130B2411	17 A
P4K0			5 kHz	120 Hz	130B2446	130B2411	17 A
P5K5	P11K	P11K	4 kHz	60 Hz	130B2447	130B2412	24 A
P7K5	P15K	P15K	4 kHz	60 Hz	130B2448	130B2413	38 A
	P18K	P18K	4 kHz	60 Hz	130B2448	130B2413	38 A
P11K	P22K	P22K	4 kHz	60 Hz	130B2307	130B2281	48 A
P15K	P30K	P30K	3 kHz	60 Hz	130B2308	130B2282	62 A
P18K	P37K	P37K	3 kHz	60 Hz	130B2309	130B2283	75 A
P22K	P45K	P55K	3 kHz	60 Hz	130B2310	130B2284	115 A
P30K	P55K	P75K	3 kHz	60 Hz	130B2310	130B2284	115 A
P37K	P75K	P90K	3 kHz	60 Hz	130B2311	130B2285	180 A
P45K	P90K	P110	3 kHz	60 Hz	130B2311	130B2285	180 A
	P110	P132	3 kHz	60 Hz	130B2312	130B2286	260 A
	P132	P160	3 kHz	60 Hz	130B2312	130B2286	260 A
	P160	P200	3 kHz	60 Hz	130B2313	130B2287	410 A
	P200	P250	3 kHz	60 Hz	130B2313	130B2287	410 A
	P250	P315	3 kHz	60 Hz	130B2314	130B2288	480 A
	P315	P355	2 kHz	60 Hz	130B2315	130B2289	660 A
	P355	P400	2 kHz	60 Hz	130B2315	130B2289	660 A
	P400	P450	2 kHz	60 Hz	130B2316	130B2290	750 A
	P450	P500	2 kHz	60 Hz	130B2317	130B2291	880 A
	P500	P560	2 kHz	60 Hz	130B2317	130B2291	880 A
	P560	P630	2 kHz	60 Hz	130B2318	130B2292	1200 A
	P630	P710	2 kHz	60 Hz	130B2318	130B2292	1200 A

NB!

When using Sine-wave filters, the switching frequency should comply with filter specifications in *par. 14-01 Switching Frequency*.

5.2.4. Ordering Numbers:Sine-Wave Filter Modules, 525-600 VAC

Mains supply 3 x 525 to 690 V

Frequency converter size		Minimum switching frequency	Maximum output frequency	Part No. IP20	Part No. IP00	Rated filter current at 50Hz
525-600V	**600V**					
PK75		2 kHz	60 Hz	130B2341	130B2321	13 A
P1K1		2 kHz	60 Hz	130B2341	130B2321	13 A
P1K5		2 kHz	60 Hz	130B2341	130B2321	13 A
P2k2		2 kHz	60 Hz	130B2341	130B2321	13 A
P3K0		2 kHz	60 Hz	130B2341	130B2321	13 A
P4K0		2 kHz	60 Hz	130B2341	130B2321	13 A
P5K5		2 kHz	60 Hz	130B2341	130B2321	13 A
P7K5		2 kHz	60 Hz	130B2341	130B2321	13 A
	P11K	2 kHz	60 Hz	130B2342	130B2322	28 A
P11K	P15K	2 kHz	60 Hz	130B2342	130B2322	28 A
P15K	P18K	2 kHz	60 Hz	130B2342	130B2322	28 A
P18K	P22K	2 kHz	60 Hz	130B2342	130B2322	28 A
P22K	P30K	2 kHz	60 Hz	130B2343	130B2323	45 A
P30K	P37K	2 kHz	60 Hz	130B2343	130B2323	45 A
P37K	P45K	2 kHz	60 Hz	130B2344	130B2324	76 A
P45K	P55K	2 kHz	60 Hz	130B2344	130B2324	76 A
P55K	P75K	2 kHz	60 Hz	130B2345	130B2325	115 A
P75K	P90K	2 kHz	60 Hz	130B2345	130B2325	115 A
P90K	P110	2 kHz	60 Hz	130B2346	130B2326	165 A
P110	P132	2 kHz	60 Hz	130B2346	130B2326	165 A
P150	P160	2 kHz	60 Hz	130B2347	130B2327	260 A
P180	P200	2 kHz	60 Hz	130B2347	130B2327	260 A
P220	P250	2 kHz	60 Hz	130B2348	130B2329	303 A
P260	P315	1.5 kHz	60 Hz	130B2270	130B2241	430 A
P300	P400	1.5 kHz	60 Hz	130B2270	130B2241	430 A
P375	P500	1.5 kHz	60 Hz	130B2271	130B2242	530 A
P450	P560	1.5 kHz	60 Hz	130B2381	130B2337	660 A
P480	P630	1.5 kHz	60 Hz	130B2381	130B2337	660 A
P560	P710	1.5 kHz	60 Hz	130B2382	130B2338	765 A
P670	P800	1.5 kHz	60 Hz	130B2383	130B2339	940 A
	P900	1.5 kHz	60 Hz	130B2383	130B2339	940 A
P820	P1M0	1.5 kHz	60 Hz	130B2384	130B2340	1320 A
P970	P1M2	1.5 kHz	60 Hz	130B2384	130B2340	1320 A

NB!

When using Sine-wave filters, the switching frequency should comply with filter specifications in *par. 14-01 Switching Frequency.*

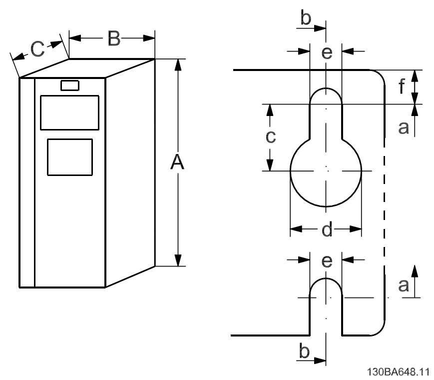
6. How to Install

Mechanical Dimensions, A enclosures

A1

A2/ A3

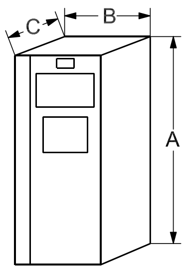
A5

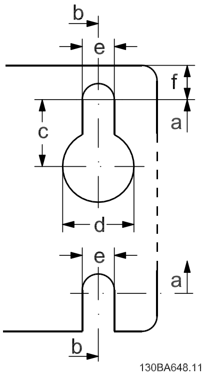


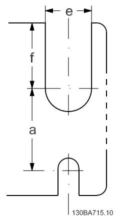
Frame size		**A1**	**A2**		**A3**		**A5**
		0.25–1.5 kW (200-240 V) 0.37-1.5 kW (380-480 V)	**0.25-3 kW (200-240 V) 0.37-4.0 kW (380-480/ 500 V) 0.75-4 kW (525-600 V)**		**3.7 kW (200-240 V) 5.5-7.5 kW (380-480/ 500 V) 5.5-7.5 kW (525-600 V)**		**0.25-3.7 kW (200-240 V) 0.37-7.5 kW (380-480/ 500 V) 0.75-7.5 kW (525-600 V)**
IP		20	20	21	20	21	55/66
NEMA		Chassis	Chassis	Type 1	Chassis	Type 1	Type 12
Height							
Height of back plate	A	200 mm	268 mm	375 mm	268 mm	375 mm	420 mm
Height with de-coupling plate	A	316 mm	374 mm		374 mm	-	-
Distance between mounting holes	a	190 mm	257 mm	350 mm	257 mm	350 mm	402 mm
Width							
Width of back plate	B	75 mm	90 mm	90 mm	130 mm	130 mm	242 mm
Width of back plate with one C option	B		130 mm	130 mm	170 mm	170 mm	242 mm
Width of back plate with two C options	B		150 mm	150 mm	190 mm	190 mm	242 mm
Distance between mounting holes	b	60 mm	70 mm	70 mm	110 mm	110 mm	215 mm
Depth							
Depth without option A/B	C	207 mm	205 mm	207 mm	205 mm	207 mm	195 mm
With option A/B	C	222 mm	220 mm	222 mm	220 mm	222 mm	195 mm
Screw holes							
	c	6.0 mm	8.0 mm	8.0 mm	8.0 mm	8.0 mm	8.25 mm
	d	ø8 mm	ø11 mm	ø11 mm	ø11 mm	ø11 mm	ø12 mm
	e	ø5 mm	ø5.5 mm	ø5.5 mm	ø5.5 mm	ø5.5 mm	ø6.5 mm
	f	5 mm	9 mm	9 mm	9 mm	9 mm	9 mm
Max weight		2.7 kg	4.9 kg	5.3 kg	6.6 kg	7.0 kg	13.5/14.2 kg

Mechanical Dimensions, B enclosures

B1/ B2	B3	B4

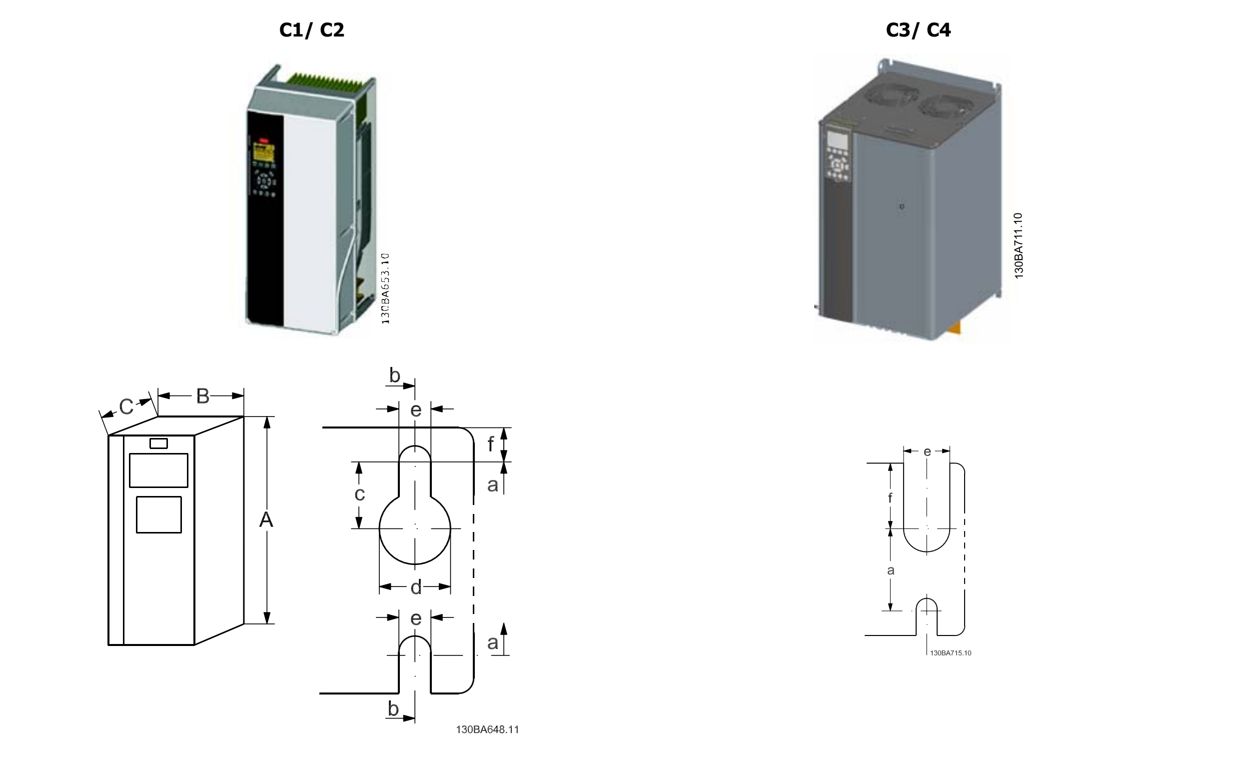






Frame size		**B1**	**B2**	**B3**	**B4**
		5.5-7.5 kW (200-240 V) 11-15 kW (380-480/500 V) 11-15 kW (525-600 V)	**11 kW (200-240 V) 18.5-22 kW (380-480/ 500 V) 18.5-22 kW (525-600 V)**	**5.5-7.5 kW (200-240 V) 11-15 kW (380-480/500 V) 11-15 kW (525-600 V)**	**11-15 kW (200-240 V) 18.5-30 kW (380-480/ 500 V) 18.5-30 kW (525-600 V)**
IP		21/ 55/66	21/55/66	20	20
NEMA		Type 1/Type 12	Type 1/Type 12	Chassis	Chassis
Height					
Height of back plate	A	480 mm	650 mm	399 mm	520 mm
Height with de-coupling plate	A	-	-	420 mm	595 mm
Distance between mounting holes	a	454 mm	624 mm	380 mm	495 mm
Width					
Width of back plate	B	242 mm	242 mm	165 mm	230 mm
Width of back plate with one C option	B	242 mm	242 mm	205 mm	230 mm
Width of back plate with two C options	B	242 mm	242 mm	225 mm	230 mm
Distance between mounting holes	b	210 mm	210 mm	140 mm	200 mm
Depth					
Depth without option A/B	C	260 mm	260 mm	249 mm	242 mm
With option A/B	C	260 mm	260 mm	262 mm	242 mm
Screw holes					
	c	12 mm	12 mm	8 mm	
	d	ø19 mm	ø19 mm	12 mm	
	e	ø9 mm	ø9 mm	6.8 mm	8.5 mm
	f	9 mm	9 mm	7.9 mm	15 mm
Max weight		23 kg	27 kg		23.5 kg

Mechanical Dimensions, C enclosures



Frame size		**C1**	**C2**	**C3**	**C4**
		15-22 kW (200-240 V) 30-45 kW (380-480/ 500 V) 30-45 kW (525-600 V)	**30-37 kW (200-240 V) 55-75 kW (380-480/ 500 V) 55-90 kW (525-600 V)**	**18.5-22 kW (200-240 V) 37-45 kW (380-480/ 500 V) 37-45 kW (525-600 V)**	**30-37 kW (200-240 V) 55-75 kW (380-480/ 500 V) 55-90 kW (525-600 V)**
IP NEMA		21/55/66 Type 1/Type 12	21/55/66 Type 1/Type 12	20 Chassis	20 Chassis
Height					
Height of back plate	A	680 mm	770 mm	550 mm	660 mm
Height with decoupling plate	A			630 mm	800 mm
Distance between mounting holes	a	648 mm	739 mm	521 mm	631 mm
Width					
Width of back plate	B	308 mm	370 mm	308 mm	370 mm
Width of back plate with one C option	B	308 mm	370 mm	308 mm	370 mm
Width of back plate with two C options	B	308 mm	370 mm	308 mm	370 mm
Distance between mounting holes	b	272 mm	334 mm	270 mm	330 mm
Depth					
Depth without option A/B	C	310 mm	335 mm	333 mm	333 mm
With option A/B	C	310 mm	335 mm	333 mm	333 mm
Screw holes					
	c	12 mm	12 mm		
	d	ø19 mm	ø19 mm		
	e	ø9.8 mm	ø9.8 mm	8.5 mm	8.5 mm
	f	17.6 mm	18 mm	17 mm	17 mm
Max weight		43 kg	61 kg	35 kg	50 kg

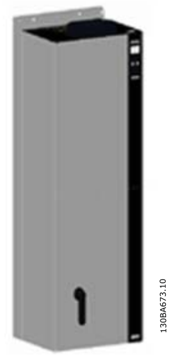
Mechanical Dimensions, D and E enclosures

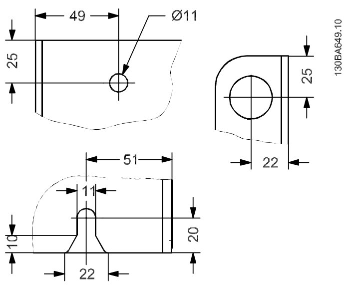
D1/ D2

D3/ D4

E1

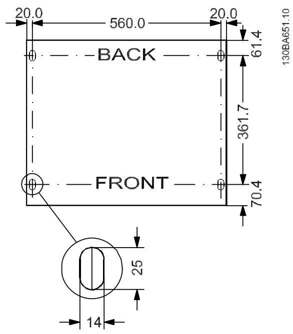
E2





Top left: Top mounting hole.

Lower: Bottom mounting hole.



Base plate mount.

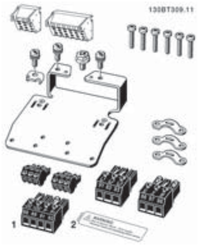
Frame size		D1	D2	D3	D4	E1	E2
		90 - 110 kW (380 - 500 V) 37 - 132 kW (525 - 690 V)	**132 - 200 kW (380 - 500 V) 160 - 315 kW (525 - 690 V)**	**90 - 110 kW (380 - 500 V) 37 - 132 kW (525 - 690 V)**	**132 - 200 kW (380 - 500 V) 160 - 315 kW (525 - 690 V)**	**250 - 400 kW (380 - 500 V) 355 - 560 kW (525 - 690 V)**	**250 - 400 kW (380 - 500 V) 355 - 560 kW (525 - 690 V)**
IP		21, 54	21, 54	00	00	21, 54	00
Nema		Type 1	Type 1	Chassis	Chassis	Type 1	Chassis
Card board box size Shipping dimensions	**Height**	650 mm	650 mm	650 mm	650 mm	840 mm	831 mm
	Width	1730 mm	1730 mm	1220 mm	1490 mm	2197 mm	1705 mm
	Depth	570 mm	570 mm	570 mm	570 mm	736 mm	736 mm
Drive dimensions	Height	1159 mm	1540 mm	997 mm	1277 mm	2000 mm	1499 mm
	Width	420 mm	420 mm	408 mm	408 mm	600 mm	585 mm
	Depth	373 mm	373 mm	373 mm	373 mm	494 mm	494 mm
	Max weight	104 kg	151 kg	91 kg	138 kg	313 kg	277 kg

6.2. Mechanical Installation - A, B and C Enclosures

NB!

This section describes the mechanical installation of A, B and C enclosures. The mechanical installation of larger drives is covered by a later section.

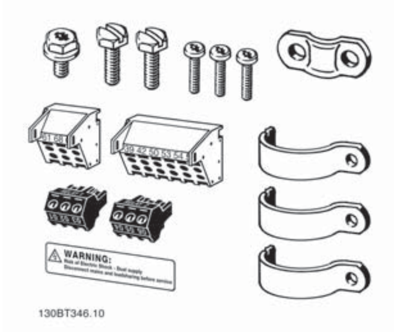
Accessory Bags: Find the following parts included in the frequency converter accessory bags



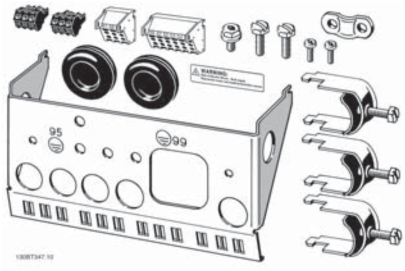
Frame sizes A1, A2 and A3, IP20/Chassis

Frame size A5, IP55/Type 12

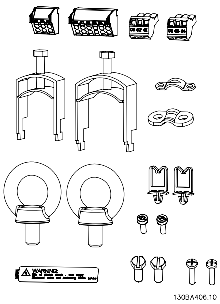
Frame sizes B1 and B2, IP21/IP55/Type 1/Type 12



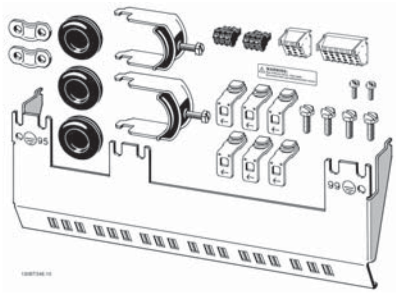
Frame size B3, IP20/Chassis



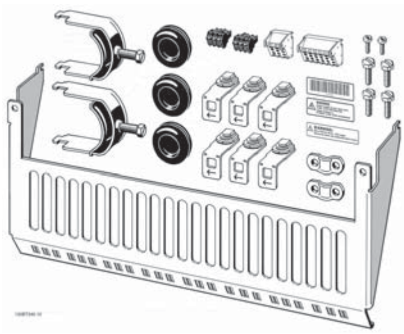
Frame size B4, IP20/Chassis



Frame sizes C1 and C2, IP55/66/Type 1/Type 12



Frame size C3, IP20/Chassis



Frame size C4, IP20/Chassis

1 + 2 only available in units with brake chopper. Only one relay connector is included for FC 301 units. For DC link connection (Load sharing) the connector 1 can be ordered separately (Code no. 130B1064)

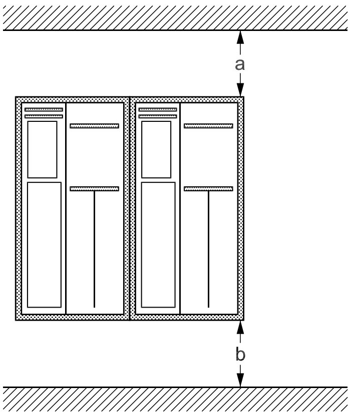
An eight pole connector is included in accessory bag for FC 301 without Safe Stop.

6.2.1. Mechanical mounting

All IP20 Frame sizes as well as IP21/ IP55 Frame sizes except A1*, A2 and A3 allow side-by-side installation.

If the IP 21 Enclosure kit (130B1122 or 130B1123) is used there must be a clearance between the drives of min. 50 mm.

For optimal cooling conditions allow a free air passage above and below the frequency converter. See table below.



Air passage for different enclosures

Enclo-sure:	A1*	A2	A3	A5	B1	B2	B3	B4	C1	C2	C3	C4
a (mm):	100	100	100	100	100	100	200	200	200	225	200	225
b (mm):	100	100	100	100	100	100	200	200	200	225	200	225

Table 6.1: * FC 301 only!

1. Drill holes in accordance with the measurements given.
2. You must provide screws suitable for the surface on which you want to mount the frequency converter. Retighten all four screws.

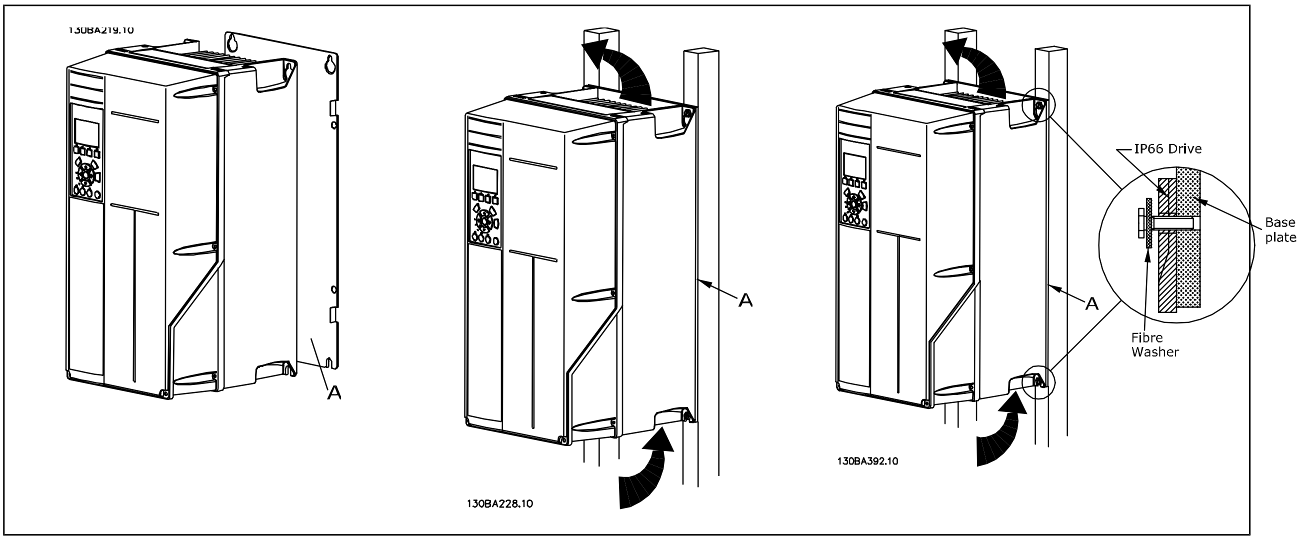


Table 6.2: Mounting frame sizes A5, B1, B2, B3, B4, C1, C2, C3 and C4 on a non-solid back wall, the drive must be provided with a back plate A due to insufficient cooling air over the heat sink.

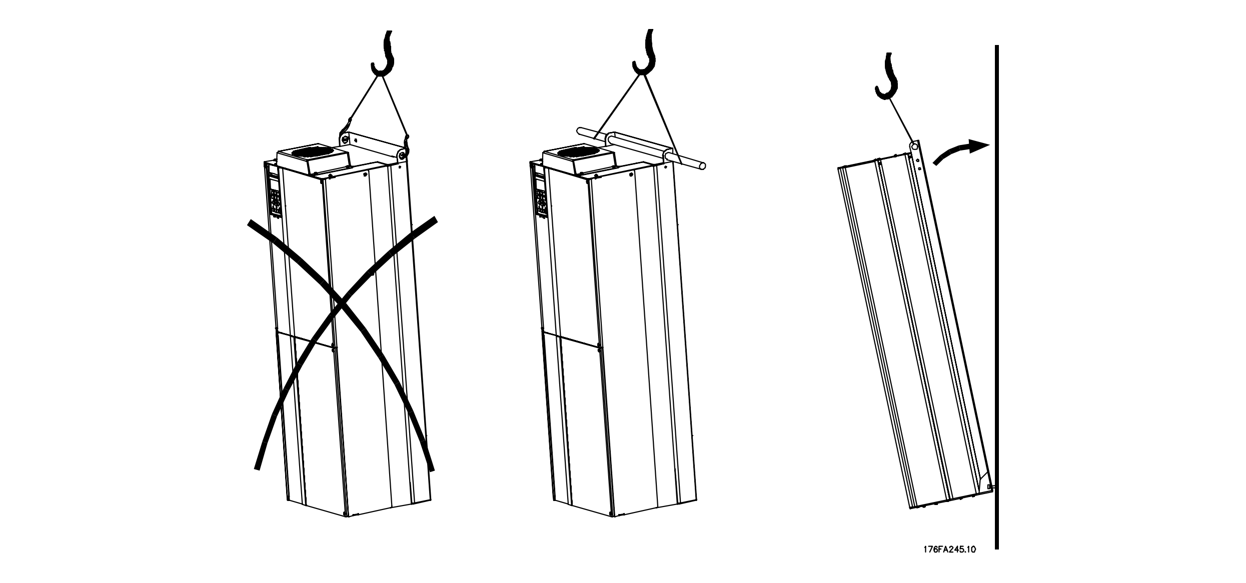


Illustration 6.1: With heavier drives, use a lift. First wall-mount the 2 lower bolts - then lift the drive onto the lower bolts - finally fasten the drive against the wall with the 2 top bolts.

6

6.2.2. Safety Requirements of Mechanical Installation

Pay attention to the requirements that apply to integration and field mounting kit. Observe the information in the list to avoid serious damage or injury, especially when installing large units.

The frequency converter is cooled by means of air circulation.
To protect the unit from overheating, it must be ensured that the ambient temperature *does not exceed the maximum temperature stated for the frequency converter* and that the 24-hour average temperature *is not exceeded*. Locate the maximum temperature and 24-hour average in the paragraph *Derating for Ambient Temperature*.
If the ambient temperature is in the range of 45 °C - 55 ° C, derating of the frequency converter will become relevant, see *Derating for Ambient Temperature*.
The service life of the frequency converter is reduced if derating for ambient temperature is not taken into account.

6.2.3. Field Mounting

For field mounting the IP 21/IP 4X top/TYPE 1 kits or IP 54/55 units are recommended.

6.3. Mechanical Installation - D and E Enclosures

NB!

This section describes the mechanical installation of D and E enclosures. The mechanical installation of smaller drives is covered by an earlier section.

Preparation of the mechanical installation of the frequency converter must be done carefully to ensure a proper result and to avoid additional work during installation. Start taking a close look at the mechanical drawings at the end of this instruction to become familiar with the space demands.

6.3.1. Tools Needed

To perform the mechanical installation the following tools are needed:

- Drill with 10 or 12 mm drill
- Tape measure
- Wrench with relevant metric sockets (7-17 mm)
- Extensions to wrench
- Sheet metal punch for conduits or cable glands in IP 21 and IP 54 units
- Lifting bar to lift the unit (rod or tube Ø 20 mm (0.75 inch)) able to lift minimum 400 kg (880 lbs).
- Crane or other lifting aid to place the frequency converter in position
- A Torx T50 tool is needed to install the E1 enclosure in IP21 and IP54 enclosure types.

6.3.2. General Considerations

Space

Ensure proper space above and below the frequency converter to allow airflow and cable access. In addition space in front of the unit must be considered to enable opening of the door of the panel.

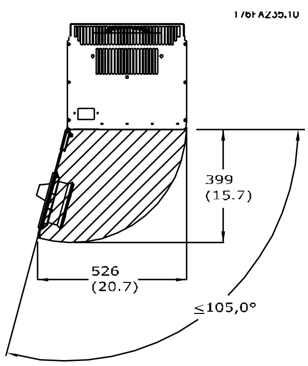


Illustration 6.2: Space in front of IP21/IP54 enclosure type D1 and D2.

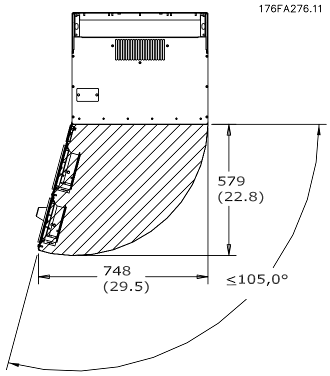


Illustration 6.3: Space in front of IP21/IP54 enclosure type E1.

NB!

Airflow, see *Mechanical Dimensions* on previous pages

Wire access

Ensure that proper cable access is present including necessary bending allowance. As the IP00 enclosure is open to the bottom cables must be fixed to the back panel of the enclosure where the frequency converter is mounted, i.e. by using cable clamps.

NB!
All cable lugs/ shoes must mount within the width of the terminal bus bar

Terminal locations
(D enclosures)

Take the following position of the terminals into consideration when you design for cables access.

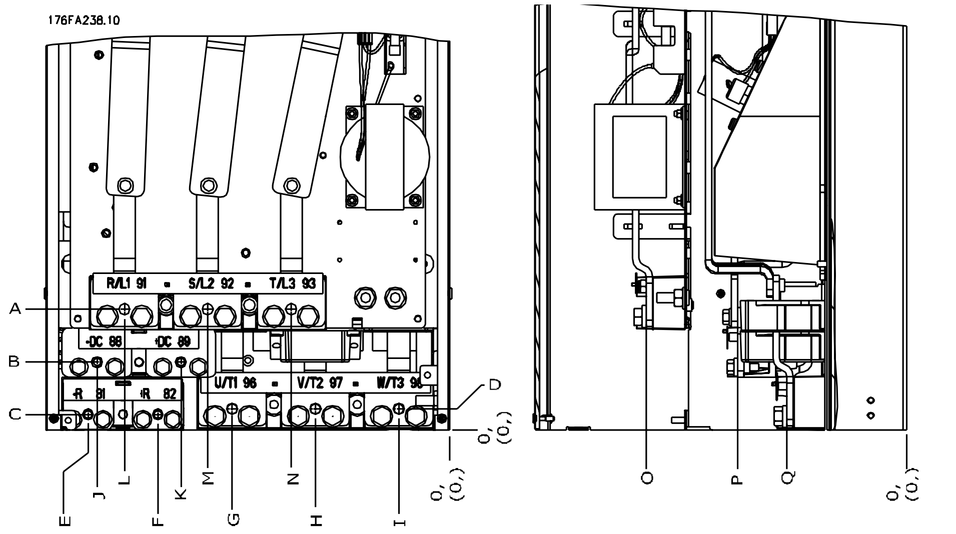


Illustration 6.4: Position of power connections, D3/ D4 enclosure

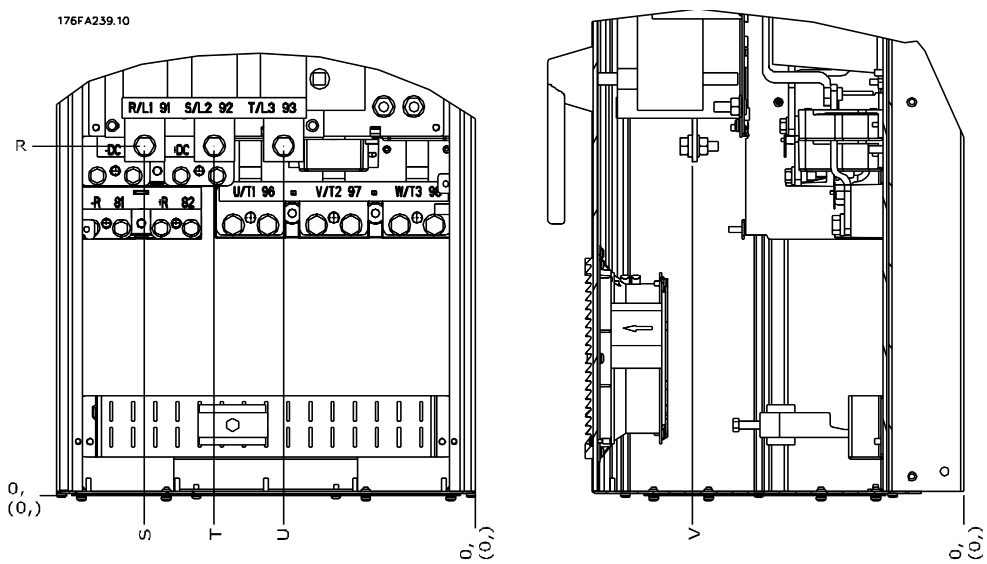


Illustration 6.5: Position of power connections with disconnect switch, D1/ D2 enclosure

Be aware that the power cables are heavy and hard to bend. Consider the optimum position of the frequency converter for ensuring easy installation of the cables.

NB!
All D enclosures are available with standard input terminals or disconnect switch. All terminal dimensions can be found in table on next page.

	IP 21 (NEMA 1) / IP 54 (NEMA 12)		IP 00 / Chassis	
	Enclosure D1	**Enclosure D2**	**Enclosure D3**	**Enclosure D4**
A	277 (10.9)	379 (14.9)	119 (4.7)	122 (4.8)
B	227 (8.9)	326 (12.8)	68 (2.7)	68 (2.7)
C	173 (6.8)	273 (10.8)	15 (0.6)	16 (0.6)
D	179 (7.0)	279 (11.0)	20.7 (0.8)	22 (0.8)
E	370 (14.6)	370 (14.6)	363 (14.3)	363 (14.3)
F	300 (11.8)	300 (11.8)	293 (11.5)	293 (11.5)
G	222 (8.7)	226 (8.9)	215 (8.4)	218 (8.6)
H	139 (5.4)	142 (5.6)	131 (5.2)	135 (5.3)
I	55 (2.2)	59 (2.3)	48 (1.9)	51 (2.0)
J	354 (13.9)	361 (14.2)	347 (13.6)	354 (13.9)
K	284 (11.2)	277 (10.9)	277 (10.9)	270 (10.6)
L	334 (13.1)	334 (13.1)	326 (12.8)	326 (12.8)
M	250 (9.8)	250 (9.8)	243 (9.6)	243 (9.6)
N	167 (6.6)	167 (6.6)	159 (6.3)	159 (6.3)
O	261 (10.3)	260 (10.3)	261 (10.3)	261 (10.3)
P	170 (6.7)	169 (6.7)	170 (6.7)	170 (6.7)
Q	120 (4.7)	120 (4.7)	120 (4.7)	120 (4.7)
R	256 (10.1)	350 (13.8)	98 (3.8)	93 (3.7)
S	308 (12.1)	332 (13.0)	301 (11.8)	324 (12.8)
T	252 (9.9)	262 (10.3)	245 (9.6)	255 (10.0)
U	196 (7.7)	192 (7.6)	189 (7.4)	185 (7.3)
V	260 (10.2)	273 (10.7)	260 (10.2)	273 (10.7)

Table 6.3: Cable positions as shown in drawings above. Dimensions in mm (inch).

Terminal locations - E1 enclosures

Take the following position of the terminals into consideration when designing the cable access.

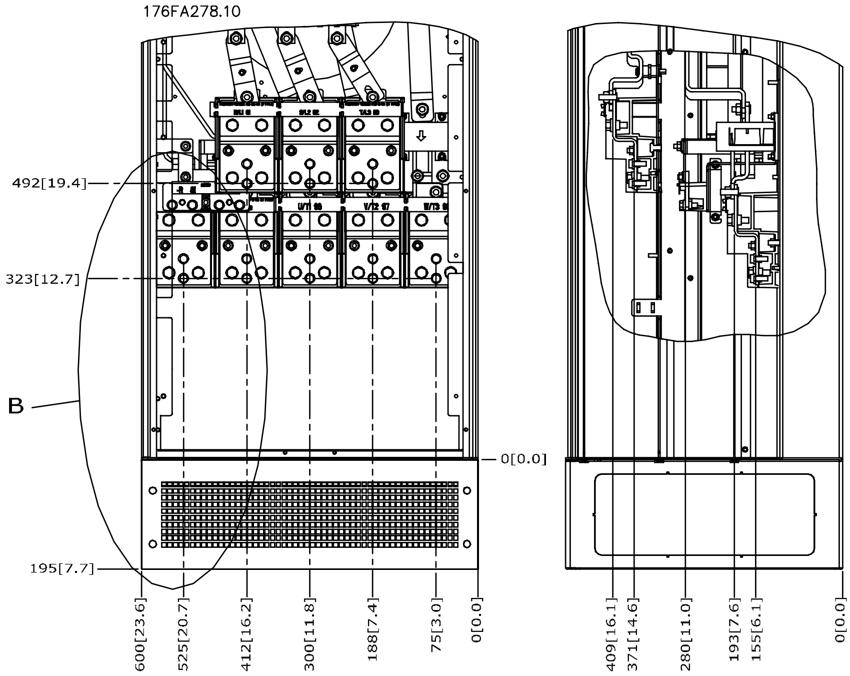


Illustration 6.6: IP21 (NEMA Type 1) and IP54 (NEMA Type 12) enclosure power connection positions

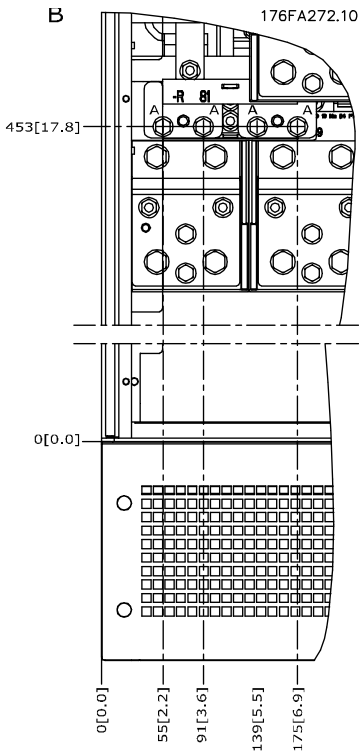


Illustration 6.7: IP21 (NEMA type 1) and IP54 (NEMA type 12) enclosure power connection positions (detail B)

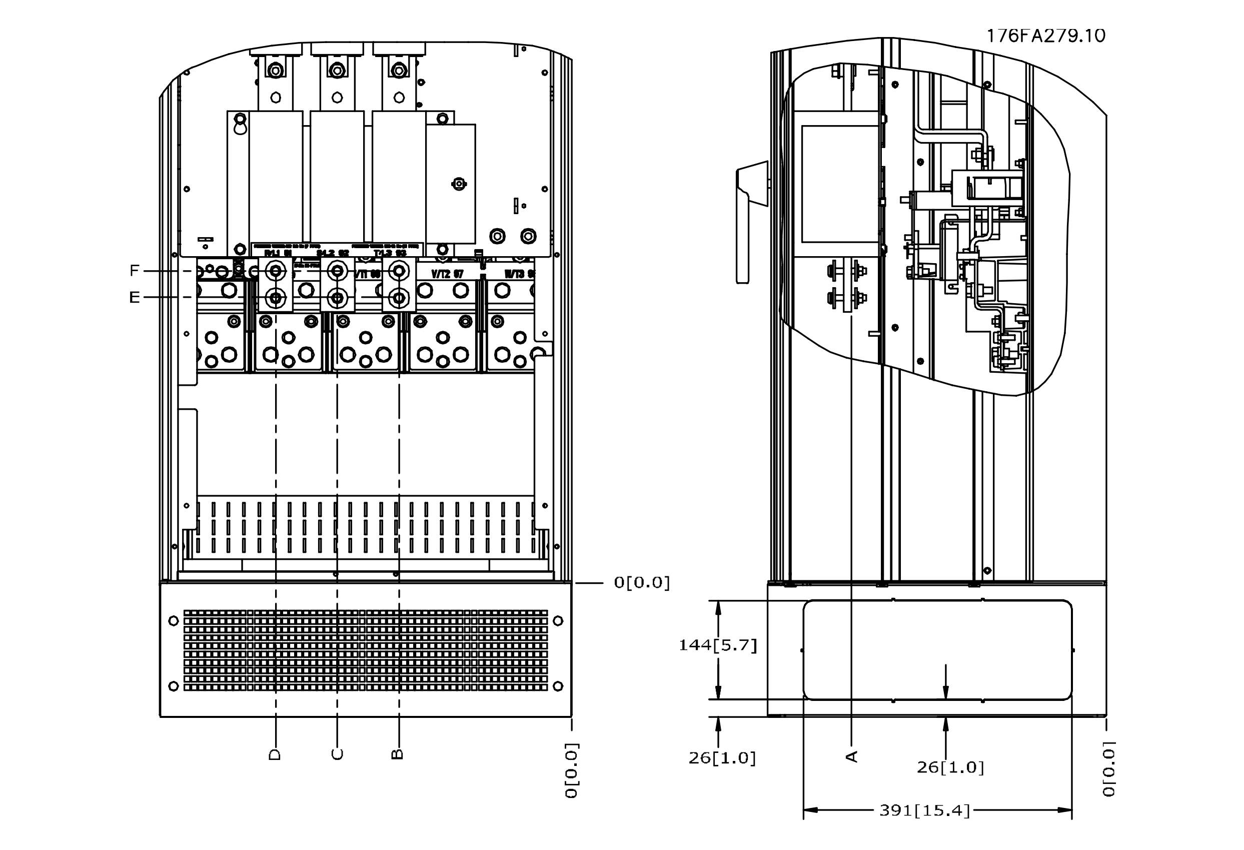


Illustration 6.8: IP21 (NEMA type 1) and IP54 (NEMA type 12) enclosure power connection position of disconnect switch

Terminal locations - E2 enclosures

Take the following position of the terminals into consideration when designing the cable access.

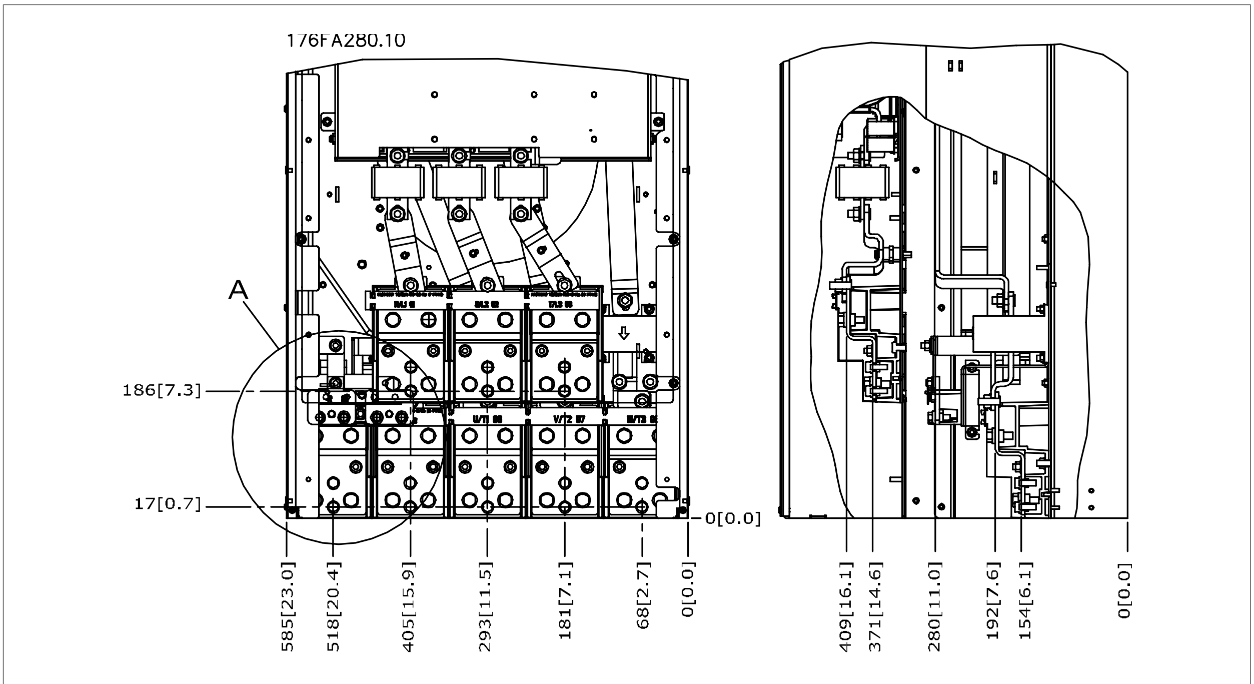


Illustration 6.9: IP00 enclosure power connection positions

6

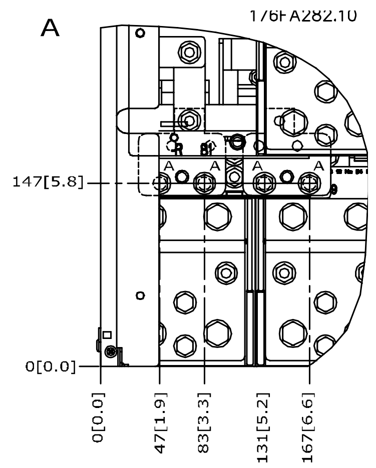


Illustration 6.10: IP00 enclosure power connection positions

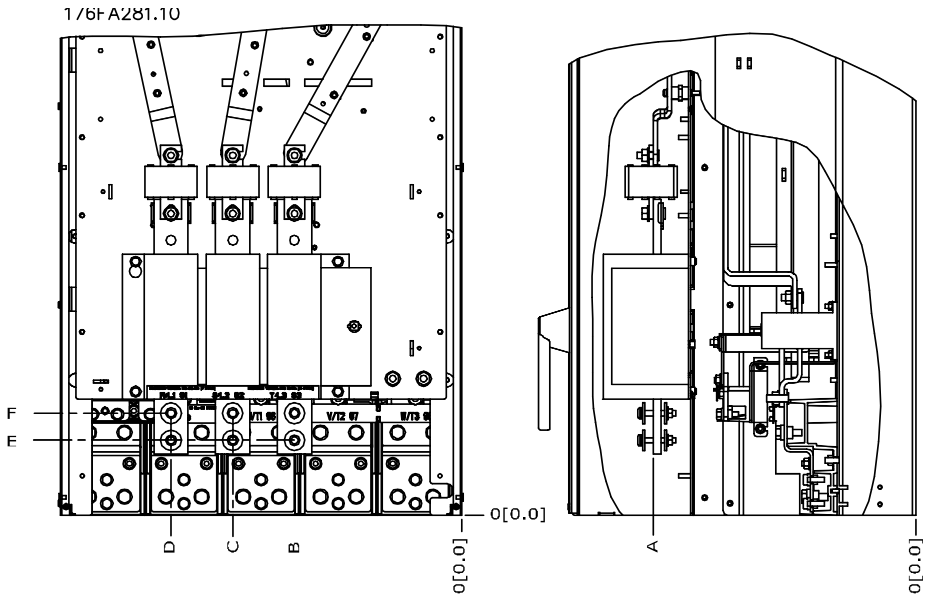


Illustration 6.11: IP00 enclosure power connections positions of disconnect switch

Note that the power cables are heavy and difficult to bend. Consider the optimum position of the frequency converter for ensuring easy installation of the cables.
Each terminal allows use of up to 4 cables with cable lugs or use of standard box lug. Earth is connected to relevant termination point in the drive.

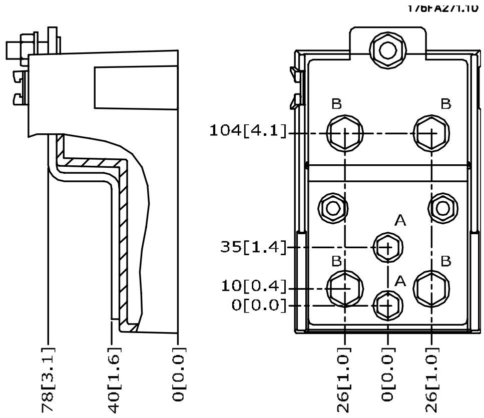


Illustration 6.12: Terminal in details

NB!
Power connections can be made to positions A or B

Cooling

Cooling can be obtained in different ways, by using the cooling ducts in the bottom and the top of the unit, by using the ducts in the rear of the unit or by combining the cooling possibilities.

Duct cooling

A dedicated option has been developed to optimise installation of IP00 / Chassis enclosed frequency converters in Rittal TS8 enclosures utilizing the fan of the frequency converter for forced cooling.

Back cooling

Using the channel from the back allows easy installation in for example control rooms. The unit mounted to the rear of the enclosure allows a similar easy cooling of the units as the duct cooling principle. The hot air is ventilated out of the back of the enclosure. This offers a solution where the hot cooling air from the frequency converter does not cause heating of the control room.

NB!
A small door fan is required on the Rittal cabinet to provide additional cooling within the drive.

Please see *Installation of Duct Cooling Kit in Rittal enclosures*, for further information.

Airflow

The necessary airflow over the heat sink must be secured. The flow rate is shown below.

Enclosure		Door fan / Top fan airflow	Airflow over heatsink
IP21 / NEMA 1 & IP54 / NEMA 12	D1 and D2	170 m^3/h (100 cfm)	765 m^3/h (450 cfm)
	E1	340 m^3/h (200 cfm)	1444 m^3/h (850 cfm)
IP00 / Chassis	D3 and D4	255 m^3/h (150 cfm)	765 m^3/h (450 cfm)
	E2	255 m^3/h (150 cfm)	1444 m^3/h (850 cfm)

Table 6.4: Heatsink Air Flow

6

6.3.3. Installation on the Wall - IP21 (NEMA 1) and IP54 (NEMA 12) Units

This only applies for D1 and D2 enclosures.
It must be considered where to install the unit.

Take the relevant points into consideration before you select the final installation site:

- Free space for cooling
- Access to open the door
- Cable entry from the bottom

Mark the mounting holes carefully using the mounting template on the wall and drill the holes as indicated. Ensure proper distance to the floor and the ceiling for cooling. A minimum of 225 mm (8.9 inch) below the frequency converter is needed. Mount the bolts at the bottom and lift the frequency converter up on the bolts. Tilt the frequency converter against the wall and mount the upper bolts. Tighten all four bolts to secure the frequency converter against the wall.

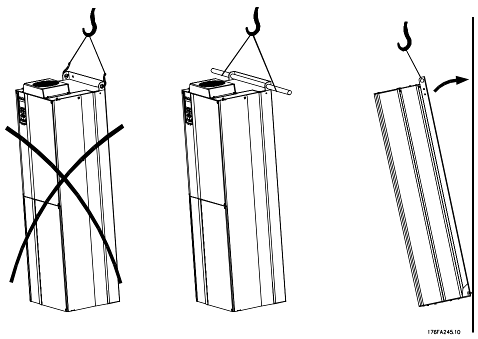


Illustration 6.13: Lifting method for mounting drive on wall

6.3.4. Gland/Conduit Entry - IP21 (NEMA 1) and IP54 (NEMA12)

Cables are connected through the gland plate from the bottom. Remove the plate and plan where to place the entry for the glands or conduits. Prepare holes in the marked area on the drawing.
The gland plate must be fitted to the frequency converter to ensure the specified protection degree, as well as ensuring proper cooling of the unit. If the gland plate is not mounted, it may trip the unit.

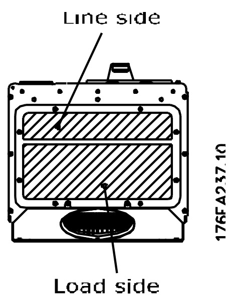


Illustration 6.14: Cable entry viewed from the bottom of the frequency converter - Enclosure D1 and D2.

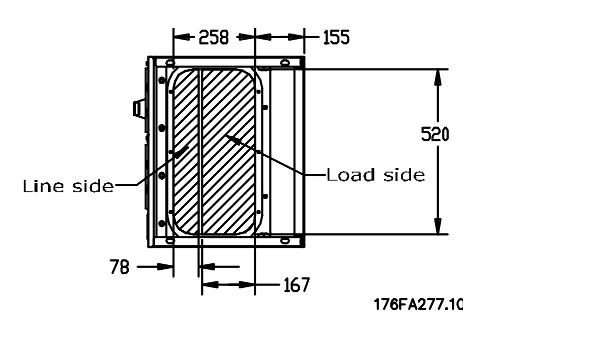


Illustration 6.15: Cable entry seen from the bottom of the frequency converter - Enclosure E1.

The bottom plate of the E1 enclosure can be mounted from either in- or outside of the enclosure, allowing flexibility in the installation process, i.e. if mounted from the bottom the glands and cables can be mounted before the frequency converter is placed on the pedestal.

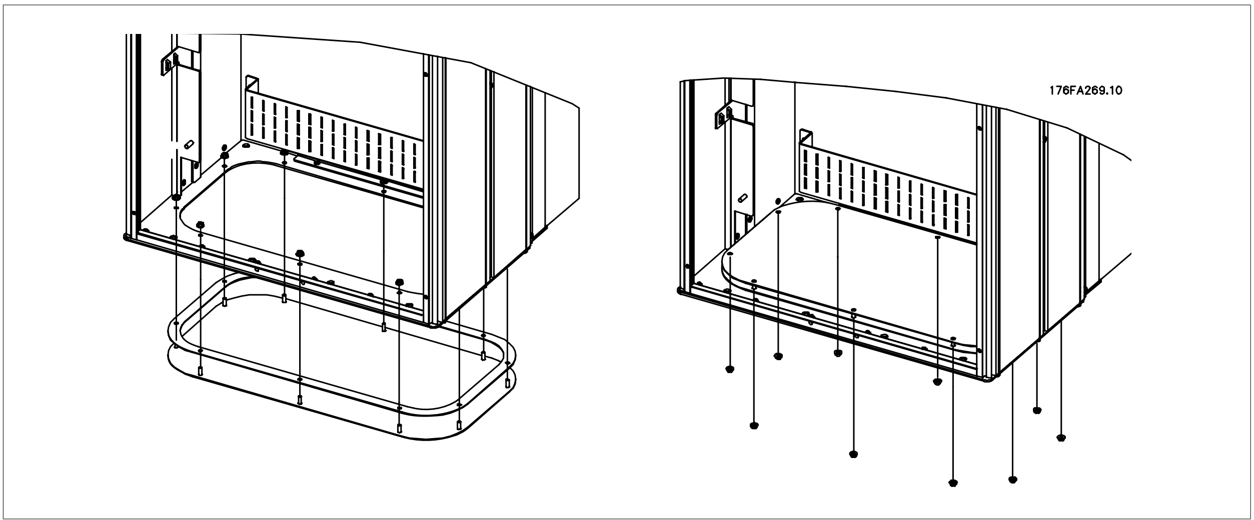


Illustration 6.16: Mounting of bottom plate, E1 enclosure.

6.3.5. IP21 Drip shield installation (D1 and D2 enclosure)

To comply with the IP21 rating, a separate drip shield is to be installed as explained below:

- Remove the two front screws
- Insert the drip shield and replace screws
- Torque the screws to 5,6 Nm (50 in-lbs)

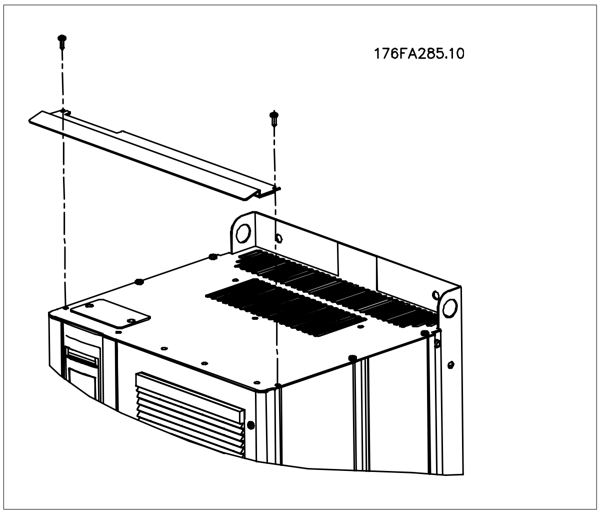


Illustration 6.17: Drip shield installation.

6.4. Electrical Installation - A, B and C Enclosures

NB!
This section describes the electrical installation of A, B and C enclosures. The electrical installation of larger drives is covered by a later section.

NB!
Cables General
All cabling must comply with national and local regulations on cable cross-sections and ambient temperature. Copper (60/75°C) conductors are recommended.

Aluminium Conductors
Terminals can accept aluminium conductors but the conductor surface has to be clean and the oxidation must be removed and sealed by neutral acid-free Vaseline grease before the conductor is connected.
Furthermore the terminal screw must be retightened after two days due to softness of the aluminium. It is crucial to keep the connection a gas tight joint, otherwise the aluminium surface will oxidize again.

Tightening-up Torque					
Enclosure	200 - 240 V	380 - 500 V	525 - 690 V	Cable for:	Tightening up torque
A1	0.25-1.5 kW	0.37-1.5 kW	-	Mains, Brake resistor, load sharing, Motor cables	0.5-0.6 Nm
A2	0.25-2.2 kW	0.37-4 kW	0.75-4 kW		
A3	3-3.7 kW	5.5-7.5 kW	5.5-7.5 kW		
A5	3-3.7 kW	5.5-7.5 kW	0.75-7.5 kW		
B1	5.5-7.5 kW	11-15 kW	-	Mains, Brake resistor, load sharing, Motor cables	1.8 Nm
				Relay	0.5-0.6 Nm
				Earth	2-3 Nm
B2	11 kW	18.5-22 kW	-	Mains, Brake resistor, load sharing cables	4.5 Nm
				Motor cables	4.5 Nm
				Relay	0.5-0.6 Nm
				Earth	2-3 Nm
B3	5.5-7.5 kW	11-15 kW	-	Mains, Brake resistor, load sharing, Motor cables	1.8 Nm
				Relay	0.5-0.6 Nm
				Earth	2-3 Nm
B4	11-15 kW	18.5-30 kW	-	Mains, Brake resistor, load sharing, Motor cables	4.5 Nm
				Relay	0.5-0.6 Nm
				Earth	2-3 Nm
C1	15-22 kW	30-45 kW	-	Mains, Brake resistor, load sharing cables	10 Nm
				Motor cables	10 Nm
				Relay	0.5-0.6 Nm
				Earth	2-3 Nm
C2	30-37 kW	55-75 kW	-	Mains, Brake resistor, load sharing cables	14 Nm
				Motor cables	10 Nm
				Relay	0.5-0.6 Nm
				Earth	2-3 Nm
C3	18.5-22 kW	30-37 kW	-	Mains, Brake resistor, load sharing, Motor cables	10 Nm
				Relay	0.5-0.6 Nm
				Earth	2-3 Nm
C4	37-45 kW	55-75 kW	-	Mains, motor cables	14 Nm (up to 95 mm^2) 24 Nm (over 95 mm^2)
				Load Sharing, brake cables	14 Nm
				Relay	0.5-0.6 Nm
				Earth	2-3 Nm

6.4.1. Removal of Knockouts for Extra Cables

1. Remove cable entry from the frequency converter (Avoiding foreign parts falling into the frequency converter when removing knockouts)
2. Cable entry has to be supported around the knockout you intend to remove.
3. The knockout can now be removed with a strong mandrel and a hammer.
4. Remove burrs from the hole.
5. Mount Cable entry on frequency converter.

6.4.2. Connection to Mains and Earthing

NB!
The plug connector for power is plugable on frequency converters up to 7.5 kW.

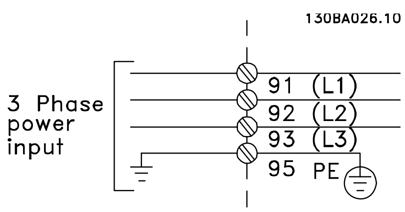
1. Fit the two screws in the de-coupling plate, slide it into place and tighten the screws.
2. Make sure the frequency converter is properly earthed. Connect to earth connection (terminal 95). Use screw from the accessory bag.
3. Place plug connector 91(L1), 92(L2), 93(L3) from the accessory bag onto the terminals labelled MAINS at the bottom of the frequency converter.
4. Attach mains wires to the mains plug connector.
5. Support the cable with the supporting enclosed brackets.

NB!
Check that mains voltage corresponds to the mains voltage of the name plate.

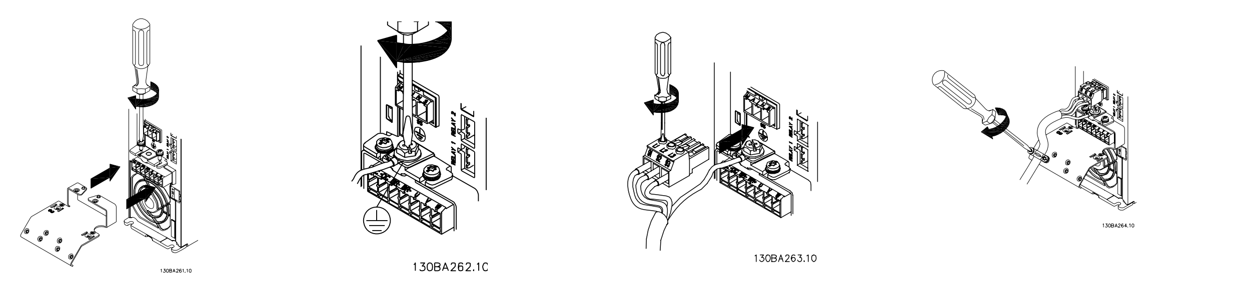
IT Mains
Do not connect 400 V frequency converters with RFI-filters to mains supplies with a voltage between phase and earth of more than 440 V.

The earth connection cable cross section must be at least 10 mm^2 or 2 x rated mains wires terminated separately according to EN 50178.

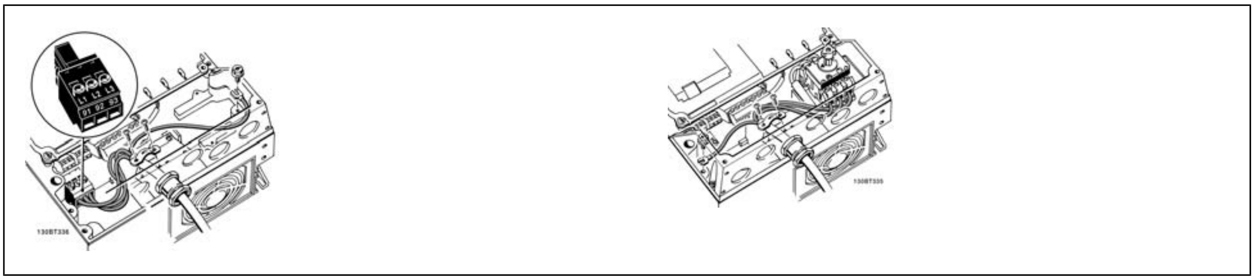
The mains connection is fitted to the mains switch if this is included.



Mains connection for frame sizes A1, A2 and A3:



Mains connector A5 (IP 55/66) Enclosure



When disconnector is used (A5 enclosure) the PE must be mounted on the left side of the drive.

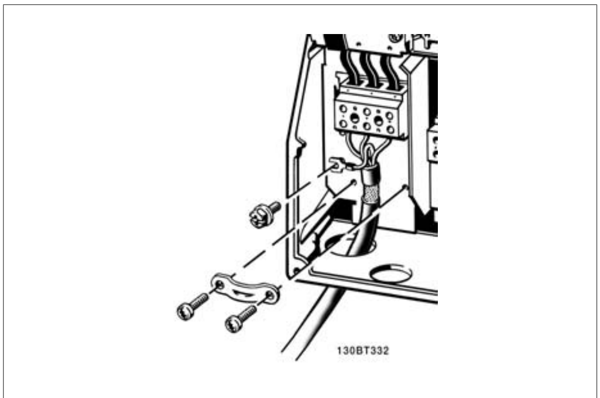


Illustration 6.18: Mains connection B1 and B2 (IP 21/NEMA Type 1 and IP 55/66/ NEMA Type 12) enclosures.

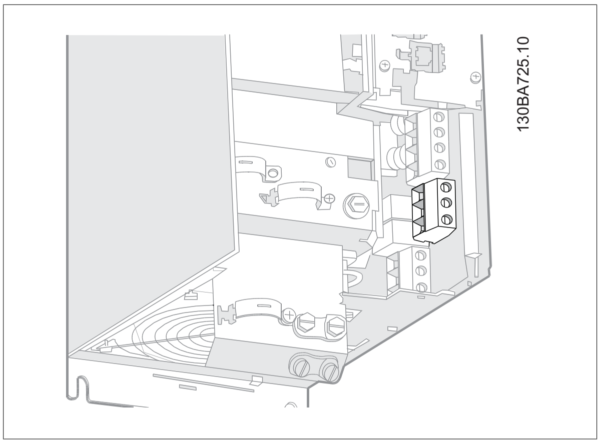


Illustration 6.19: Mains connection B3 (IP20) enclosures.

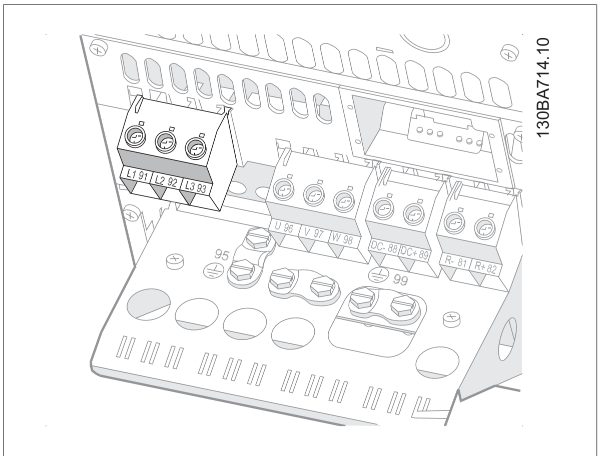


Illustration 6.20: Mains connection B4 (IP20) enclosure.

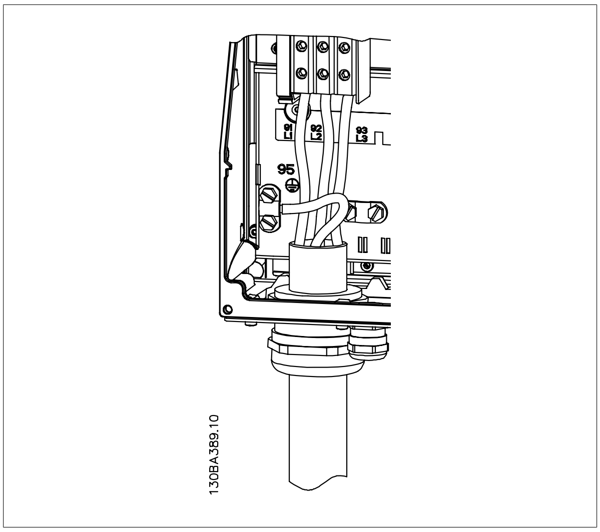


Illustration 6.21: Mains connection C1 and C2 (IP 21/ NEMA Type 1 and IP 55/66/ NEMA Type 12) enclosures.

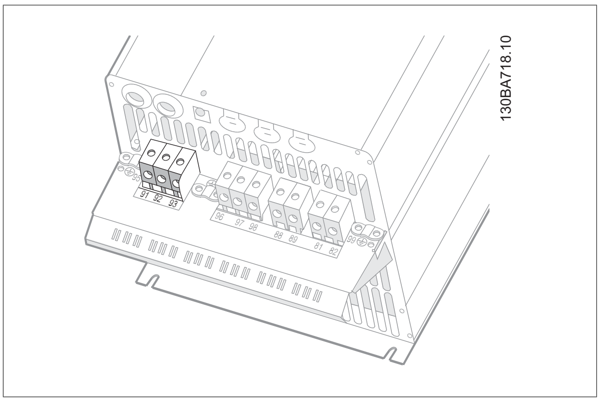


Illustration 6.22: Mains connection C3 (IP20) enclosures.

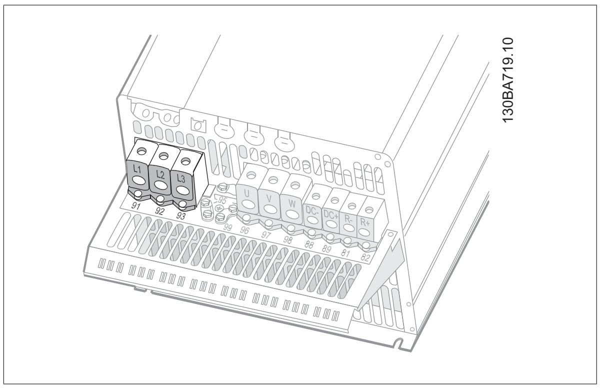


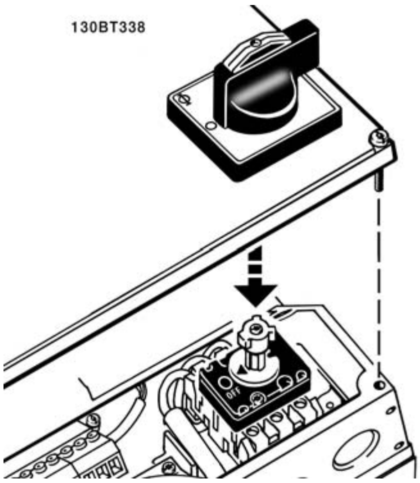
Illustration 6.23: Mains connection C4 (IP20) enclosures.

Usually the power cables for mains are unshielded cables.

6.4.3. Mains Disconnectors

Assembling of IP55 / NEMA Type 12 (A5 housing) with mains disconnector

Mains switch is placed on left side on B1, B2, C1 and C2 enclosures. Mains switch on A5 enclosure is placed on right side



Enclosure:	**Type:**
A5	Kraus&Naimer KG20A T303
B1	Kraus&Naimer KG64 T303
B2	Kraus&Naimer KG64 T303
C1 30 kW High Overload	Kraus&Naimer KG100 T303
C1 37-45 kW High Overload	Kraus&Naimer KG105 T303
C2 55 kW High Overload	Kraus&Naimer KG160 T303
C2 75 kW High Overload	Kraus&Naimer KG250 T303

6.4.4. Motor Connection

NB!
Motor cable must be screened/armoured. If an unscreened/unarmoured cable is used, some EMC requirements are not complied with. Use a screened/armoured motor cable to comply with EMC emission specifications. For more information, see *EMC Test Results*.

See section General Specifications for correct dimensioning of motor cable cross-section and length.

Screening of cables: Avoid installation with twisted screen ends (pigtails). They spoil the screening effect at higher frequencies. If it is necessary to break the screen to install a motor isolator or motor contactor, the screen must be continued at the lowest possible HF impedance.
Connect the motor cable screen to both the decoupling plate of the frequency converter and to the metal housing of the motor.
Make the screen connections with the largest possible surface area (cable clamp). This is done by using the supplied installation devices in the frequency converter.
If it is necessary to split the screen to install a motor isolator or motor relay, the screen must be continued with the lowest possible HF impedance.

Cable-length and cross-section: The frequency converter has been tested with a given length of cable and a given cross-section of that cable. If the cross-section is increased, the cable capacitance - and thus the leakage current - may increase, and the cable length must be reduced correspondingly. Keep the motor cable as short as possible to reduce the noise level and leakage currents.

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

1. Fasten decoupling plate to the bottom of the frequency converter with screws and washers from the accessory bag.
2. Attach motor cable to terminals 96 (U), 97 (V), 98 (W).
3. Connect to earth connection (terminal 99) on decoupling plate with screws from the accessory bag.
4. Insert plug connectors 96 (U), 97 (V), 98 (W) (up to 7.5 kW) and motor cable to terminals labelled MOTOR.
5. Fasten screened cable to decoupling plate with screws and washers from the accessory bag.

All types of three-phase asynchronous standard motors can be connected to the frequency converter. Normally, small motors are star-connected (230/400 V, Y). Large motors are normally delta-connected (400/690 V, Δ). Refer to the motor name plate for correct connection mode and voltage.

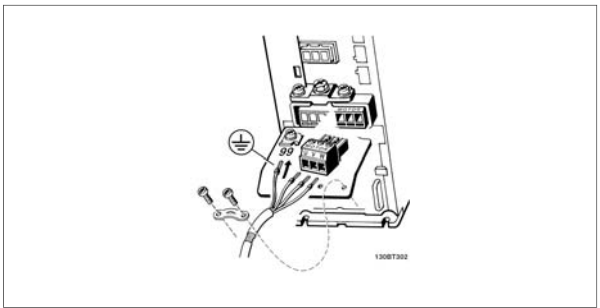


Illustration 6.24: Motor connection for A1, A2 and A3

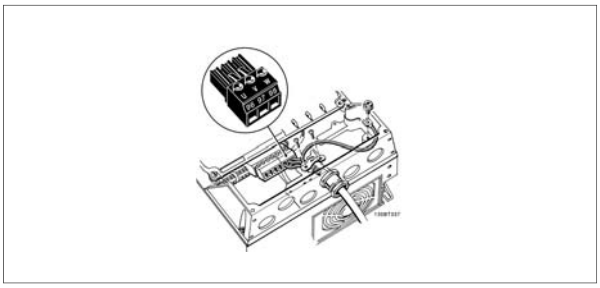


Illustration 6.25: Motor connection for A5 (IP 55/66/NEMA Type 12) enclosure

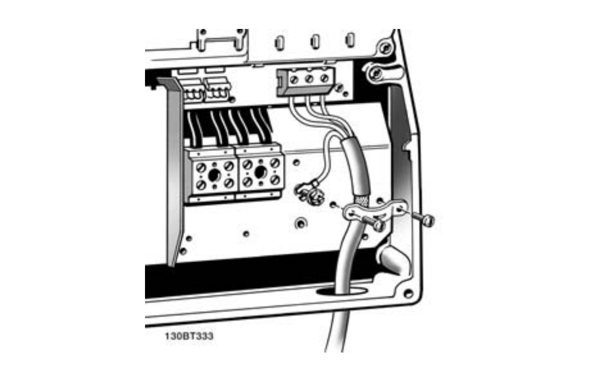


Illustration 6.26: Motor connection for B1 and B2 (IP 21/ NEMA Type 1, IP 55/ NEMA Type 12 and IP66/ NEMA Type 4X) enclosure

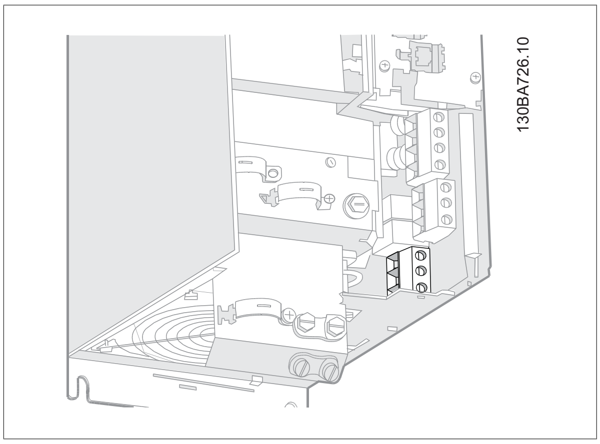


Illustration 6.27: Motor connection for B3 enclosure.

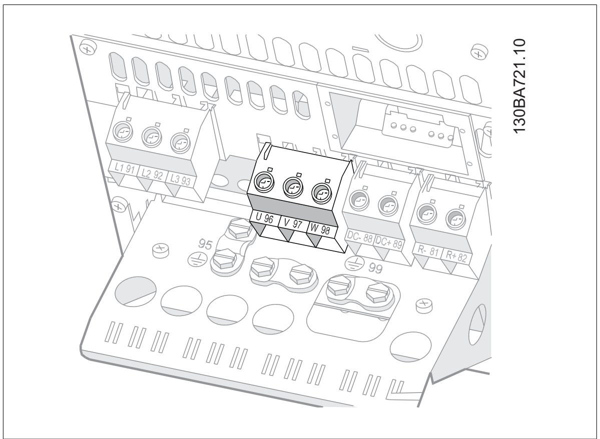


Illustration 6.28: Motor connection for B4 enclosure.

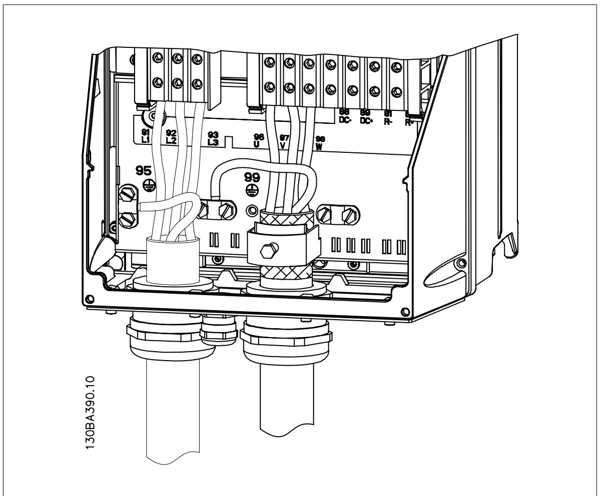


Illustration 6.29: Motor connection C1 and C2 (IP 21/ NEMA Type 1 and IP 55/66/ NEMA Type 12) enclosure

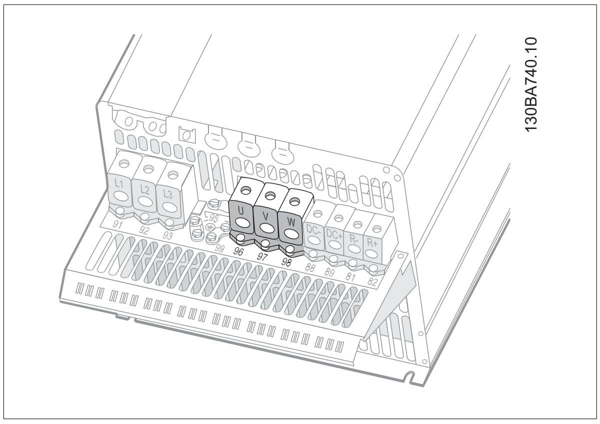


Illustration 6.30: Motor connection for C3 and C4 enclosure.

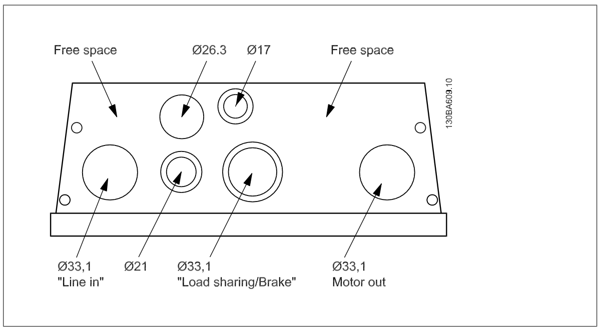


Illustration 6.31: Cable entry holes for enclosure B1. The suggested use of the holes are purely recommendations and other solutions are possible.

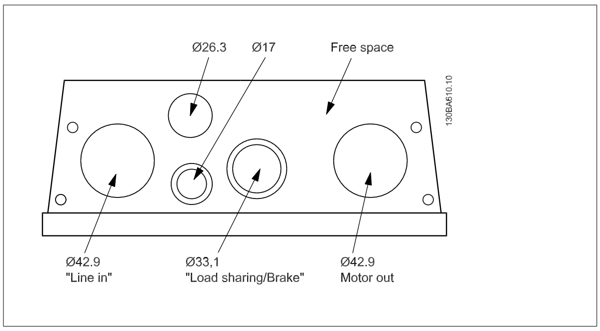


Illustration 6.32: Cable entry holes for enclosure B2. The suggested use of the holes are purely recommendations and other solutions are possible.

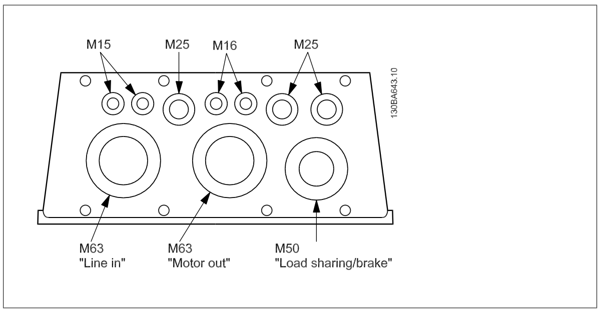


Illustration 6.33: Cable entry holes for enclosure C1. The suggested use of the holes are purely recommendations and other solutions are possible.

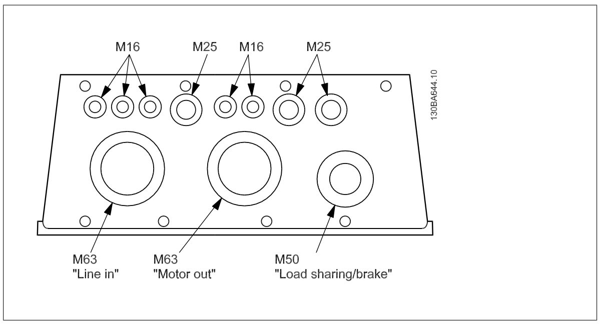
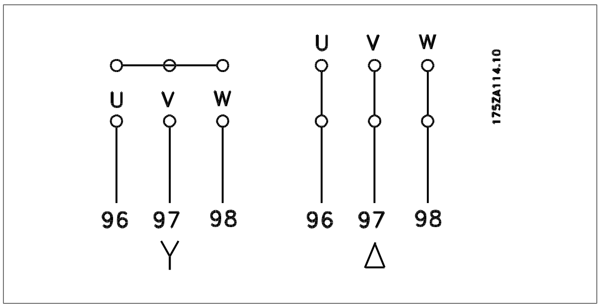


Illustration 6.34: Cable entry holes for enclosure C2. The suggested use of the holes are purely recommendations and other solutions are possible.

Term. no.	96	97	98	99	
	U	V	W	PE[1)]	Motor voltage 0-100% of mains voltage. 3 wires out of motor
	U1 W2	V1 U2	W1 V2	PE[1)]	Delta-connected 6 wires out of motor
	U1	V1	W1	PE[1)]	Star-connected U2, V2, W2 U2, V2 and W2 to be interconnected separately.

[1)]Protected Earth Connection



NB!

In motors without phase insulation paper or other insulation reinforcement suitable for operation with voltage supply (such as a frequency converter), fit a Sine-wave filter on the output of the frequency converter.

6.5. Electrical Installation - D and E Enclosures

NB!
This section describes the electrical installation of D and E enclosures. The electrical installation of smaller drives is covered by an earlier section.

6.5.1. Control Wires

Control cable routing
Tie down all control wires to the designated control cable routing as shown in the picture. Remember to connect the shields in a proper way to ensure optimum electrical immunity.

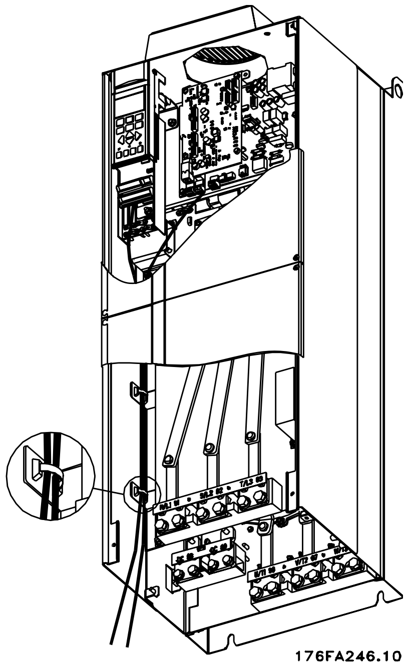


Illustration 6.35: Wire path for control wiring.

Fieldbus connection
Connections are made to the relevant options at the control card. For details see the relevant fieldbus instruction. The cable must be placed to the left inside the frequency converter and tied down together with other control wires.

In the IP 00 (Chassis) and IP 21 (NEMA 1) units it is also possible to connect the fieldbus from the top of the unit as shown on the picture below. On the IP 21 (NEMA 1) unit a cover plate must be removed.

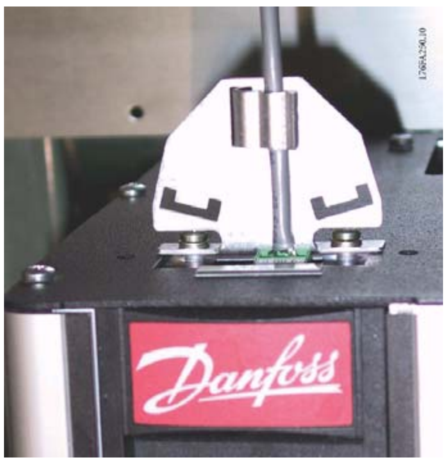


Illustration 6.36: Top connection for fieldbus.

Installation of 24 Volt external DC Supply
Torque: 0.5 - 0.6 Nm (5 in-lbs)
Screw size: M3

No.	Function
35 (-), 36 (+)	24 V external DC supply

24 V external DC supply can be used as low-voltage supply to the control card and any option cards installed. This enables full operation of the LCP (incl. parameter setting) without connection to mains. Please note that a warning of low voltage will be given when 24 V DC has been connected; however, there will be no tripping.

Use 24 V DC supply of type PELV to ensure correct galvanic isolation (type PELV) on the control terminals of the frequency converter.

6.5.2. Power Connections

Cabling and Fusing

NB!

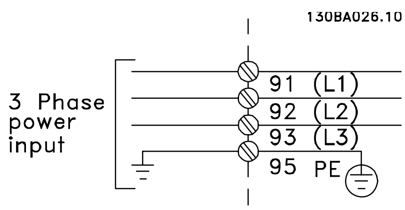
Cables General

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

The power cable connections are situated as shown below. Dimensioning of cable cross section must be done in accordance with the current ratings and local legislation. See the *Specifications section* for details.

For protection of the frequency converter the recommended fuses must be used or the unit must be with built-in fuses. Recommended fuses can be seen in the tables in the fuses section. Always ensure that proper fusing is made according to local regulation.

The mains connection is fitted to the mains switch if this is included.



NB!

Motor cable must be screened/armoured. If an unscreened/unarmoured cable is used, some EMC requirements are not complied with. Use a screened/armoured motor cable to comply with EMC emission specifications. For more information, see *EMC specifications* in the *Design Guide*.

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

Screening of cables:

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

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

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

Cable-length and cross-section:

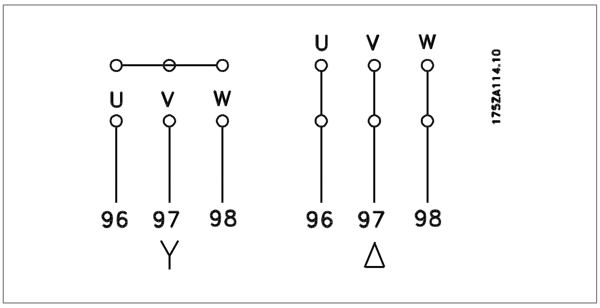
The frequency converter has been EMC tested with a given length of cable. Keep the motor cable as short as possible to reduce the noise level and leakage currents.

Switching frequency:

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

Term. no.	96	97	98	99	
	U	V	W	PE[1]	Motor voltage 0-100% of mains voltage. 3 wires out of motor
	U1 W2	V1 U2	W1 V2	PE[1]	Delta-connected 6 wires out of motor
	U1	V1	W1	PE[1]	Star-connected U2, V2, W2 U2, V2 and W2 to be interconnected separately.

[1]Protected Earth Connection



NB!

In motors without phase insulation paper or other insulation reinforcement suitable for operation with voltage supply (such as a frequency converter), fit a Sine-wave filter on the output of the frequency converter.

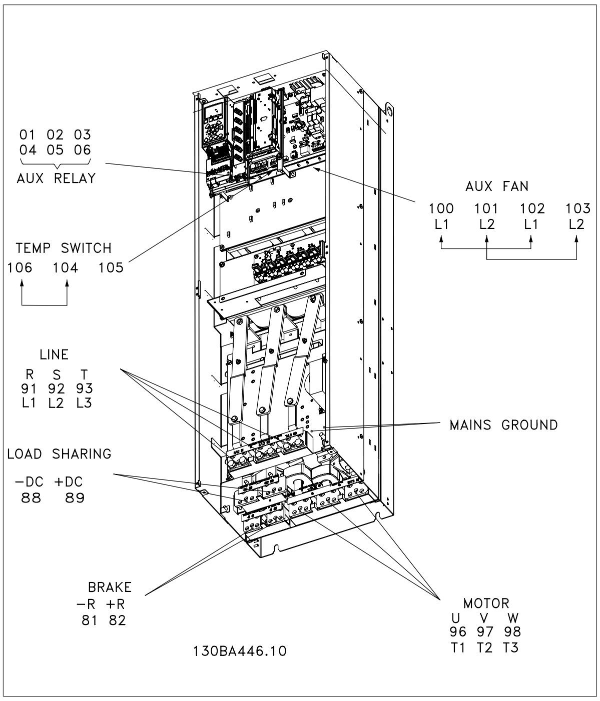


Illustration 6.37: Compact IP 00 (Chassis), enclosure D3

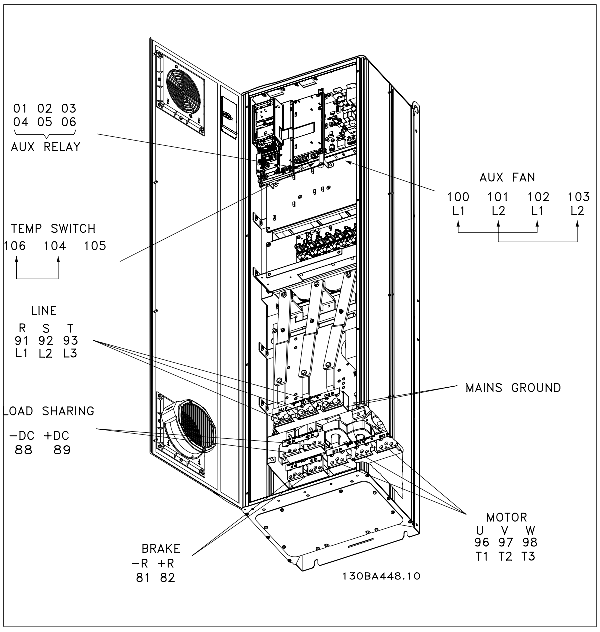


Illustration 6.38: Compact IP 21 (NEMA 1) and IP 54 (NEMA 12), enclosure D1

6

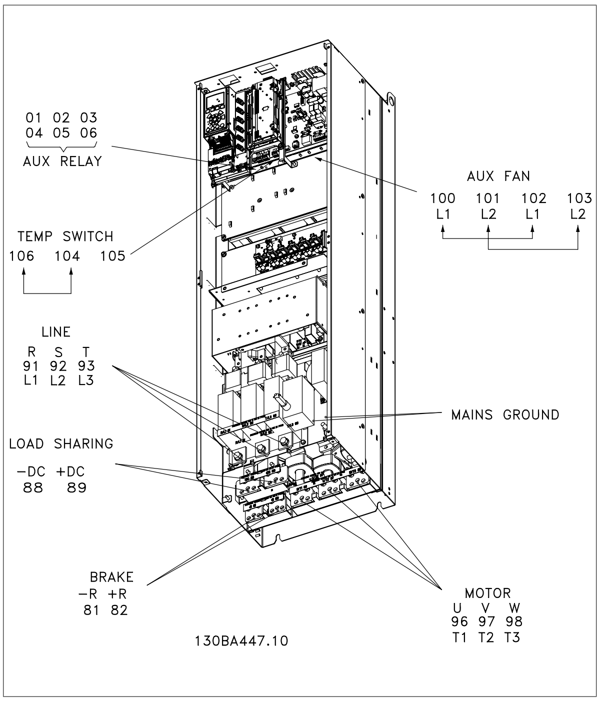


Illustration 6.39: Compact IP 00 (Chassis) with disconnect, fuse and RFI filter, enclosure D4

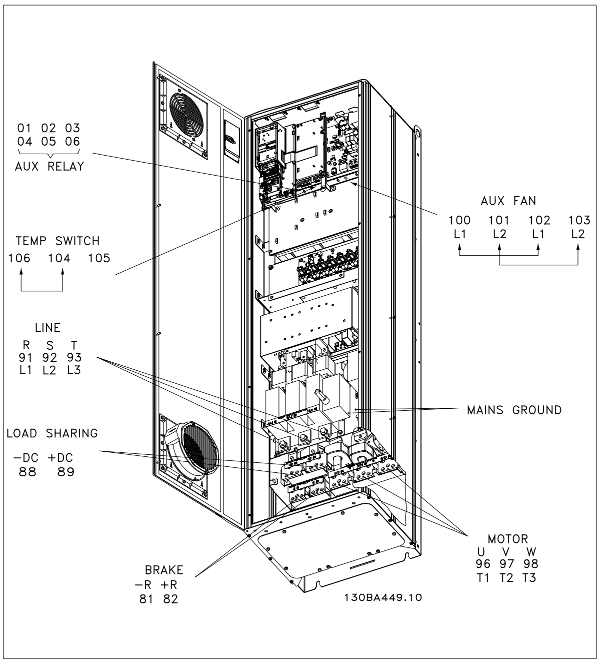


Illustration 6.41: Compact IP 21 (NEMA 1) and IP 54 (NEMA 12) with disconnect, fuse and RFI filter, enclosure D2

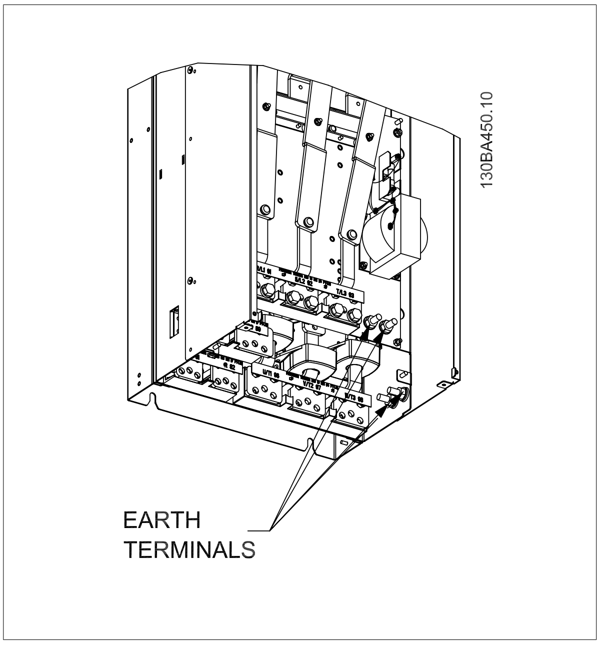


Illustration 6.40: Position of earth terminals IP00, D enclosures

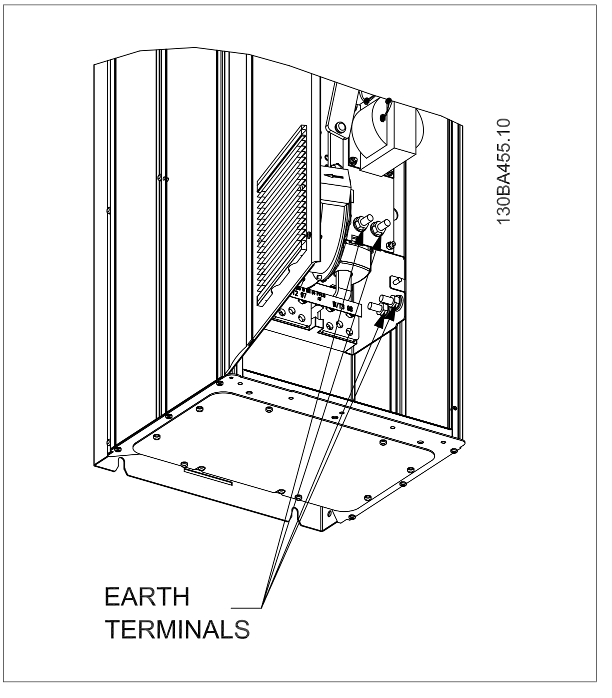


Illustration 6.42: Position of earth terminals IP21 (NEMA type 1) and IP54 (NEMA type 12)

NB!

D2 and D4 shown as examples. D1 and D3 are equivalent.

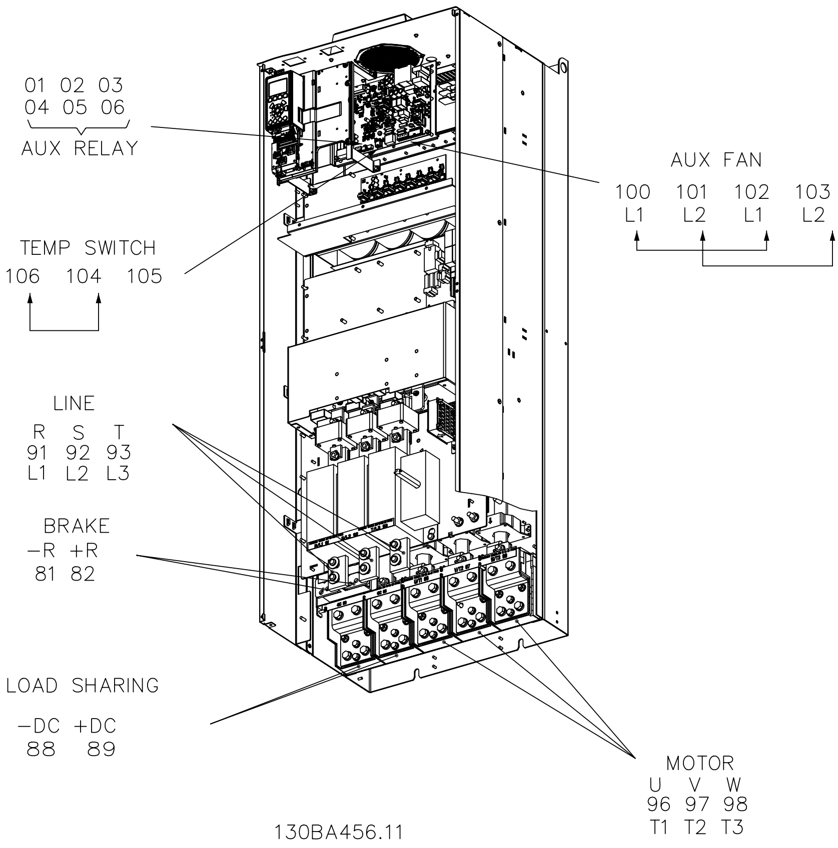


Illustration 6.43: Compact IP 00 (Chassis) with disconnect, fuse and RFI filter, enclosure E2

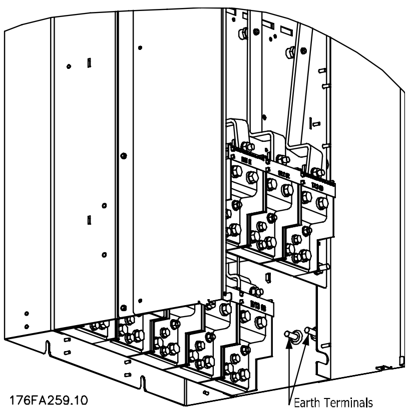


Illustration 6.44: Position of earth terminals IP00, E enclosures

6

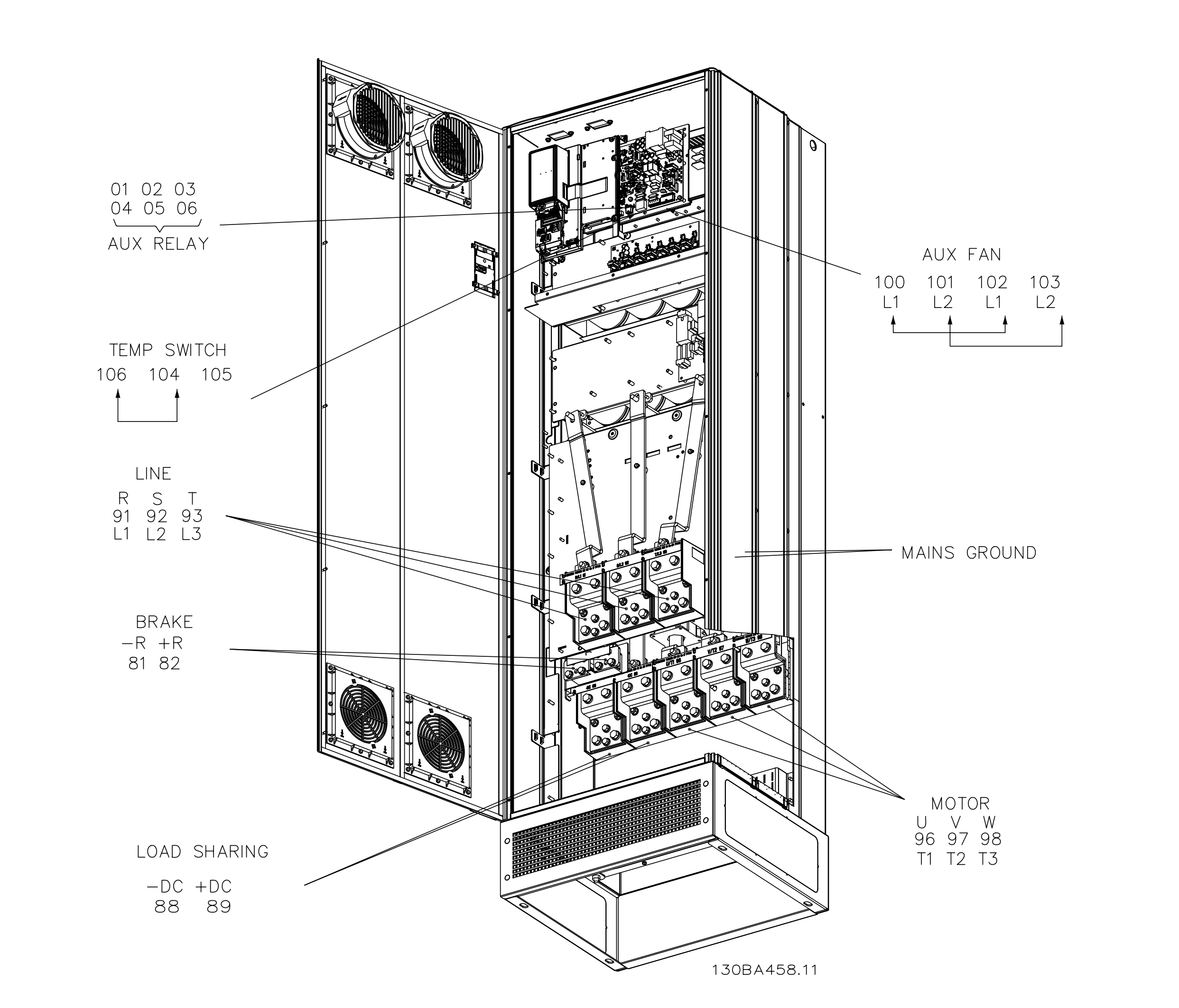


Illustration 6.45: Compact IP 21 (NEMA 1) and IP 54 (NEMA 12) enclosure E1

6.5.3. Earthing

The following basic issues need to be considered when installing a frequency converter, so as to obtain electromagnetic compatibility (EMC).

- Safety earthing: Please note that the frequency converter has a high leakage current and must be earthed appropriately for safety reasons. Apply local safety regulations.
- High-frequency earthing: Keep the earth wire connections as short as possible.

Connect the different earth systems at the lowest possible conductor impedance. The lowest possible conductor impedance is obtained by keeping the conductor as short as possible and by using the greatest possible surface area.
The metal cabinets of the different devices are mounted on the cabinet rear plate using the lowest possible HF impedance. This avoids having different HF voltages for the individual devices and avoids the risk of radio interference currents running in connection cables that may be used between the devices. The radio interference will have been reduced.
In order to obtain a low HF impedance, use the fastening bolts of the devices as HF connection to the rear plate. It is necessary to remove insulating paint or similar from the fastening points.

6.5.4. Extra Protection (RCD)

ELCB relays, multiple protective earthing or earthing can be used as extra protection, provided that local safety regulations are complied with.

In the case of an earth fault, a DC content may develop in the faulty current.

If ELCB relays are used, local regulations must be observed. Relays must be suitable for protection of 3-phase equipment with a bridge rectifier and for a brief discharge on power-up.

See also the section *Special Conditions* in the Design Guide.

6.5.5. RFI Switch

Mains supply isolated from earth

If the frequency converter is supplied from an isolated mains source (IT mains, floating delta and grounded delta) or TT/TN-S mains with grounded leg, the RFI switch is recommended to be turned off (OFF) 1) via par. 14-50. For further reference, see IEC 364-3. In case optimum EMC performance is needed, parallel motors are connected or the motor cable length is above 25 m, it is recommended to set par. 14-50 to [ON].

1) Not available for 525-600/690 V drives.

In OFF, the internal RFI capacities (filter capacitors) between the chassis and the intermediate circuit are cut off to avoid damage to the intermediate circuit and to reduce the earth capacity currents (according to IEC 61800-3).

Please also refer to the application note *VLT on IT mains, MN.90.CX.02*. It is important to use isolation monitors that are capable for use together with power electronics (IEC 61557-8).

6.5.6. Torque

When tightening all electrical connections it is very important to tighten with the correct torque. Too low or too high torque results in a bad electrical connection. Use a torque wrench to ensure correct torque

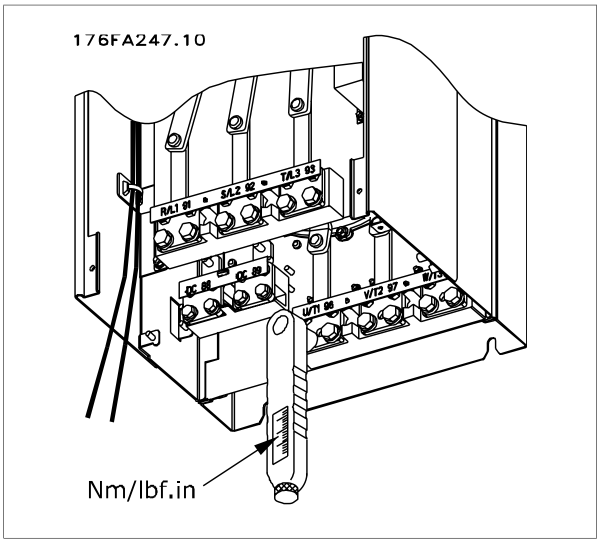


Illustration 6.46: Always use a torque wrench to tighten the bolts.

Enclosure	Terminal	Torque	Bolt size
D1, D2, D3 and D4	Mains	19 Nm (168 in-lbs)	M10
	Motor		
	Load sharing	9.5 (84 in-lbs)	M8
	Brake		
E1 and E2	Mains	19 NM (168 in-lbs)	M10
	Motor		
	Load sharing		
	Brake	9.5 (84 in-lbs)	M8

Table 6.5: Torque for terminals

6.5.7. Shielded Cables

It is important that shielded and armoured cables are connected in a proper way to ensure high EMC immunity and low emissions.

Connection can be made with either cable glands or clamps:

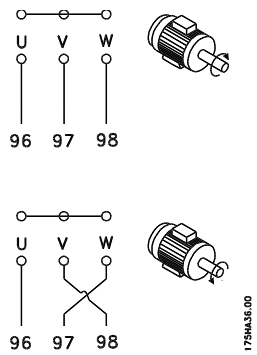
- EMC cable glands: Generally available cable glands can be used to ensure an optimum EMC connection.
- EMC cable clamp: Clamps allowing easy connection are supplied with the frequency converter.

6.5.8. Motor cable

The motor must be connected to terminals U/T1/96, V/T2/97, W/T3/98. Earth to terminal 99. All types of three-phase asynchronous standard motors can be used with a frequency converter unit. The factory setting is for clockwise rotation with the VLT frequency converter output connected as follows:

Terminal No.	Function
96, 97, 98, 99	Mains U/T1, V/T2, W/T3 Ground/Earth

- Terminal U/T1/96 connected to U-phase
- Terminal V/T2/97 connected to V-phase
- Terminal W/T3/98 connected to W-phase



The direction of rotation can be changed by switching two phases in the motor cable or by changing the setting of par. 4-10.

6.5.9. Brake Cable

(Only standard with letter B in position 18 of typecode).

Terminal No.	Function
81, 82	Brake resistor terminals

The connection cable to the brake resistor must be screened. Connect the screen by means of cable clamps to the conductive back plate at the frequency converter and to the metal cabinet of the brake resistor.
Size the brake cable cross-section to match the brake torque. See also *Brake Instructions, MI.90.Fx.yy* and *MI.50.Sx.yy* for further information regarding safe installation.

! Please note that voltages up to 1099 VDC, depending on the supply voltage, may occur on the terminals.

6.5.10. Load Sharing

(Only extended with letter D in position 21 of the typecode).

Terminal No.	Function
88, 89	Loadsharing

The connection cable must be screened and the max. length from the frequency converter to the DC bar is 25 metres (82 feet).
Load sharing enables linking of the DC intermediate circuits of several frequency converters.

Please note that voltages up to 1099 VDC may occur on the terminals.
Load sharing calls for extra equipment. For further information please contact Danfoss.

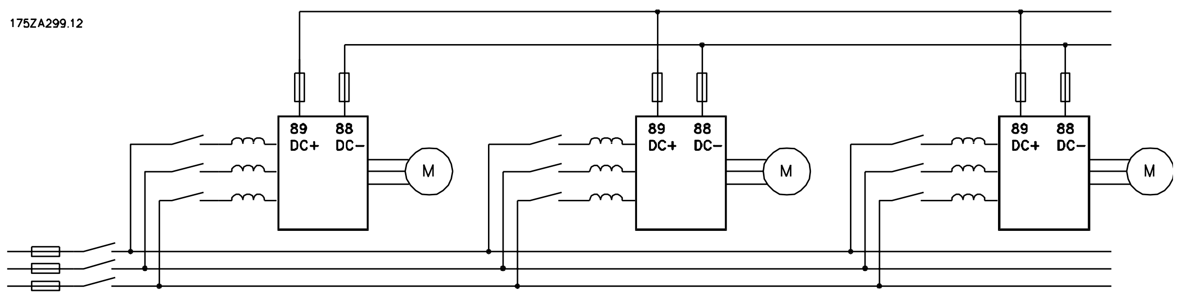


Illustration 6.47: Possible load sharing connection.

6.5.11. Shielding against Electrical Noise

Before mounting the mains power cable, mount the EMC metal cover to ensure best EMC performance.

NOTE: The EMC metal cover is only included in units with an RFI filter.

Illustration 6.48: Mounting of EMC shield.

6.5.12. Mains connection

Mains must be connected to terminals 91, 92 and 93. Earth/ground is connected to the terminal to the right of terminal 93.

Terminal No.	Function
91, 92, 93	Mains R/L1, S/L2, T/L3
94	Ground/Earth

Check the name plate to ensure that the mains voltage of the frequency converter matches the power supply of your plant.

Ensure that the power supply can supply the necessary current to the frequency converter.

If the unit is without built-in fuses, ensure that the appropriate fuses have the correct current rating.

6.5.13. External Fan Supply

In case the frequency converter is supplied by DC or if the fan must run independently of the power supply, an external power supply can be applied. The connection is done to the power card.

Terminal No.	Function
100, 101	Auxiliary supply S, T
102, 103	Internal supply S, T

The connector located on the power card provides the connection of line voltage for the cooling fans. The fans are connected from factory to be supplied form a common AC line (jumpers between 100-102 and 101-103). If external supply is needed, the jumpers are removed and the supply is connected to terminals 100 and 101. A 5 Amp fuse should be used for protection. In UL applications this should be LittelFuse KLK-5 or equivalent.

6.6. Electrical Installation - Continued, all enclosures

6.6.1. Fuses

Branch circuit protection:

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

Short-circuit protection:

The frequency converter must be protected against short-circuit to avoid electrical or fire hazard. Danfoss recommends using the fuses mentioned below to protect service personnel and equipment in case of an internal failure in the drive. The frequency converter provides full short-circuit protection in case of a short-circuit on the motor output.

Overcurrent protection:

Provide overload protection to avoid fire hazard due to overheating of the cables in the installation. The frequency converter is equipped with an internal overcurrent protection that can be used for upstream overload protection (UL-applications excluded). See par. 4-18. Moreover, fuses or circuit breakers can be used to provide the overcurrent protection in the installation. Overcurrent protection must always be carried out according to national regulations.

Fuses must be designed for protection in a circuit capable of supplying a maximum of 100,000 A_{rms} (symmetrical), 500 V maximum.

Non UL compliance

If UL/cUL is not to be complied with, we recommend using the following fuses, which will ensure compliance with EN50178:
In case of malfunction, not following the recommendation may result in unnecessary damage to the frequency converter.

	Max. fuse size1)	Voltage	Type
K25-K75	10A	200-240 V	type gG
1K1-2K2	20A	200-240 V	type gG
3K0-3K7	32A	200-240 V	type gG
5K5-7K5	63A	380-500 V	type gG
11K	80A	380-500 V	type gG
15K-18K5	125A	380-500 V	type gG
22K	160A	380-500 V	type aR
30K	200A	380-500 V	type aR
37K	250A	380-500 V	type aR

1) Max. fuses - refer to national/international regulations to select an appropriate fuse size.

	Max. fuse size1)	Voltage	Type
K37-1K5	10A	380-500 V	type gG
2K2-4K0	20A	380-500 V	type gG
5K5-7K5	32A	380-500 V	type gG
11K-18K	63A	380-500 V	type gG
22K	80A	380-500 V	type gG
30K	100A	380-500 V	type gG
37K	125A	380-500 V	type gG
45K	160A	380-500 V	type aR
55K-75K	250A	380-500 V	type aR

6

UL Compliance

200-240 V

	Bussmann	Bussmann	Bussmann	Bussmann	Bussmann	Bussmann
kW	Type RK1	Type J	Type T	Type CC	Type CC	Type CC
K25-K37	KTN-R05	JKS-05	JJN-06	FNQ-R-5	KTK-R-5	LP-CC-5
K55-1K1	KTN-R10	JKS-10	JJN-10	FNQ-R-10	KTK-R-10	LP-CC-10
1K5	KTN-R15	JKS-15	JJN-15	FNQ-R-15	KTK-R-15	LP-CC-15
2K2	KTN-R20	JKS-20	JJN-20	FNQ-R-20	KTK-R-20	LP-CC-20
3K0	KTN-R25	JKS-25	JJN-25	FNQ-R-25	KTK-R-25	LP-CC-25
3K7	KTN-R30	JKS-30	JJN-30	FNQ-R-30	KTK-R-30	LP-CC-30
5K5	KTN-R50	KS-50	JJN-50	-	-	-
7K5	KTN-R60	JKS-60	JJN-60	-	-	-
11K	KTN-R80	JKS-80	JJN-80	-	-	-
15K-18K5	KTN-R125	JKS-150	JJN-125	-	-	-

	SIBA	Littel fuse	Ferraz-Shawmut	Ferraz-Shawmut
kW	Type RK1	Type RK1	Type CC	Type RK1
K25-K37	5017906-005	KLN-R05	ATM-R05	A2K-05R
K55-1K1	5017906-010	KLN-R10	ATM-R10	A2K-10R
1K5	5017906-016	KLN-R15	ATM-R15	A2K-15R
2K2	5017906-020	KLN-R20	ATM-R20	A2K-20R
3K0	5017906-025	KLN-R25	ATM-R25	A2K-25R
3K7	5012406-032	KLN-R30	ATM-R30	A2K-30R
5K5	5014006-050	KLN-R50	-	A2K-50R
7K5	5014006-063	KLN-R60	-	A2K-60R
11K	5014006-080	KLN-R80	-	A2K-80R
15K-18K5	2028220-125	KLN-R125	-	A2K-125R

	Bussmann	SIBA	Littel fuse	Ferraz-Shawmut
kW	Type JFHR2	Type RK1	JFHR2	JFHR2
22K	FWX-150	2028220-150	L25S-150	A25X-150
30K	FWX-200	2028220-200	L25S-200	A25X-200
37K	FWX-250	2028220-250	L25S-250	A25X-250

KTS-fuses from Bussmann may substitute KTN for 240 V frequency converters.

FWH-fuses from Bussmann may substitute FWX for 240 V frequency converters.

KLSR fuses from LITTEL FUSE may substitute KLNR fuses for 240 V frequency converters.

L50S fuses from LITTEL FUSE may substitute L50S fuses for 240 V frequency converters.

A6KR fuses from FERRAZ SHAWMUT may substitute A2KR for 240 V frequency converters.

A50X fuses from FERRAZ SHAWMUT may substitute A25X for 240 V frequency converters.

380-500 V

	Bussmann	Bussmann	Bussmann	Bussmann	Bussmann	Bussmann
kW	Type RK1	Type J	Type T	Type CC	Type CC	Type CC
K37-1K1	KTS-R6	JKS-6	JJS-6	FNQ-R-6	KTK-R-6	LP-CC-6
1K5-2K2	KTS-R10	JKS-10	JJS-10	FNQ-R-10	KTK-R-10	LP-CC-10
3K0	KTS-R15	JKS-15	JJS-15	FNQ-R-15	KTK-R-15	LP-CC-15
4K0	KTS-R20	JKS-20	JJS-20	FNQ-R-20	KTK-R-20	LP-CC-20
5K5	KTS-R25	JKS-25	JJS-25	FNQ-R-25	KTK-R-25	LP-CC-25
7K5	KTS-R30	JKS-30	JJS-30	FNQ-R-30	KTK-R-30	LP-CC-30
11K	KTS-R40	JKS-40	JJS-40	-	-	-
15K	KTS-R50	JKS-50	JJS-50	-	-	-
18K	KTS-R60	JKS-60	JJS-60	-	-	-
22K	KTS-R80	JKS-80	JJS-80	-	-	-
30K	KTS-R100	JKS-100	JJS-100	-	-	-
37K	KTS-R125	JKS-150	JJS-150	-	-	-
45K	KTS-R150	JKS-150	JJS-150	-	-	-

	SIBA	Littel fuse	Ferraz-Shawmut	Ferraz-Shawmut
kW	Type RK1	Type RK1	Type CC	Type RK1
K37-1K1	5017906-006	KLS-R6	ATM-R6	A6K-6R
1K5-2K2	5017906-010	KLS-R10	ATM-R10	A6K-10R
3K0	5017906-016	KLS-R15	ATM-R15	A6K-15R
4K0	5017906-020	KLS-R20	ATM-R20	A6K-20R
5K5	5017906-025	KLS-R25	ATM-R25	A6K-25R
7K5	5012406-032	KLS-R30	ATM-R30	A6K-30R
11K	5014006-040	KLS-R40	-	A6K-40R
15K	5014006-050	KLS-R50	-	A6K-50R
18K	5014006-063	KLS-R60	-	A6K-60R
22K	2028220-100	KLS-R80	-	A6K-80R
30K	2028220-125	KLS-R100	-	A6K-100R
37K	2028220-125	KLS-R125	-	A6K-125R
45K	2028220-160	KLS-R150	-	A6K-150R

	Bussmann	Bussmann	Bussmann	Bussmann
kW	JFHR2	Type H	Type T	JFHR2
55K	FWH-200	-	-	-
75K	FWH-250	-	-	-
90K	FWH-300	NOS-300	JJS-300	170M3017
P110	FWH-350	NOS-350	JJS-350	170M3018
P132	FWH-400	NOS-400	JJS-400	170M4012
P160	FWH-500	NOS-500	JJS-500	170M4014
P200	FWH-600	NOS-600	JJS-600	170M4016
P250	-	-	-	170M4017
				170M5013
P315	-	-	-	170M6013
P355	-	-	-	170M6013
P400	-	-	-	170M6013

	SIBA	Littel fuse	Ferraz-Shawmut	Ferraz-Shawmut
kW	Type RK1	JFHR2	JFHR2	JFHR2
55K	2028220-200	L50S-225	-	A50-P225
75K	2028220-250	L50S-250		A50-P250
90K	2028220-315	L50S-300	-	A50-P300
P110	2028220-315	L50S-350	-	A50-P350
P132	206xx32-400	L50S-400	-	A50-P400
P160	206xx32-500	L50S-500	-	A50-P500
P200	206xx32-600	L50S-600	-	A50-P600
P250	2061032.700	-	6.9URD31D08A0700	-
P315	2063032.900	-	6.9URD33D08A0900	-
P355	2063032.900	-	6.9URD33D08A0900	-
P400	2063032.900	-	6.9URD33D08A0900	-

Ferraz-Shawmut A50QS fuses may be substituted for A50P fuses.

170M fuses shown from Bussmann use the -/80 visual indicator. –TN/80 Type T, -/110 or TN/110 Type T indicator fuses of the same size and amperage may be substituted.

550 - 600V

	Bussmann	Bussmann	Bussmann	Bussmann	Bussmann	Bussmann
kW	Type RK1	Type J	Type T	Type CC	Type CC	Type CC
K75-1K5	KTS-R-5	JKS-5	JJS-6	FNQ-R-5	KTK-R-5	LP-CC-5
2K2-4K0	KTS-R10	JKS-10	JJS-10	FNQ-R-10	KTK-R-10	LP-CC-10
5K5-7K5	KTS-R20	JKS-20	JJS-20	FNQ-R-20	KTK-R-20	LP-CC-20

	SIBA	Littel fuse	Ferraz-Shawmut
kW	Type RK1	Type RK1	Type RK1
K75-1K5	5017906-005	KLSR005	A6K-5R
2K2-4K0	5017906-010	KLSR010	A6K-10R
5K5-7K5	5017906-020	KLSR020	A6K-20R

	Bussmann	SIBA	Ferraz-Shawmut
kW	JFHR2	Type RK1	Type RK1
P37K	170M3013	2061032.125	6.6URD30D08A0125
P45K	170M3014	2061032.160	6.6URD30D08A0160
P55K	170M3015	2061032.200	6.6URD30D08A0200
P75K	170M3015	2061032.200	6.6URD30D08A0200
P90K	170M3016	2061032.250	6.6URD30D08A0250
P110K	170M3017	2061032.315	6.6URD30D08A0315
P132K	170M3018	2061032.350	6.6URD30D08A0350
P160K	170M4011	2061032.350	6.6URD30D08A0350
P200K	170M4012	2061032.400	6.6URD30D08A0400
P250K	170M4014	2061032.500	6.6URD30D08A0500
P315K	170M5011	2062032.550	6.6URD32D08A0550
P355K	170M4017	2061032.700	6.9URD31D08A0700
	170M5013		
P400K	170M4017	2061032.700	6.9URD31D08A0700
	170M5013		
P500K	170M6013	2063032.900	6.9URD33D08A0900
P560K	170M6013	2063032.900	6.9URD33D08A0900

6

170M fuses shown from Bussmann use the -/80 visual indicator. –TN/80 Type T, -/110 or TN/110 Type T indicator fuses of the same size and amperage may be substituted.

170M fuses from Bussmann when provided in the 525-600/690 V FC 302 P37K-P75K frequency converters are 170M3015.

170M fuses from Bussmann when provided in the 525-600/690V FC 302 P90K-P132 frequency converters are 170M3018.

170M fuses from Bussmann when provided in the 525-600/690V FC 302 P160-P315 frequency converters are 170M5011.

6.6.2. Access to Control Terminals

All terminals to the control cables are located underneath the terminal cover on the front of the frequency converter. Remove the terminal cover by means of a screwdriver (see illustration).

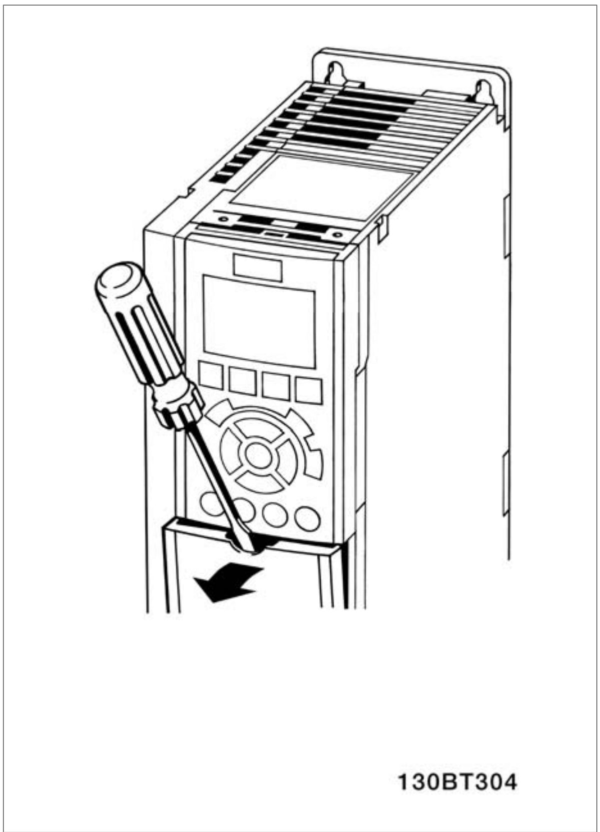


Illustration 6.49: A1, A2, A3,B3, B4, C3 and C4 enclosures

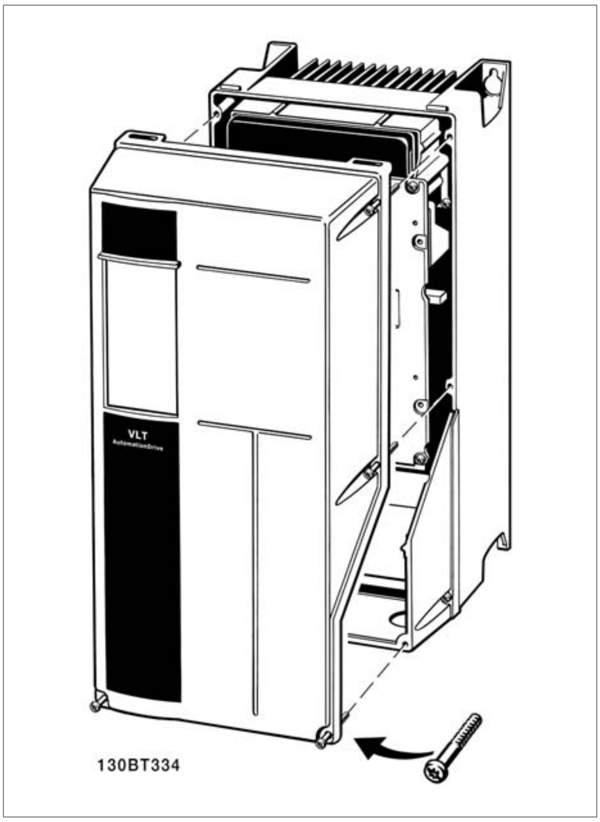


Illustration 6.50: A5, B1, B2, C1 and C2 enclosures

6.6.3. Control Terminals

Control Terminals, FC 301

Drawing reference numbers:

1. 8 pole plug digital I/O.
2. 3 pole plug RS485 Bus.
3. 6 pole analog I/O.
4. USB Connection.

Control Terminals, FC 302

Drawing reference numbers:

1. 10 pole plug digital I/O.
2. 3 pole plug RS485 Bus.
3. 6 pole analog I/O.
4. USB Connection.

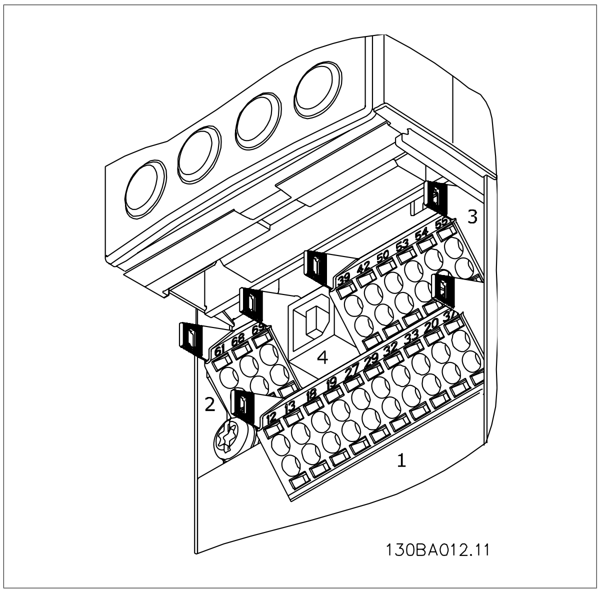


Illustration 6.51: Control terminals (all enclosures)

6.6.4. Electrical Installation, Control Terminals

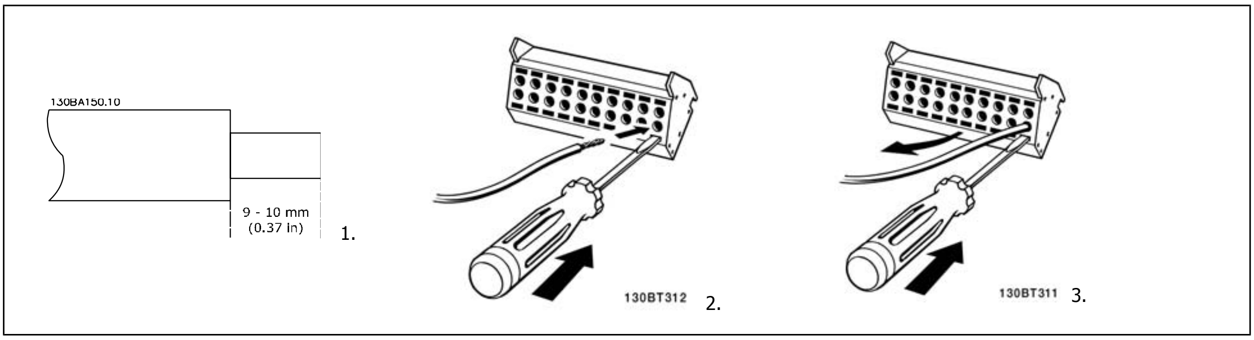
To mount the cable to the terminal:

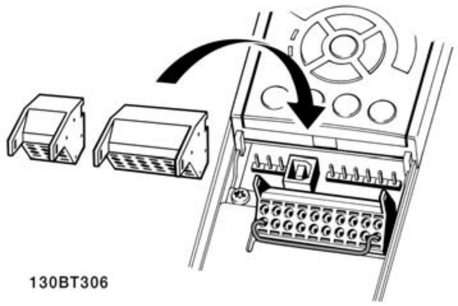
1. Strip insulation of 9-10 mm
2. Insert a screwdriver[1)] in the square hole.
3. Insert the cable in the adjacent circular hole.
4. Remove the screw driver. The cable is now mounted to the terminal.

To remove the cable from the terminal:

1. Insert a screwdriver[1)] in the square hole.
2. Pull out the cable.

[1)] Max. 0.4 x 2.5 mm

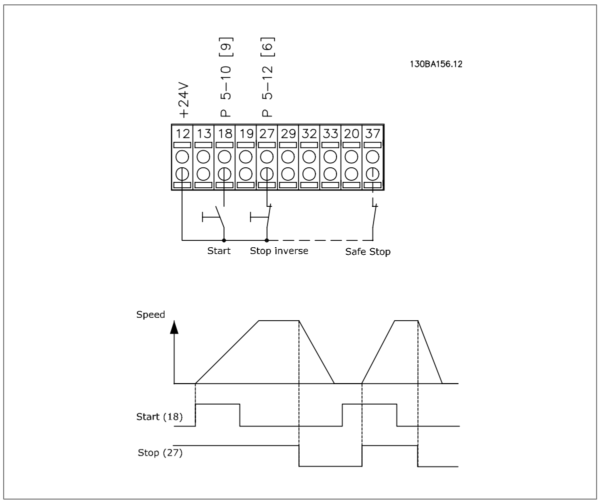



130BT306

6.6.5. Basic Wiring Example

1. Mount terminals from the accessory bag to the front of the frequency converter.
2. Connect terminals 18, 27 and 37 (FC 302 only) to +24 V (terminal 12/13)

Default settings:
18 = Start, Par 5-10 [9]
27 = Stop inverse, Par 5-12 [6]
37 = safe stop inverse



6

6.6.6. Electrical Installation, Control Cables

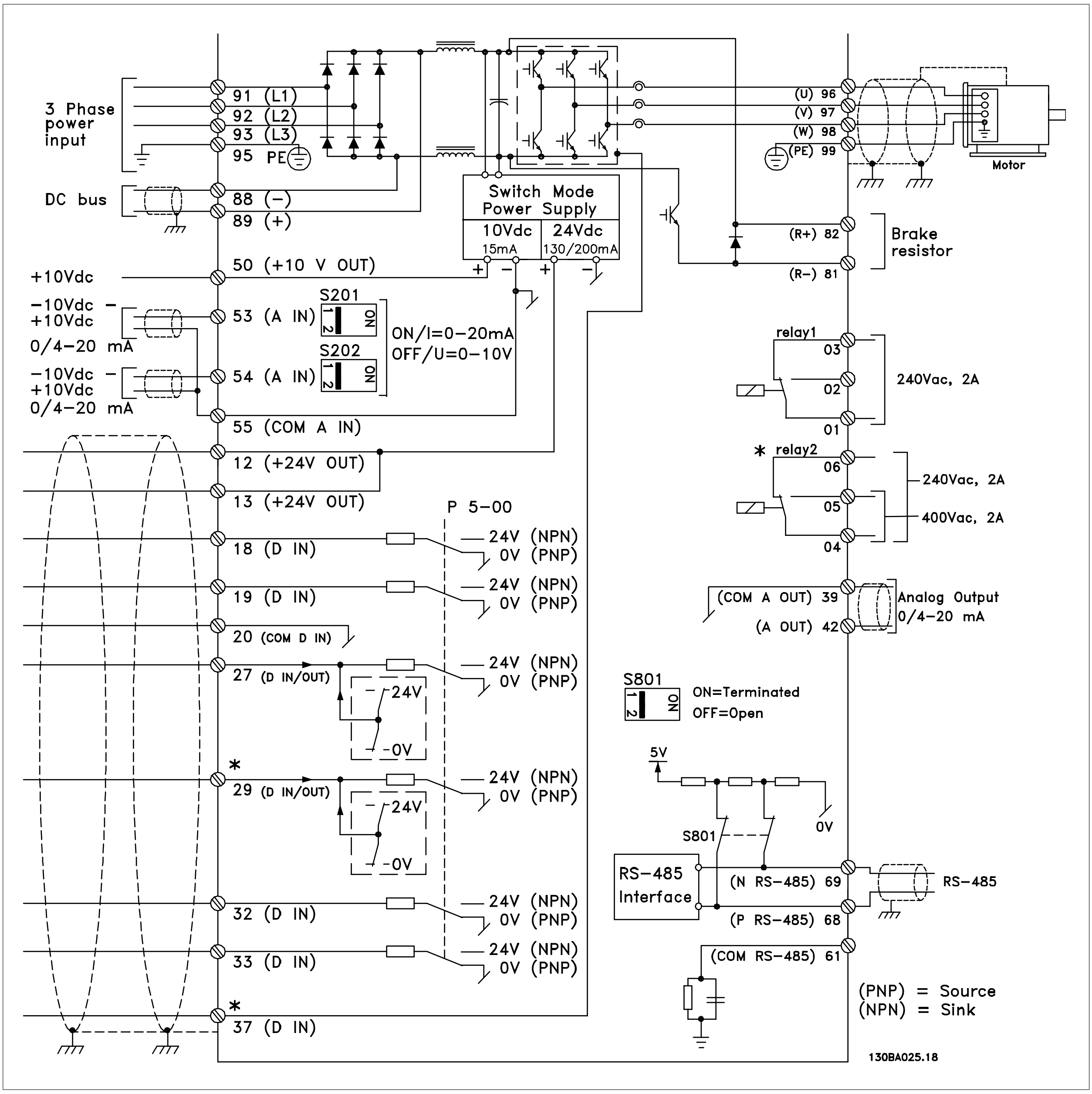


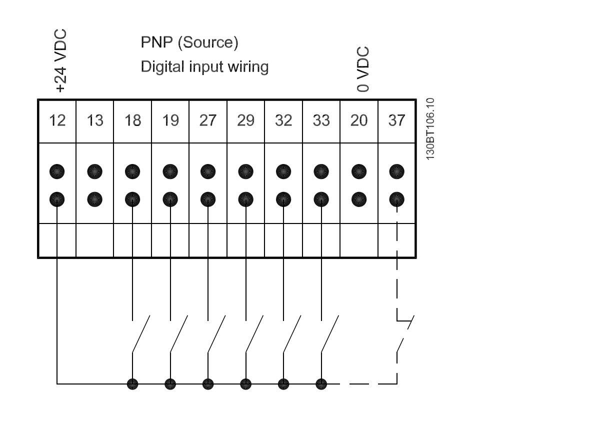
Illustration 6.52: Diagram showing all electrical terminals without options.
Terminal 37 is the input to be used for Safe Stop. For instructions on Safe Stop installation please refer to the section *Safe Stop Installation* of the Design Guide.
* Terminal 37 is not included in FC 301 (Except FC 301 A1, which includes Safe Stop).
Terminal 29 and Relay 2, are not included in FC 301.

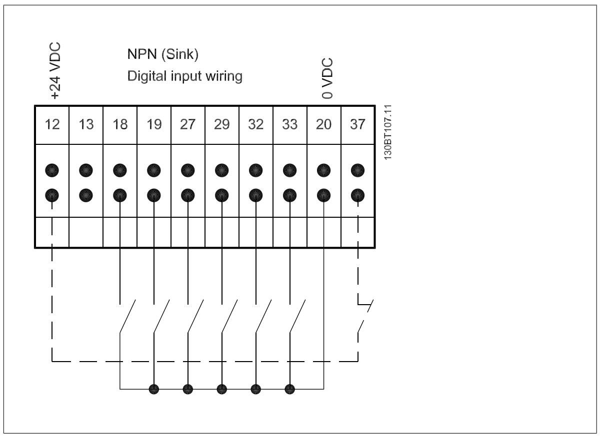
Very long control cables and analogue signals may in rare cases and depending on installation result in 50/60 Hz earth loops due to noise from mains supply cables.

If this occurs, it may be necessary to break the screen or insert a 100 nF capacitor between screen and chassis.

The digital and analogue in- and outputs must be connected separately to the common inputs (terminal 20, 55, 39) of the frequency converter to avoid ground currents from both groups to affect other groups. For example, switching on the digital input may disturb the analog input signal.

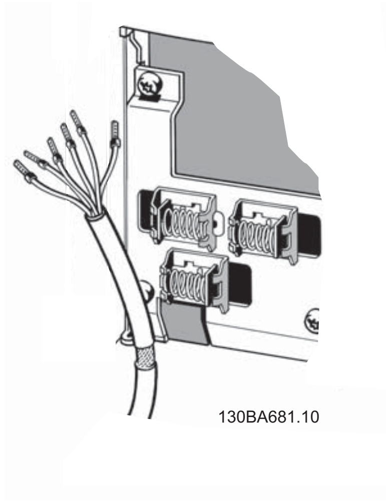
Input polarity of control terminals





NB!
Control cables must be screened/armoured.

See section entitled *Earthing of Screened/Armoured Control Cables* for the correct termination of control cables.



6.6.7. Motor Cables

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

- Use a screened/armoured motor cable to comply with EMC emission specifications.
- Keep the motor cable as short as possible to reduce the noise level and leakage currents.
- Connect the motor cable screen to both the decoupling plate of the frequency converter and to the metal cabinet of the motor.
- Make the screen connections with the largest possible surface area (cable clamp). This is done by using the supplied installation devices in the frequency converter.
- Avoid mounting with twisted screen ends (pigtails), which will spoil high frequency screening effects.
- If it is necessary to split the screen to install a motor isolator or motor relay, the screen must be continued with the lowest possible HF impedance.

6.6.8. Electrical Installation of Motor Cables

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

Cable length and cross-section

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

Switching frequency

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

Aluminium conductors

Aluminium conductors are not recommended. Terminals can accept aluminium conductors but the conductor surface has to be clean and the oxidation must be removed and sealed by neutral acid free Vaseline grease before the conductor is connected.

Furthermore, the terminal screw must be retightened after two days due to the softness of the aluminium. It is crucial to keep the connection a gas tight joint, otherwise the aluminium surface will oxidize again.

6.6.9. Switches S201, S202, and S801

Switches S201 (A53) and S202 (A54) are used to select a current (0-20 mA) or a voltage (-10 to 10 V) configuration of the analog input terminals 53 and 54 respectively.

Switch S801 (BUS TER.) can be used to enable termination on the RS-485 port (terminals 68 and 69).

See drawing *Diagram showing all electrical terminals* in section *Electrical Installation.*

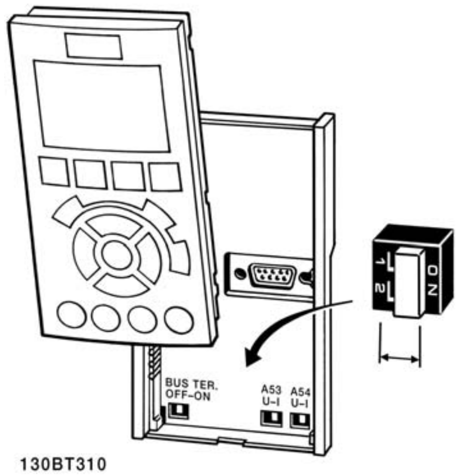
Default setting:

S201 (A53) = OFF (voltage input)

S202 (A54) = OFF (voltage input)

S801 (Bus termination) = OFF

!	When changing the function of S201, S202 or S801 be careful not to use force for the switch over. It is recommended to remove the LCP fixture (cradle) when operating the switches. The switches must not be operated with power on the frequency converter.

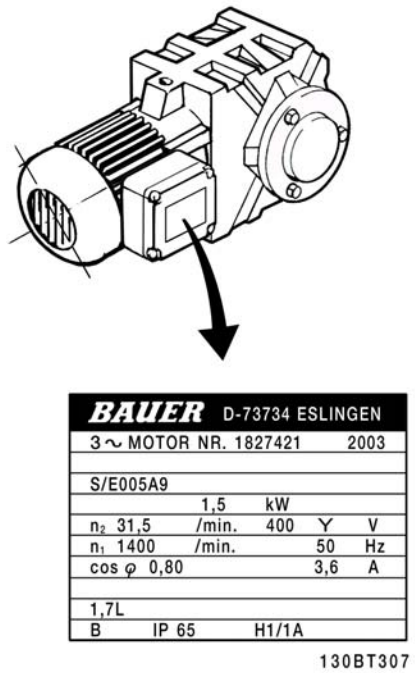


6.7.1. Final Set-Up and Test

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

Step 1. Locate the motor name plate

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



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

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

Step 3. Activate the Automatic Motor Adaptation (AMA)

Performing an AMA will ensure optimum performance. The AMA measures the values from the motor model equivalent diagram.

1. Connect terminal 37 to terminal 12 (if terminal 37 is available).
2. Connect terminal 27 to terminal 12 or set par. 5-12 to 'No function' (par. 5-12 [0])
3. Activate the AMA par. 1-29.
4. Choose between complete or reduced AMA. If a Sine-wave filter is mounted, run only the reduced AMA, or remove the Sine-wave filter during the AMA procedure.
5. Press the [OK] key. The display shows "Press [Hand on] to start".
6. Press the [Hand on] key. A progress bar indicates if the AMA is in progress.

Stop the AMA during operation

1. Press the [OFF] key - the frequency converter enters into alarm mode and the display shows that the AMA was terminated by the user.

Successful AMA

1. The display shows "Press [OK] to finish AMA".
2. Press the [OK] key to exit the AMA state.

Unsuccessful AMA

1. The frequency converter enters into alarm mode. A description of the alarm can be found in the *Warnings and Alarms* chapter.
2. "Report Value" in the [Alarm Log] shows the last measuring sequence carried out by the AMA, before the frequency converter entered alarm mode. This number along with the description of the alarm will assist you in troubleshooting. If you contact Danfoss for service, make sure to mention number and alarm description.

NB!

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

Step 4. Set speed limit and ramp time

Minimum Reference	par. 3-02
Maximum Reference	par. 3-03

Table 6.6: Set up the desired limits for speed and ramp time.

Motor Speed Low Limit	par. 4-11 or 4-12
Motor Speed High Limit	par. 4-13 or 4-14

Ramp-up Time 1 [s]	par. 3-41
Ramp-down Time 1 [s]	par. 3-42

6.8. Additional Connections

6.8.1. DC bus connection

The DC bus terminal is used for DC back-up, with the intermediate circuit being supplied from an external source.

Terminal numbers used: 88, 89

Please contact Danfoss if you require further information.

6.8.2. Installation of Load sharing

The connection cable must be screened and the max. length from the frequency converter to the DC bar is 25 metres.

NB!
DC bus and load sharing calls for extra equipment and safety considerations. For further information, see Load sharing Instructions MI.50.NX.YY.

NB!
Voltages up to 975 V DC (@ 600 V AC) may occur between the terminals.

6

6.8.3. Brake Connection Option

The connection cable to the brake resistor must be screened/armoured.

Enclosure	A+B+C+D+F	A+B+C+D+F
Brake resistor	81	82
Terminals	R-	R+

NB!
Dynamic brake calls for extra equipment and safety considerations. For further information, please contact Danfoss.

1. Use cable clamps to connect the screen to the metal cabinet of the frequency converter and to the decoupling plate of the brake resistor.
2. Dimension the cross-section of the brake cable to match the brake current.

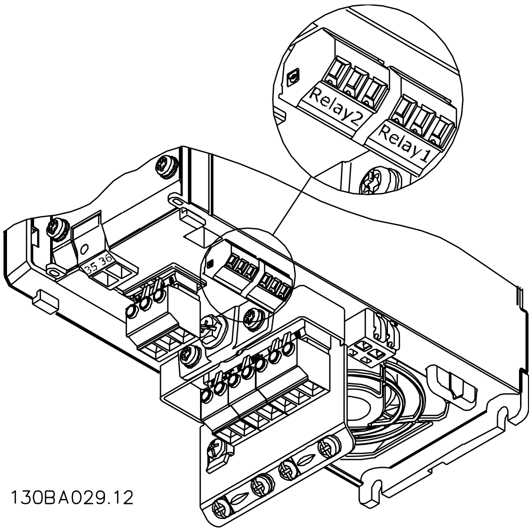
NB!
Voltages up to 975 V DC (@ 600 V AC) may occur between the terminals.

NB!
If a short circuit in the brake IGBT occurs, prevent power dissipation in the brake resistor by using a mains switch or contactor to disconnect the mains for the frequency converter. Only the frequency converter shall control the contactor.

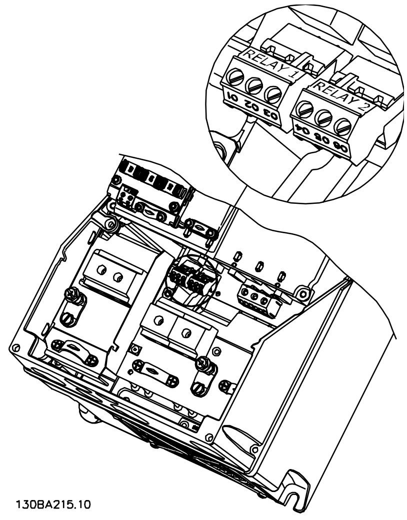
6.8.4. Relay Connection

To set relay output, see par. group 5-4* Relays.

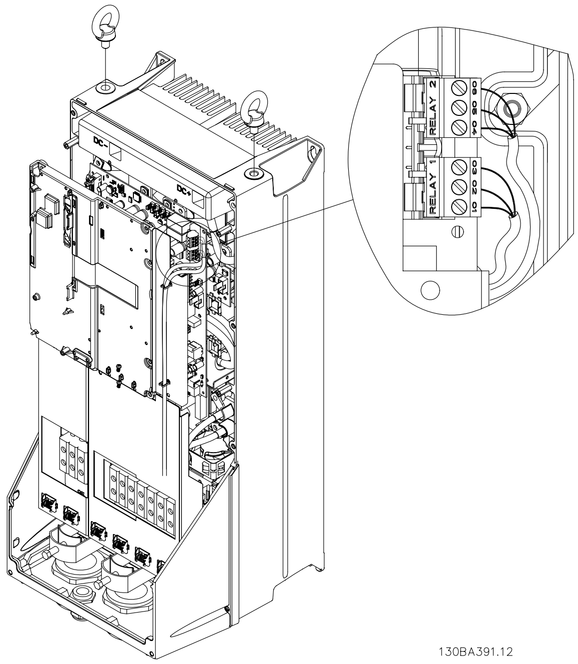
No.		
	01 - 02	make (normally open)
	01 - 03	break (normally closed)
	04 - 05	make (normally open)
	04 - 06	break (normally closed)



Terminals for relay connection
(Frame sizes A1, A2 and A3).



Terminals for relay connection
(Frame sizes A5, B1 and B2).



Terminals for relay connection
(Frame sizes C1 and C2).

Relay connection terminals for D and E enclosures are shown in the section *Electrical Installation - D and E enclosures*

6.8.5. Relay Output

Relay 1

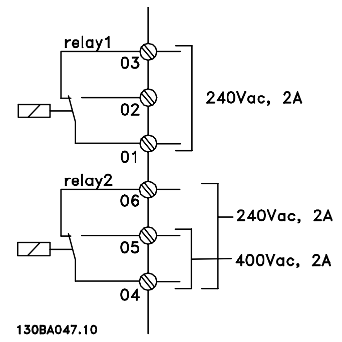
- Terminal 01: common
- Terminal 02: normal open 240 V AC
- Terminal 03: normal closed 240 V AC

Relay 2 (Not FC 301)

- Terminal 04: common
- Terminal 05: normal open 400 V AC
- Terminal 06: normal closed 240 V AC

Relay 1 and relay 2 are programmed in par. 5-40, 5-41, and 5-42.

Additional relay outputs by using option module MCB 105.



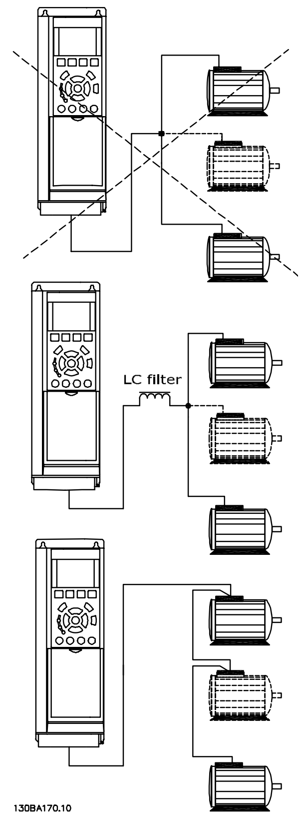
6

6.8.6. Parallel Connection of Motors

The frequency converter can control several parallel-connected motors. The total current consumption of the motors must not exceed the rated output current I_{INV} for the frequency converter.
This is only recommended when U/f is selected in par. 1-01.

NB!
Installations with cables connected in a common joint as in illustration 1 is only recommended for short cable lengths.

NB!
When motors are connected in parallel, par. 1-02 *Automatic Motor Adaptation (AMA)* cannot be used, and par. 1-01 *Motor Control Principle* must be set to *Special motor characteristics (U/f)*.



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

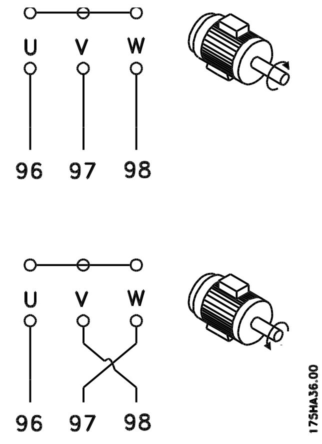
The electronic thermal relay (ETR) of the frequency converter cannot be used as motor protection for the individual motor of systems with parallel-connected motors. Provide further motor protection by e.g. thermistors in each motor or individual thermal relays. (Circuit breakers are not suitable as protection).

6.8.7. Direction of Motor Rotation

The default setting is clockwise rotation with the frequency converter output connected as follows.

Terminal 96 connected to U-phase
Terminal 97 connected to V-phase
Terminal 98 connected to W-phase

Thedirection of motor rotation is changed by switching two motor phases.



6.8.8. Motor Thermal Protection

The electronic thermal relay in the frequency converter has received the UL-approval for single motor protection, when par. 1-90 *Motor Thermal Protection* is set for *ETR Trip* and par. 1-24 *Motor current,* $I_{M,N}$ is set to the rated motor current (see motor name plate).
For thermal motor protection it is also possible to use the MCB 112 PTC Thermistor Card option. This card provides ATEX certificate to protect motors in explosion hazardous areas, Zone 1/21 and Zone 2/22. Please refer to the *Design Guide* for further information.

6.9.1. Installation of Brake Cable

(Only for frequency converters ordered with brake chopper option).

The connection cable to the brake resistor must be screened.

1. Connect the screen by means of cable clamps to the conductive back plate on the frequency converter and to the metal cabinet of the brake resistor.
2. Size the brake cable cross-section to match the brake torque.

No.	Function
81, 82	Brake resistor terminals

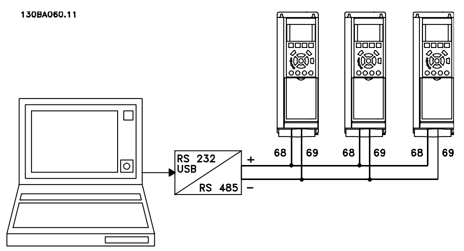
See Brake instructions, MI.90.FX.YY and MI.50.SX.YY for more information about safe installation.

NB!
Voltages up to 960 V DC, depending on the supply voltage, may occur on the terminals.

6.9.2. RS 485 Bus Connection

One or more frequency converters can be connected to a control (or master) using the RS485 standardized interface. Terminal 68 is connected to the P signal (TX+, RX+), while terminal 69 is connected to the N signal (TX-,RX-).

If more than one frequency converter is connected to a master, use parallel connections.



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

Bus termination

The RS485 bus must be terminated by a resistor network at both ends. For this purpose, set switch S801 on the control card for "ON".
For more information, see the paragraph *Switches S201, S202, and S801*.

NB!
Communication protocol must be set to FC MC par. 8-30.

6.9.3. How to Connect a PC to the frequency converter

To control the frequency converter from a PC, install the MCT 10 Set-up Software.
The PC is connected via a standard (host/device) USB cable, or via the RS485 interface as shown in the section *Bus Connection* in the Programming Guide.

NB!
The USB connection is galvanically isolated from the supply voltage (PELV) and other high-voltage terminals. The USB connection is connected to protection earth on the frequency converter. Use only isolated laptop as PC connection to the USB connector on the frequency converter.

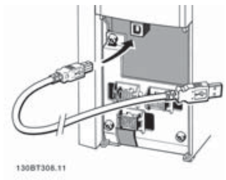


Illustration 6.53: USB connection.

6.9.4. The FC 300 PC Software

Data storage in PC via MCT 10 Set-Up Software:

1. Connect a PC to the unit via USB com port
2. Open MCT 10 Set-up Software
3. Select in the "network" section the USB port
4. Choose "Copy"
5. Select the "project" section
6. Choose "Paste"
7. Choose "Save as"

All parameters are now stored.

Data transfer from PC to drive via MCT 10 Set-Up Software:

1. Connect a PC to the unit via USB com port
2. Open MCT 10 Set-up software
3. Choose "Open"– stored files will be shown
4. Open the appropriate file
5. Choose "Write to drive"

All parameters are now transferred to the drive.

A separate manual for MCT 10 Set-up Software is available.

6.10.1. High Voltage Test

Carry out a high voltage test by short-circuiting terminals U, V, W, L_1, L_2 and L_3. Energize by max. 2.15 kV DC for one second between this short-circuit and the chassis.

NB!
When running high voltage tests of the entire installation, interrupt the mains and motor connection if the leakage currents are too high.

6.10.2. Safety Earth Connection

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

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

6.11.1. Electrical Installation - EMC Precautions

The following is a guideline to good engineering practice when installing frequency converters. Follow these guidelines to comply with EN 61800-3 *First environment*. If the installation is in EN 61800-3 *Second environment,* i.e. industrial networks, or in an installation with its own transformer, deviation from these guidelines is allowed but not recommended. See also paragraphs *CE Labelling, General Aspects of EMC Emission* and *EMC Test Results*.

Good engineering practice to ensure EMC-correct electrical installation:

- Use only braided screened/armoured motor cables and braided screened/armoured control cables. The screen should provide a minimum coverage of 80%. The screen material must be metal, not limited to but typically copper, aluminium, steel or lead. There are no special requirements for the mains cable.
- Installations using rigid metal conduits are not required to use screened cable, but the motor cable must be installed in conduit separate from the control and mains cables. Full connection of the conduit from the drive to the motor is required. The EMC performance of flexible conduits varies a lot and information from the manufacturer must be obtained.
- Connect the screen/armour/conduit to earth at both ends for motor cables as well as for control cables. In some cases, it is not possible to connect the screen in both ends. If so, connect the screen at the frequency converter. See also *Earthing of Braided Screened/Armoured Control Cables*.
- Avoid terminating the screen/armour with twisted ends (pigtails). It increases the high frequency impedance of the screen, which reduces its effectiveness at high frequencies. Use low impedance cable clamps or EMC cable glands instead.
- Avoid using unscreened/unarmoured motor or control cables inside cabinets housing the drive(s), whenever this can be avoided.

Leave the screen as close to the connectors as possible.

The illustration shows an example of an EMC-correct electrical installation of an IP 20 frequency converter. The frequency converter is fitted in an installation cabinet with an output contactor and connected to a PLC, which is installed in a separate cabinet. Other ways of doing the installation may have just as good an EMC performance, provided the above guide lines to engineering practice are followed.

If the installation is not carried out according to the guideline and if unscreened cables and control wires are used, some emission requirements are not complied with, although the immunity requirements are fulfilled. See the paragraph *EMC test results*.

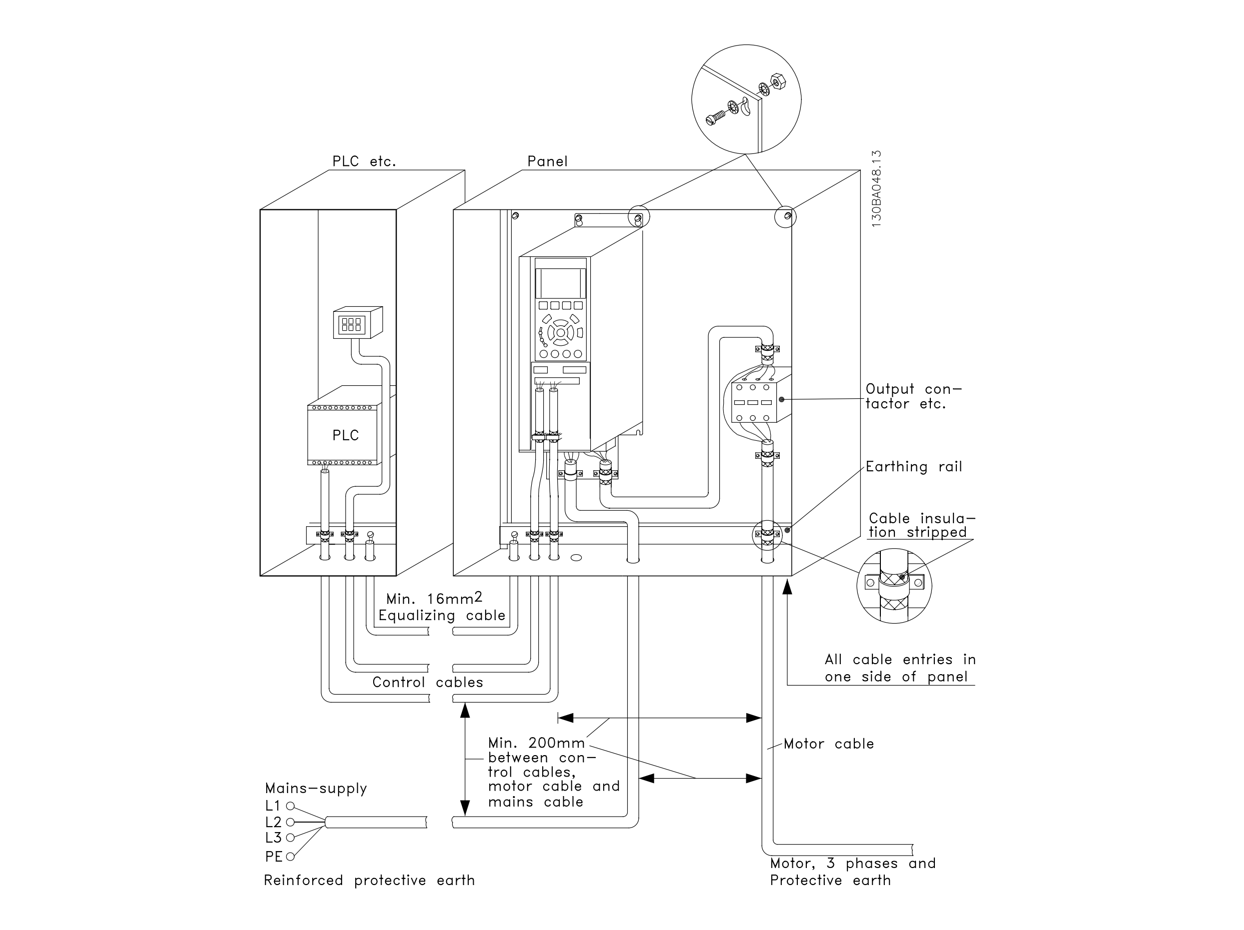


Illustration 6.54: EMC-correct electrical installation of a frequency converter in cabinet.

6

6.11.2. Use of EMC-Correct Cables

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

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

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

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

- The conductibility of the screen material.
- The contact resistance between the individual screen conductors.
- The screen coverage, i.e. the physical area of the cable covered by the screen - often stated as a percentage value.
- Screen type, i.e. braided or twisted pattern.

a. Aluminium-clad with copper wire.1

b. Twisted copper wire or armoured steel wire cable. 1

c. Single-layer braided copper wire with varying percentage screen coverage.
This is the typical Danfoss reference cable.1

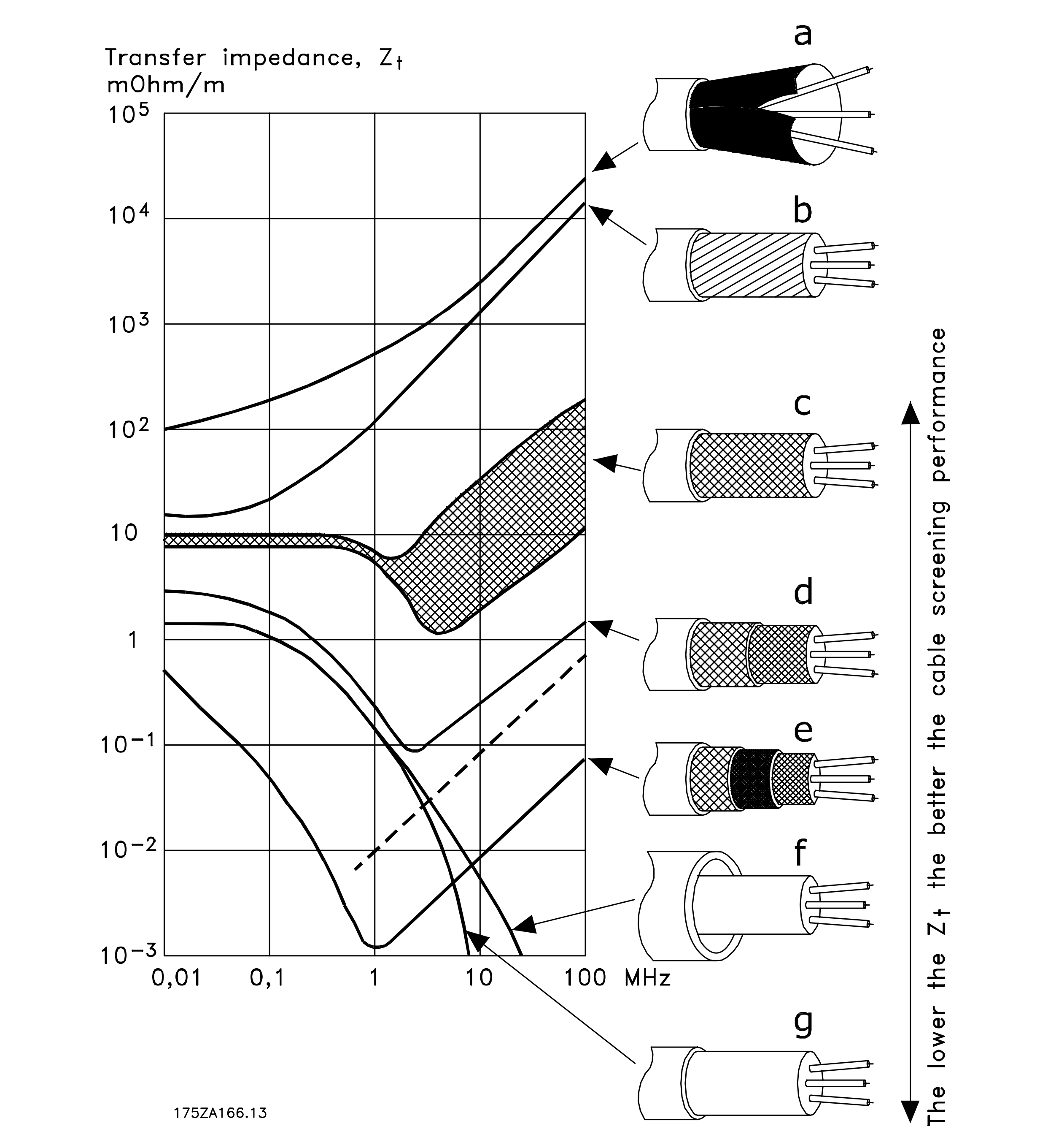
d. Double-layer braided copper wire.1

e. Twin layer of braided copper wire with a magnetic, screened/armoured intermediate layer.1

f. Cable that runs in copper tube or steel tube.1

g. Lead cable with 1.1 mm wall thickness.1

6


Transfer impedance, Zt
mOhm/m
10^5
10^4
10^3
10^2
10
1
10^-1
10^-2
10^-3
0,01
0,1
1
10
100 MHz
a
b
c
d
e
f
g
The lower the Zt the better the cable screening performance
175ZA166.13

6.11.3. Earthing of Screened/Armoured Control Cables

Generally speaking, control cables must be braided screened/armoured and the screen must be connected by means of a cable clampat both ends to the metal cabinet of the unit.

The drawing below indicates how correct earthing is carried out and what to do if in doubt.

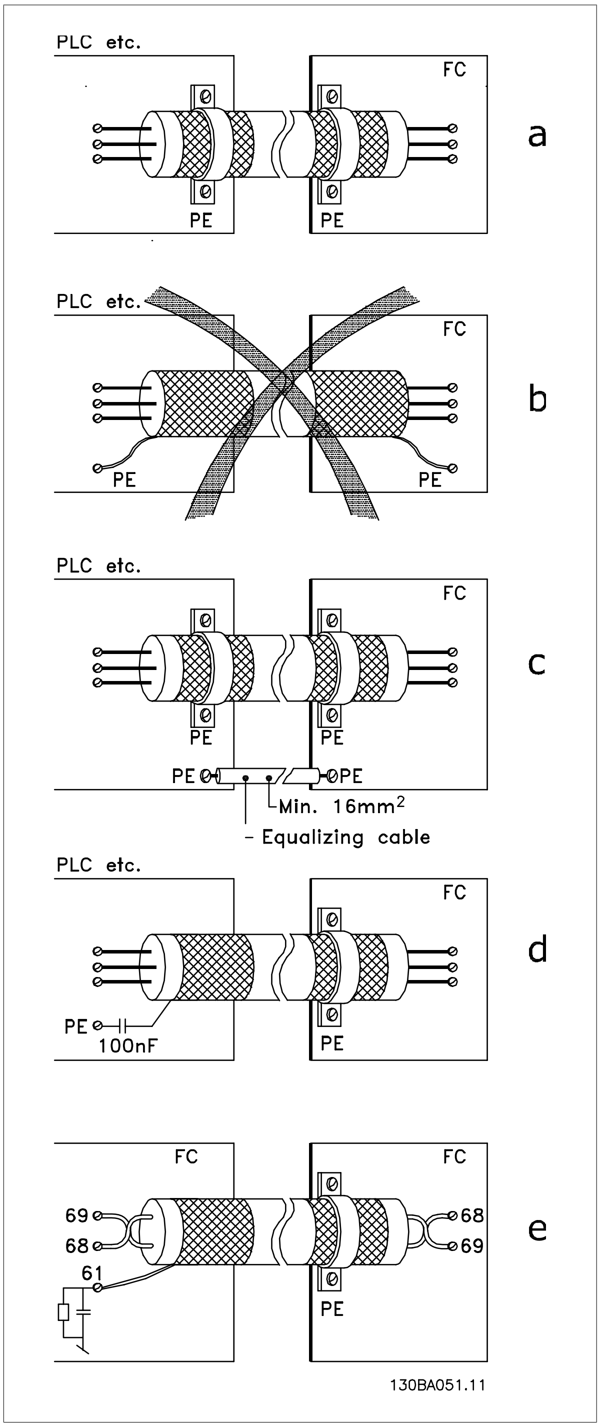
a. **Correct earthing**
Control cables and cables for serial communication must be fitted with cable clamps at both ends to ensure the best possible electrical contact.1

b. **Wrong earthing**
Do not use twisted cable ends (pigtails). They increase the screen impedance at high frequencies.1

c. **Protection with respect to earth potential between PLC and**
If the earth potential between the frequency converter and the PLC (etc.) is different, electric noise may occur that will disturb the entire system. Solve this problem by fitting an equalising cable, next to the control cable. Minimum cable cross-section: 16 mm ^{2}.1

d. **For 50/60 Hz earth loops**
If very long control cables are used, 50/60 Hz earth loops may occur. Solve this problem by connecting one end of the screen to earth via a 100nF capacitor (keeping leads short).1

e. **Cables for serial communication**
Eliminate low-frequency noise currents between two frequency converters by connecting one end of the screen to terminal 61. This terminal is connected to earth via an internal RC link. Use twisted-pair cables to reduce the differential mode interference between the conductors.1

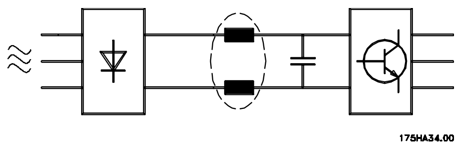


6.12.1. Mains Supply Interference/Harmonics

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

Harmonic currents	I_1	I_5	I_7
Hz	50 Hz	250 Hz	350 Hz

The harmonics do not affect the power consumption directly but increase the heat losses in the installation (transformer, cables). Consequently, 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.



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

Harmonic currents compared to the RMS input current:

	Input current
I_{RMS}	1.0
I_1	0.9
I_5	0.4
I_7	0.2
I_{11-49}	< 0.1

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 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 on the basis of the individual voltage harmonics using this formula:

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

(U_N% of U)

6.13.1. Residual Current Device

You can use RCD relays, multiple protective earthing or earthing as extra protection, provided that local safety regulations are complied with.

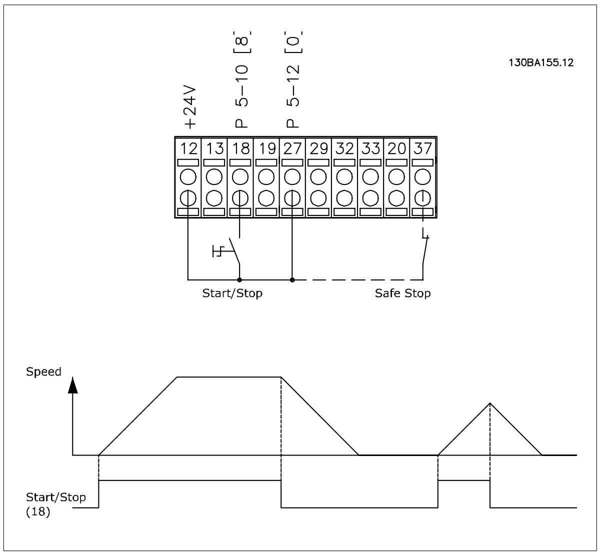
If an earth fault appears, a DC content may develop in the faulty current.

If RCD relays are used, you must observe local regulations. Relays must be suitable for protection of 3-phase equipment with a bridge rectifier and for a brief discharge on power-up see section *Earth Leakage Current* for further information.

7. Application Examples

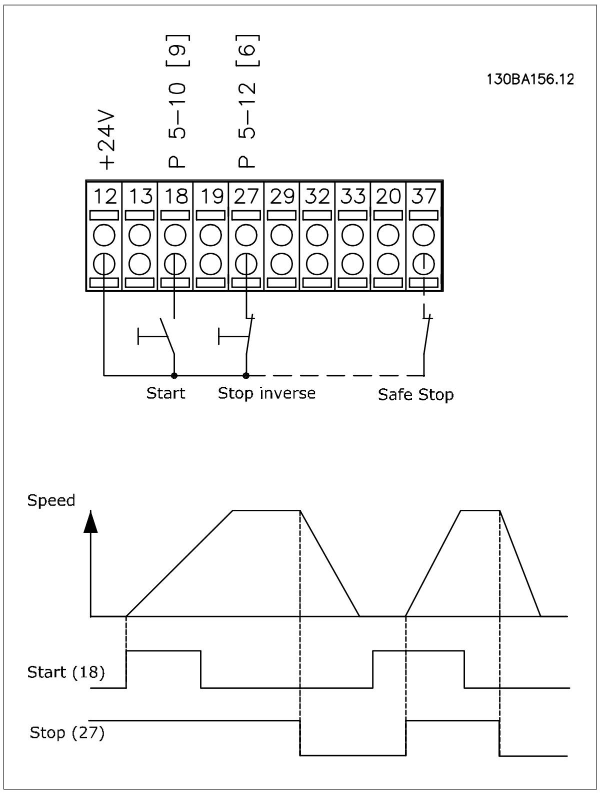
7.1.1. Start/Stop

Terminal 18 = Par. 5-10 [8] *Start*
Terminal 27 = Par. 5-12 [0] *No operation* (Default *coast inverse*)
Terminal 37 = Safe stop (where available!)



7.1.2. Pulse Start/Stop

Terminal 18 = Par. 5-10 [9] *Latched start*
Terminal 27= Par. 5-12 [6] *Stop inverse*
Terminal 37 = Safe stop (where available!)



7.1.3. Potentiometer Reference

Voltage reference via a potentiometer:

Reference Source 1 = [1] *Analogue input 53* (default)

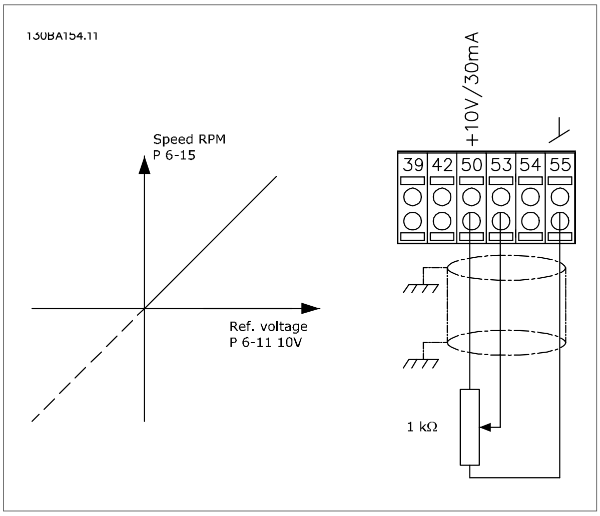
Terminal 53, Low Voltage = 0 Volt

Terminal 53, High Voltage = 10 Volt

Terminal 53, Low Ref./Feedback = 0 RPM

Terminal 53, High Ref./Feedback = 1500 RPM

Switch S201 = OFF (U)

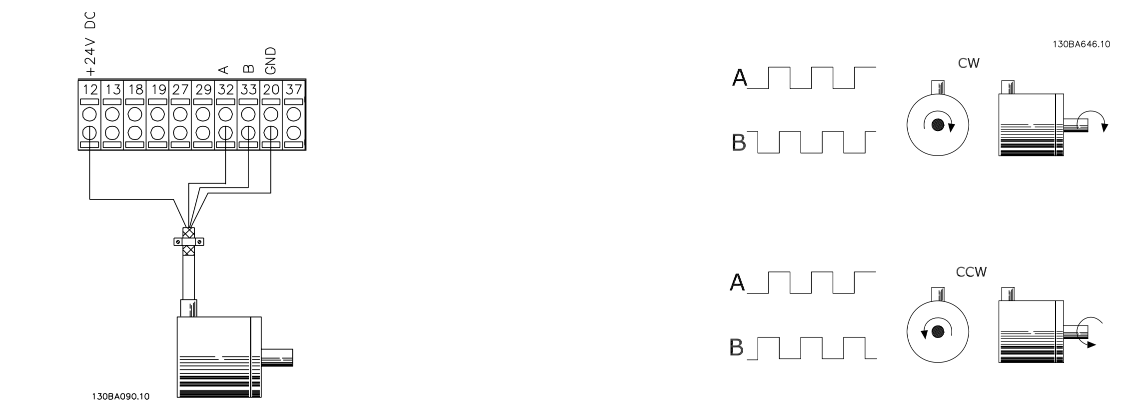


7

7.1.4. Encoder Connection

The purpose of this guideline is to ease the set-up of encoder connection to the frequency converter. Before setting up the encoder the basic settings for a closed loop speed control system will be shown.

Encoder Connection to the frequency converter



24 V incremental encoder. Max. cable length 5 m.

7.1.5. Encoder Direction

The direction of encoder is determined by which order the pulses are entering the drive.
Clockwise direction means channel A is 90 electrical degrees before channel B.
Counter Clockwise direction means channel B is 90 electrical degrees before A.
The direction determined by looking into the shaft end.

7.1.6. Closed Loop Drive System

A drive system consist usually of more elements such as:

- Motor
- Add
  (Gearbox)
  (Mechanical Brake)
- FC 302 AutomationDrive
- Encoder as feed-back system
- Brake resistor for dynamic braking
- Transmission
- Load

Applications demanding mechanical brake control will usually need a brake resistor.

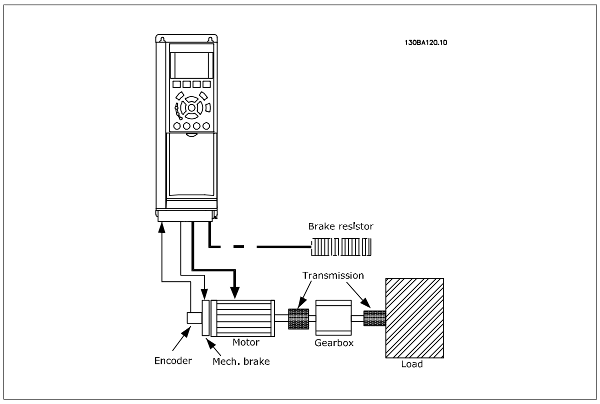


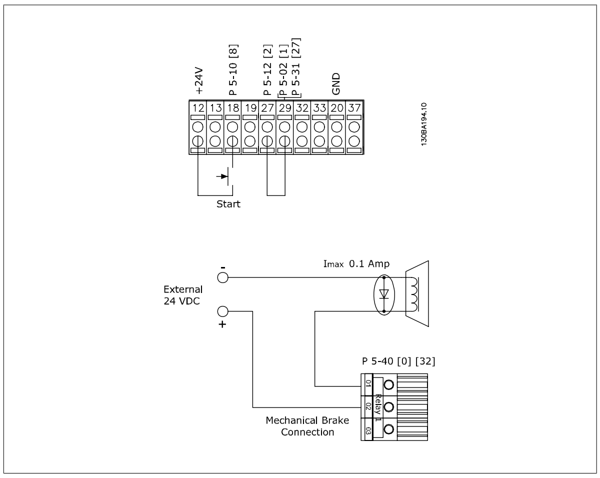
Illustration 7.1: **Basic Set-up for FC 302 Closed Loop Speed Control**

7.1.7. Programming of Torque Limit and Stop

In applications with an external electro-mechanical brake, such as hoisting applications, it is possible to stop the frequency converter via a 'standard' stop command and simultaneously activate the external electro-mechanical brake.
The example given below illustrates the programming of frequency converter connections.
The external brake can be connected to relay 1 or 2, see paragraph *Control of Mechanical Brake*. Program terminal 27 to Coast, inverse [2] or Coast and Reset, inverse [3], and program terminal 29 to Terminal mode 29 Output [1] and Torque limit & stop [27].

Description:
If a stop command is active via terminal 18 and the frequency converter is not at the torque limit, the motor ramps down to 0 Hz.
If the frequency converter is at the torque limit and a stop command is activated, terminal 29 Output (programmed to Torque limit and stop [27]) is activated. The signal to terminal 27 changes from 'logic 1' to 'logic 0', and the motor starts to coast, thereby ensuring that the hoist stops even if the frequency converter itself cannot handle the required torque (i.e. due to excessive overload).

- Start/stop via terminal 18
  Par. 5-10 Start [8]
- Quickstop via terminal 27
  Par. 5-12 Coasting Stop, Inverse [2]
- Terminal 29 Output
  Par. 5-02 Terminal 29 Mode Output [1]
  Par. 5-31 Torque Limit & Stop [27]
- Relay output [0] (Relay 1)
  Par. 5-40 Mechanical Brake Control [32]



7.1.8. Automatic Motor Adaptation (AMA)

AMA is an algorithm to measure the electrical motor parameters on a motor at standstill. This means that AMA itself does not supply any torque.
AMA is useful when commissioning systems and optimising the adjustment of the frequency converter to the applied motor. This feature is particularly used where the default setting does not apply to the connected motor.
Par. 1-29 allows a choice of complete AMA with determination of all electrical motor parameters or reduced AMA with determination of the stator resistance Rs only.
The duration of a total AMA varies from a few minutes on small motors to more than 15 minutes on large motors.

Limitations and preconditions:

- For the AMA to determine the motor parameters optimally, enter the correct motor nameplate data in par. 1-20 to 1-26.
- For the best adjustment of the frequency converter, carry out AMA on a cold motor. Repeated AMA runs may lead to a heating of the motor, which results in an increase of the stator resistance, Rs. Normally, this is not critical.
- AMA can only be carried out if the rated motor current is minimum 35% of the rated output current of the frequency converter. AMA can be carried out on up to one oversize motor.
- It is possible to carry out a reduced AMA test with a Sine-wave filter installed. Avoid carrying out a complete AMA with a Sine-wave filter. If an overall setting is required, remove the Sine-wave filter while running a total AMA. After completion of the AMA, reinsert the Sine-wave filter.
- If motors are coupled in parallel, use only reduced AMA if any.
- Avoid running a complete AMA when using synchronous motors. If synchronous motors are applied, run a reduced AMA and manually set the extended motor data. The AMA function does not apply to permanent magnet motors.
- The frequency converter does not produce motor torque during an AMA. During an AMA, it is imperative that the application does not force the motor shaft to run, which is known to happen with e.g. wind milling in ventilation systems. This disturbs the AMA function.

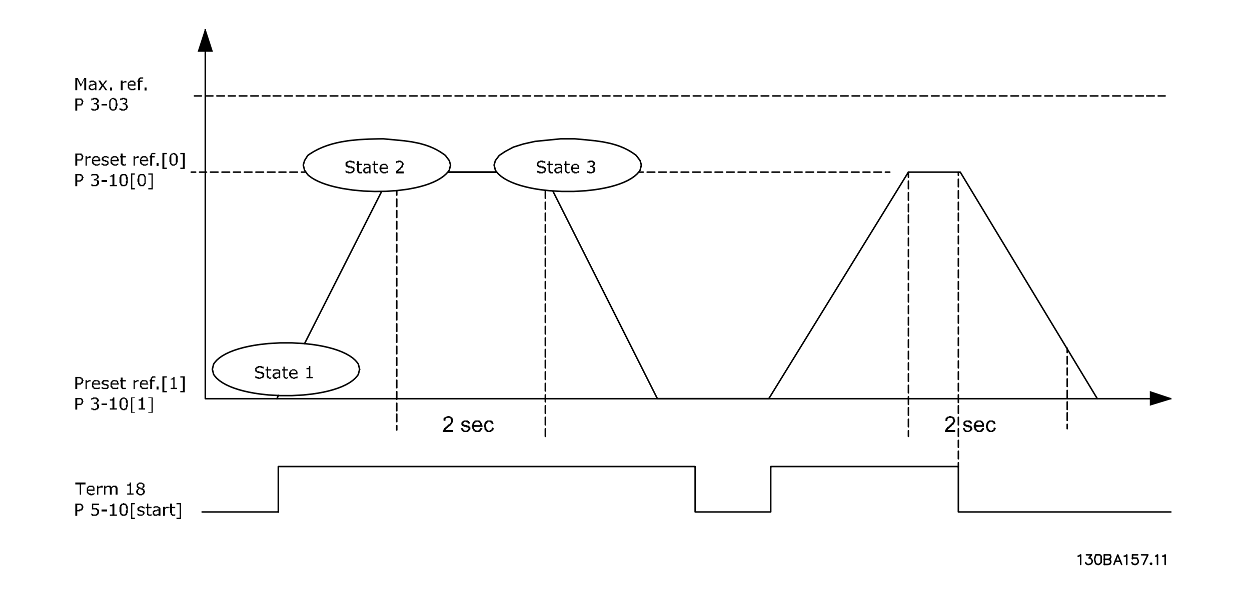
7.1.9. Smart Logic Control Programming

A new useful facility in FC 300 is the Smart Logic Control (SLC).
In applications where a PLC is generating a simple sequence the SLC may take over elementary tasks from the main control.
SLC is designed to act from event sent to or generated in the frequency converter. The frequency converter will then perform the pre-programmed action.

7.1.10. SLC Application Example

One sequence 1:

Start – ramp up – run at reference speed 2 sec – ramp down and hold shaft until stop.



Set the ramping times in par. 3-41 and 3-42 to the wanted times

$$t_{ramp} = \frac{t_{acc} \times n_{norm}(par.\ 1 - 25)}{\Delta\ ref\ [RPM]}$$

Set term 27 to *No Operation* (par. 5-12)

Set Preset reference 0 to first preset speed (par. 3-10 [0]) in percentage of Max reference speed (par. 3-03). Ex.: 60%

Set preset reference 1 to second preset speed (par. 3-10 [1] Ex.: 0 % (zero).

Set the timer 0 for constant running speed in par. 13-20 [0]. Ex.: 2 sec.

Set Event 1 in par. 13-51 [1] to *True* [1]

Set Event 2 in par. 13-51 [2] to *On Reference* [4]

Set Event 3 in par. 13-51 [3] to *Time Out 0* [30]

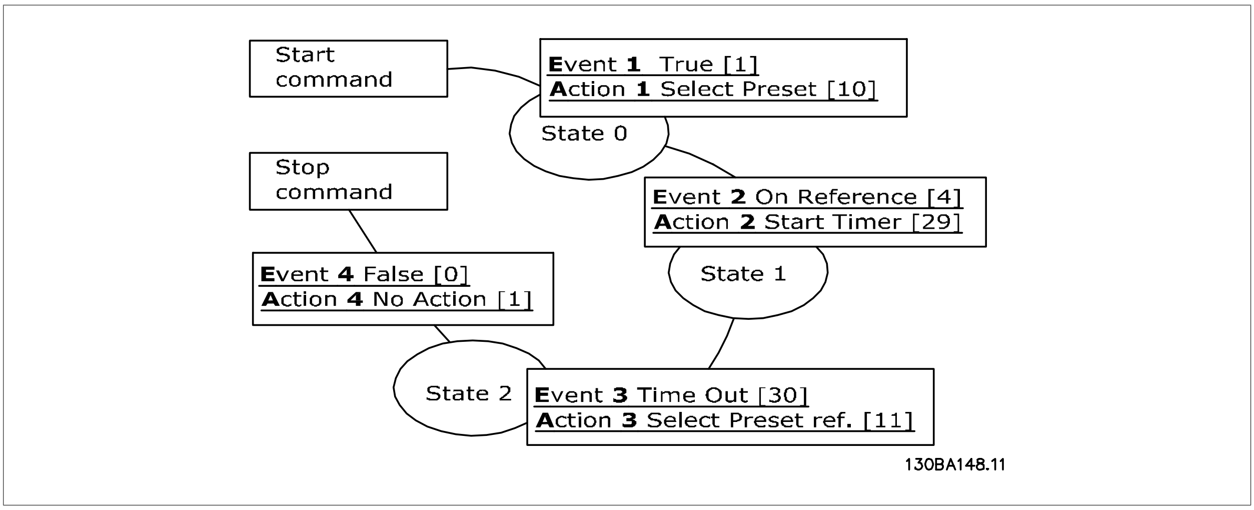
Set Event 4 in par. 13-51 [1] to *False* [0]

Set Action 1 in par. 13-52 [1] to *Select preset 0* [10]

Set Action 2 in par. 13-52 [2] to *Start Timer 0* [29]

Set Action 3 in par. 13-52 [3] to *Select preset 1* [11]

Set Action 4 in par. 13-52 [4] to *No Action* [1]



Set the Smart Logic Control in par. 13-00 to ON.

Start / stop command is applied on terminal 18. If stop signal is applied the frequency converter will ramp down and go into free mode.

8. Options and Accessories

Danfoss offers a wide range of options and accessories for VLT AutomationDrive FC 300 Series.

8.1.1. Mounting of Option Modules in Slot A

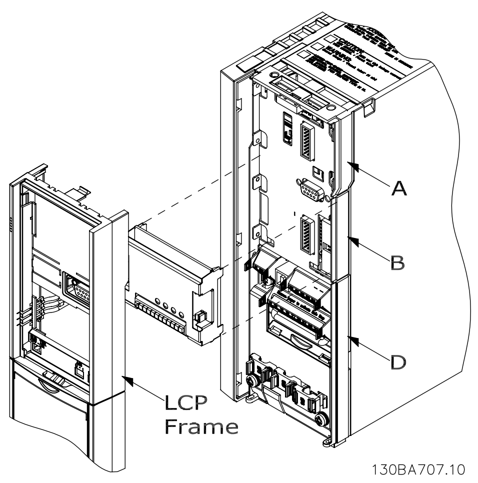
Slot A position is dedicated to Fieldbus options. For further information, see separate operating instructions.

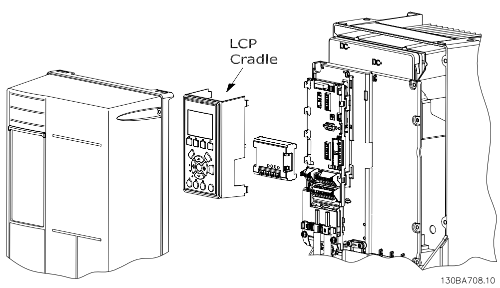
8.1.2. Mounting of Option Modules in Slot B

The power to the frequency converter must be disconnected.

It is strongly recommended to make sure the parameter data is saved (i.e. by MCT10 software) before option modules are inserted/removed from the drive.

- Remove the LCP (Local Control Panel), the terminal cover, and the LCP frame from the frequency converter.
- Fit the MCB10x option card into slot B.
- Connect the control cables and relieve the cable by the enclosed cable strips.
  * Remove the knock out in the extended LCP frame, so that the option will fit under the extended LCP frame.
- Fit the extended LCP frame and terminal cover.
- Fit the LCP or blind cover in the extended LCP frame.
- Connect power to the frequency converter.
- Set up the input/output functions in the corresponding parameters, as mentioned in the section *General Technical Data*.





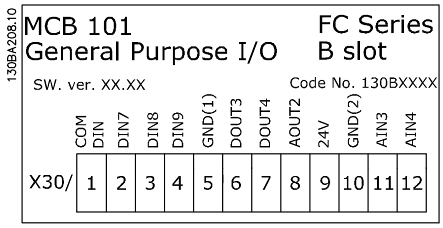
A2, A3 and B3 enclosures	A5, B1, B2, B4, C1, C2, C3 and C4 enclosures

8.2. General Purpose Input Output Module MCB 101

MCB 101 is used for extension of digital and analog inputs and outputs of FC 301 and FC 302 AutomationDrive.

Contents: MCB 101 must be fitted into slot B in the AutomationDrive.

- MCB 101 option module
- Extended fixture for LCP
- Terminal cover



8.2.1. Galvanic Isolation In The MCB 101

Digital/analog inputs are galvanically isolated from other inputs/outputs on the MCB 101 and in the control card of the drive. Digital/analogue outputs in the MCB 101 are galvanically isolated from other inputs/outputs on the MCB 101, but not from these on the control card of the drive.

If the digital inputs 7, 8 or 9 are to be switched by use of the internal 24 V power supply (terminal 9) the connection between terminal 1 and 5 which is illustrated in the drawing has to be established.

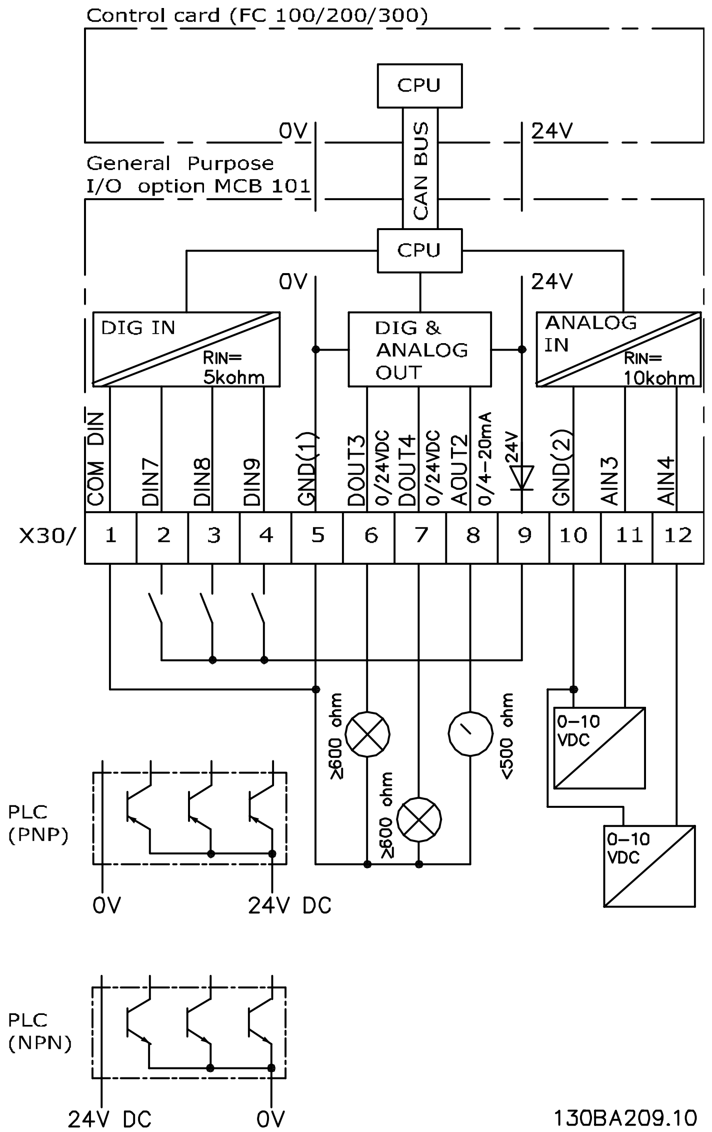


Illustration 8.1: Principle Diagram

8.2.2. Digital inputs - Terminal X30/1-4

Digital input:	
Number of digital inputs	3
Terminal number	X30.2, X30.3, X30.4
Logic	PNP or NPN
Voltage level	0 - 24 V DC
Voltage level, logic'0' PNP (GND = 0 V)	< 5 V DC
Voltage level, logic'1' PNP (GND = 0 V)	> 10 V DC
Voltage level, logic '0' NPN (GND = 24V)	< 14 V DC
Voltage level, logic '1' NPN (GND = 24 V)	> 19 V DC
Maximum voltage on input	28 V continous
Pulse frequency range	0 - 110 kHz
Duty cycle, min. pulse width	4.5 ms
Input impedance	> 2 kΩ

8.2.3. Analog inputs - Terminal X30/11, 12:

Analog input:	
Number of analog inputs	2
Terminal number	X30.11, X30.12
Modes	Voltage
Voltage level	0 - 10 V
Input impedance	> 10 kΩ
Max. voltage	20 V
Resolution for analog inputs	10 bit (+ sign)
Accuracy of analog inputs	Max. error 0.5% of full scale
Bandwidth	FC 301: 20 Hz/ FC 302: 100 Hz

8.2.4. Digital outputs - Terminal X30/6, 7:

Digital output:	
Number of digital outputs	2
Terminal number	X30.6, X30.7
Voltage level at digital/frequency output	0 - 24 V
Max. output current	40 mA
Max. load	≥ 600 Ω
Max. capacitive load	< 10 nF
Minimum output frequency	0 Hz
Maximum output frequency	≤ 32 kHz
Accuracy of frequency output	Max. error: 0.1 % of full scale

8.2.5. Analog output - Terminal X30/8:

Analog output:	
Number of analog outputs	1
Terminal number	X30.8
Current range at analog output	0 - 20 mA
Max. load GND - analog output	500 Ω
Accuracy on analog output	Max. error: 0.5 % of full scale
Resolution on analog output	12 bit

8.3. Encoder Option MCB 102

The encoder module can be used as feedback source for closed loop Flux control (par. 1-02) as well as closed loop speed control (par. 7-00). Configure encoder option in parameter group 17-xx

Used for:

- VVC^{plus} closed loop
- Flux Vector Speed control
- Flux Vector Torque control
- Permanent magnet motor

Supported encoder types:
Incremental encoder: 5 V TTL type, RS422, max. frequency: 410 kHz
Incremental encoder: 1Vpp, sine-cosine
Hiperface® Encoder: Absolute and Sine-Cosine (Stegmann/SICK)
EnDat encoder: Absolute and Sine-Cosine (Heidenhain) Supports version 2.1
SSI encoder: Absolute
Encoder monitor:
The 4 encoder channels (A, B, Z, and D) are monitored, open and short circuit can be detected. There is a green LED for each channel which lights up when the channel is OK.

NB!
The LEDs are only visible when removing the LCP. Reaction in case of an encoder error can be selected in par. 17-61: None, Warning or Trip.

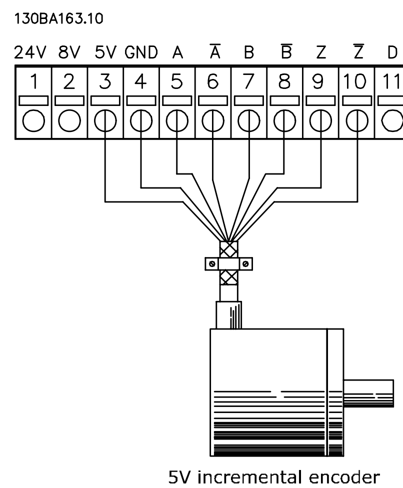
When the encoder option kit is ordered separately the kit includes:

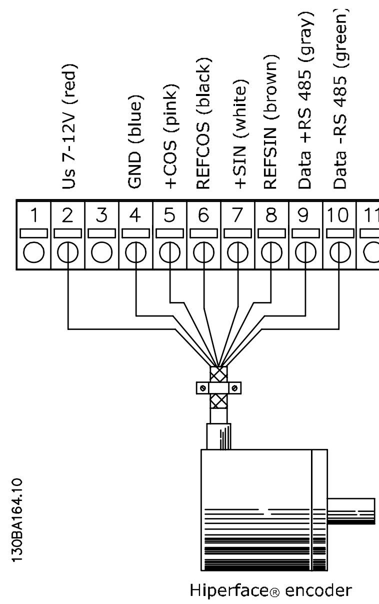
- Encoder module MCB 102
- Enlarged LCP fixture and enlarged terminal cover

The encoder option does not support FC 302 frequency converters manufactured before week 50/2004.
Min. software version: 2.03 (par. 15-43)

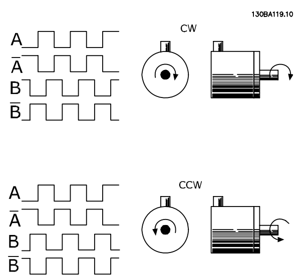
Connector Designation X31	Incremental Encoder (please refer to Graphic A)	SinCos Encoder Hiperface® (please refer to Graphic B)	EnDat Encoder	SSI Encoder	Description
1	NC			24 V	24 V Output (21-25 V, I_{max}:125 mA)
2	NC	8 Vcc			8 V Output (7-12 V, I_{max}: 200 mA)
3	5 VCC		5 Vcc	5 V	5 V Output (5 V ± 5%, I_{max}: 200 mA)
4	GND		GND	GND	GND
5	A input	+COS	+COS	A input	A input
6	A inv input	REFCOS	REFCOS	A input inv.	A inv input
7	B input	+SIN	+SIN	B input	B input
8	B inv input	REFSIN	REFSIN	B input inv.	B inv input
9	Z input	+Data RS485	Clock out	Clock out	Z input OR +Data RS485
10	Z inv input	-Data RS485	Clock out inv.	Clock out inv.	Z input OR -Data RS485
11	NC	NC	Data in	Data in	Future use
12	NC	NC	Data in inv.	Data in inv.	Future use

Max. 5V on X31.5-12





Max. cable length 150 m.



8

8.4. Resolver Option MCB 103

MCB 103 Resolver option is used for interfacing resolver motor feedback to FC 300 AutomationDrive. Resolvers are used basically as motor feedback device for Permanent Magnet brushless synchronous motors.

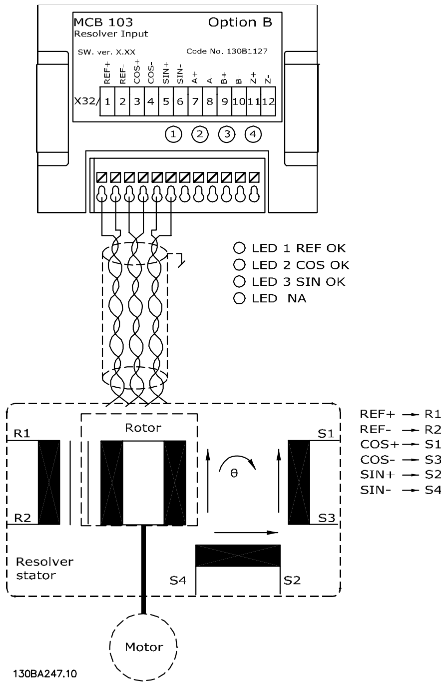
When the Resolver option is ordered separately the kit includes:

- Resolver option MCB 103
- Enlarged LCP fixture and enlarged terminal cover

Selection of parameters: 17-5x resolver Interface.

MCB 103 Resolver Option supports a various number of resolver types.

Resolver specifications:	
Resolver Poles	Par 17-50: 2 *2
Resolver Input Voltage	Par 17-51: 2.0 – 8.0 Vrms *7.0Vrms
Resolver Input Frequency	Par 17-52: 2 – 15 kHz *10.0 kHz
Transformation ratio	Par 17-53: 0.1 – 1.1 *0.5
Secondary input voltage	Max 4 Vrms
Secondary load	App. 10 kΩ



NB!
The resolver option MCB 103 can only be used with rotor-supplied resolver types. Stator-supplied resolvers cannot be used.

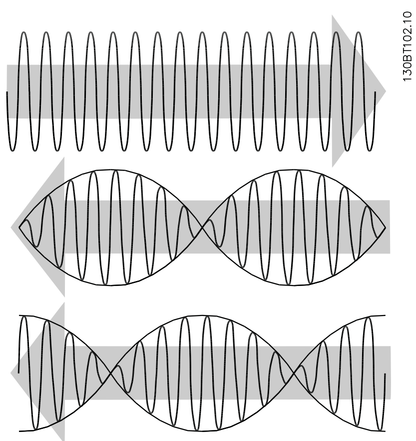
LED indicators

LED 1 is on when the reference signal is OK to resolver

LED 2 is on when Cosinus signal is OK from resolver

LED 3 is on when Sinus signal is OK from resolver

The LEDs are active when par. 17-61 is set to *Warning* or *Trip*.



Set-up example

In this example a Permanent Magnet (PM) Motor is used with resolver as speed feedback. A PM motor must usually operate in flux mode.

Wiring:

The max cable length is 150 m when a twisted pair type of cable is used.

NB!

Resolver cables must be screened and separated from the motor cables.

NB!

The screen of the resolver cable must be correctly connected to the de-coupling plate and connected to chassis (earth) on the motor side.

NB!

Always use screened motor cables and brake chopper cables.

Adjust following parameters:		
Par. 1-00	Configuration Mode	Speed closed loop [1]
Par. 1-01	Motor Control Principle	Flux with feedback [3]
Par. 1-10	Motor Construction	PM, non salient SPM [1]
Par. 1-24	Motor Current	Nameplate
Par. 1-25	Motor Nominal Speed	Nameplate
Par. 1-26	Motor Cont. Rated Torque	Nameplate
AMA is not possible on PM motors		
Par. 1-30	Stator Resistance	Motor data sheet
Par. 1-37	d-axis Inductance (Ld)	Motor data sheet (mH)
Par. 1-39	Motor Poles	Motor data sheet
Par. 1-40	Back EMF at 1000 RPM	Motor data sheet
Par. 1-41	Motor Angle Offset	Motor data sheet (Usually zero)
Par. 17-50	Poles	Resolver data sheet
Par. 17-51	Input Voltage	Resolver data sheet
Par. 17-52	Input Frequency	Resolver data sheet
Par. 17-53	Transformation Ratio	Resolver data sheet
Par. 17-59	Resolver Interface	Enabled [1]

8.5. Relay Option MCB 105

The MCB 105 option includes 3 pieces of SPDT contacts and must be fitted into option slot B.

Electrical Data:	
Max terminal load (AC-1) [1] (Resistive load)	240 V AC 2A
Max terminal load (AC-15) [1] (Inductive load @ cosφ 0.4)	240 V AC 0.2 A
Max terminal load (DC-1) [1] (Resistive load)	24 V DC 1 A
Max terminal load (DC-13) [1] (Inductive load)	24 V DC 0.1 A
Min terminal load (DC)	5 V 10 mA
Max switching rate at rated load/min load	6 min^{-1}/20 sec^{-1}

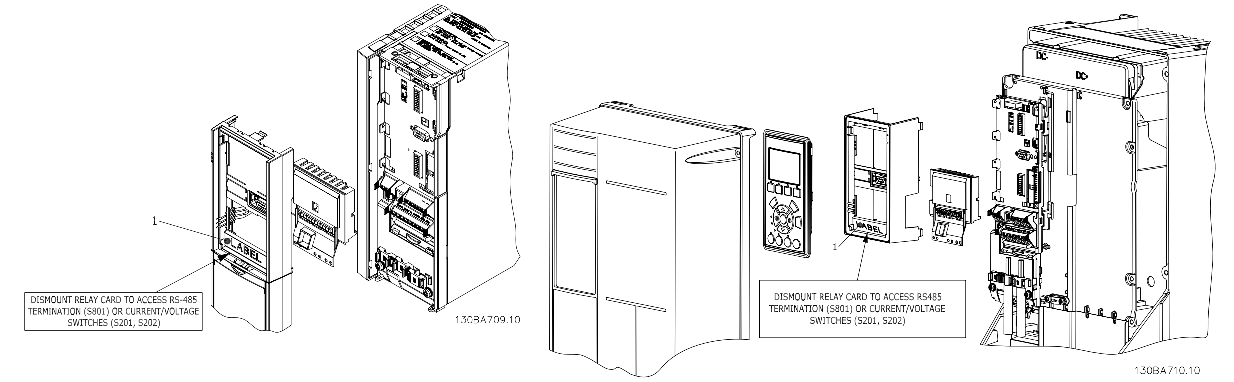
1) IEC 947 part 4 and 5

When the relay option kit is ordered separately the kit includes:

- Relay Module MCB 105
- Enlarged LCP fixture and enlarged terminal cover
- Label for covering access to switches S201, S202 and S801

- Cable strips for fastening cables to relay module

The relay option does not support FC 302 frequency converters manufactured before week 50/2004.
Min. software version: 2.03 (par. 15-43).



A2-A3-B3 A5-B1-B2-B4-C1-C2-C3-C4

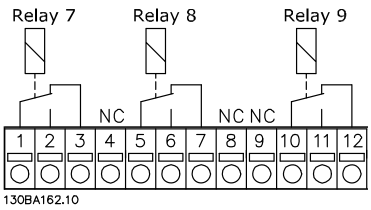
1) **IMPORTANT**! The label MUST be placed on the LCP frame as shown (UL approved).

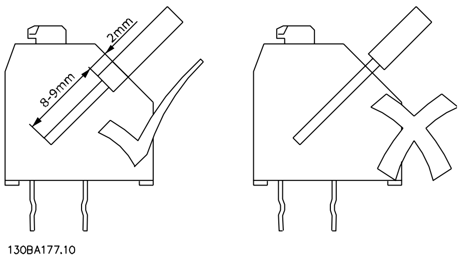
Warning Dual supply

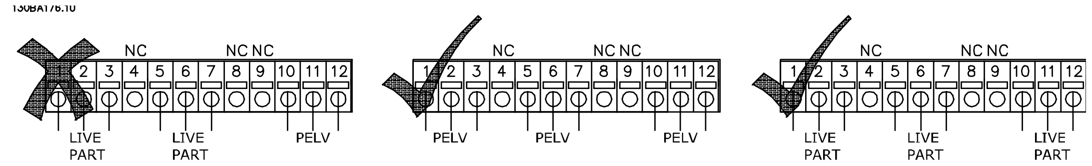
How to add the MCB 105 option:

- The power to the frequency converter must be disconnected.
- The power to the live part connections on relay terminals must be disconnected.
- Remove the LCP, the terminal cover and the LCP fixture from the FC 30x.
- Fit the MCB 105 option in slot B.
- Connect the control cables and fasten the cables with the enclosed cable strips.
- Make sure the length of the stripped wire is correct (see the following drawing).
- Do not mix live parts (high voltage) with control signals (PELV).
- Fit the enlarged LCP fixture and enlarged terminal cover.
- Replace the LCP.
- Connect power to the frequency converter.
- Select the relay functions in par. 5-40 [6-8], 5-41 [6-8] and 5-42 [6-8].

NB!
Array [6] is relay 7, array [7] is relay 8, and array [8] is relay 9







Do not combine 24/ 48 V systems with high voltage systems.

8.6. 24 V Back-Up Option MCB 107

External 24 V DC Supply

An external 24 V DC supply can be installed for low-voltage supply to the control card and any option card installed. This enables full operation of the LCP (including the parameter setting) without connection to mains.

External 24 V DC supply specification:	
Input voltage range	24 V DC ±15 % (max. 37 V in 10 s)
Max. input current	2.2 A
Average input current for FC 302	0.9 A
Max cable length	75 m
Input capacitance load	< 10 uF
Power-up delay	< 0.6 s

The inputs are protected.

Terminal numbers:

Terminal 35: - external 24 V DC supply.

Terminal 36: + external 24 V DC supply.

Follow these steps:

1. Remove the LCP or Blind Cover
2. Remove the Terminal Cover
3. Remove the Cable Decoupling Plate and the plastic cover underneath
4. Insert the 24 V DC Back-up External Supply Option in the Option Slot
5. Mount the Cable Decoupling Plate
6. Attach the Terminal Cover and the LCP or Blind Cover.

When MCB 107, 24 V back-up option is supplying the control circuit, the internal 24 V supply is automatically disconnected.

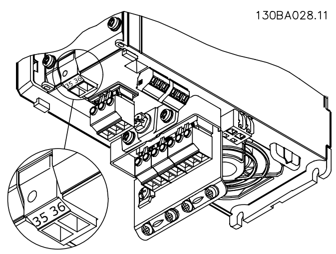


Illustration 8.2: Connection to 24 V back-up supply on frame sizes A2 and A3.

8

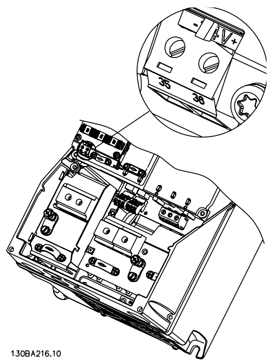


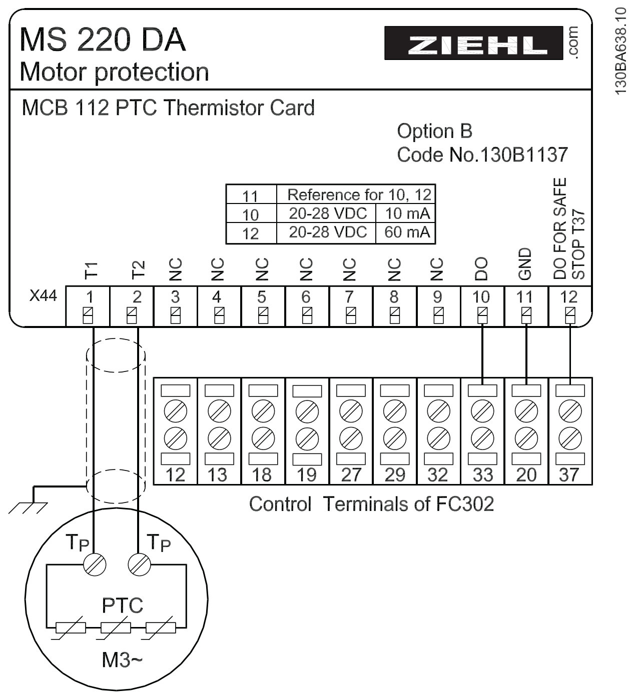
Illustration 8.3: Connection to 24 V back-up supply on frame sizes A5, B1, B2, C1 and C2.

8.7. MCB 112 VLT® PTC Thermistor Card

The MCB 112 option makes it possible to monitor the temperature of an electrical motor through a PTC thermistor input. It is a B-option for VLT® AutomationDrive FC 302 with Safe Stop.

For information on mounting and installation of the option, please see *Mounting of Option Modules in Slot B* earlier in this section

X44/ 1 and X44/ 2 are the thermistor inputs, X44/ 12 will enable safe stop of the FC 302 (T-37) if the thermistor values make it necessary and X44/ 10 will inform the FC 302 that a request for Safe Stop came from the MCB 112 in order to ensure a suitable alarm handling. One of the Digital Inputs of the FC302 (or a DI of a mounted option) must be set to PCT Card 1 [80] in order to use the information from X44/ 10. Par. 5-19 Terminal 37 Safe Stop must be configured to the desired Safe Stop functionality (default is Safe Stop Alarm).



ATEX Certification with VLT® AutomationDrive FC 302

The MCB 112 has been certified for ATEX which means that the VLT® AutomationDrive FC 302 together with the MCB 112 can now be used with motors in potentially explosive atmospheres. See the Operating Instructions for the MCB 112 for more information.

ATmosphère EXplosive (ATEX)

Electrical Data

Resistor connection:	
PTC compliant with DIN 44081 and DIN 44082	
Number	1..6 resistors in series
Shut-off value	3.3 Ω.... 3.65 Ω ... 3.85 Ω
Reset value	1.7 Ω .... 1.8 Ω ... 1.95 Ω
Trigger tolerance	± 6ºC
Collective resistance of the sensor loop	< 1.65 Ω
Terminal voltage	≤ 2.5 V for R ≤ 3.65 Ω, ≤ 9 V for R = ∞
Sensor current	≤ 1 mA
Short circuit	20 Ω ≤ R ≤ 40 Ω
Power consumption	60 mA

Testing conditions:	
EN 60 947-8	
Measurement voltage surge resistance	6000 V
Overvoltage category	III
Degree of pollution	2
Measurement isolation voltage Vbis	690 V
Reliable galvanis isolation until Vi	500 V
Perm. ambient temperature	-20ºC ... +60ºC
	EN 60068-2-1 Dry heat
Moisture	5 --- 95%, no condensation permissible
EMC resistance	EN61000-6-2
EMC emissions	EN61000-6-4
Vibration resistance	10 ... 1000 Hz 1.14g
Shock resistance	50 g

Safety system values:	
EN 61508, ISO 13849 for Tu = 75ºC ongoing	
Category	2
SIL	2 for maintenance cycle of 2 years
	1 for maintenance cycle of 3 years
HFT	0
PFD (for yearly functional test)	$4.10 *10^{-3}$
SFF	90%
$\lambda_s + \lambda_{DD}$	8515 FIT
λ_{DU}	932 FIT
Ordering number 130B1137	

8.8. Brake Resistors

In applications where the motor is used as a brake, energy is generated in the motor and send back into the frequency converter. If the energy can not be transported back to the motor it will increase the voltage in the converter DC-line. In applications with frequent braking and/or high inertia loads this increase may lead to an over voltage trip in the converter and finally a shut down. Brake resistors are used to dissipate the excess energy resulting from the regenerative braking. The resistor is selected in respect to its ohmic value, its power dissipation rate and its physical size. Danfoss offers a wide verity of different resistors that are specially designed to our drive code numbers can be found in section *How to order*.

8.9. Remote Mounting Kit for LCP

8.9.1. Remote mounting Kit for LCP

The Local Control Panel can be moved to the front of a cabinet by using the remote build in kit. The enclosure is the IP65. The fastening screws must be tightened with a torque of max. 1 Nm.

Technical data	
Enclosure:	IP 65 front
Max. cable length between and unit:	3 m
Communication std:	RS 485

Ordering no. 130B1113

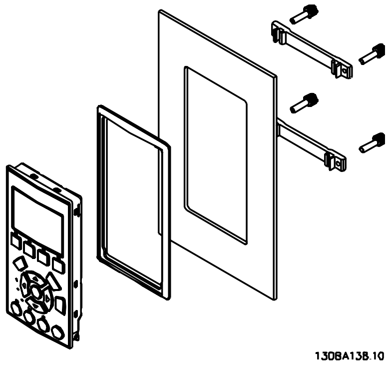


Illustration 8.4: LCP Kit with graphical LCP, fasteners, 3 m cable and gasket.

Ordering no. 130B1114

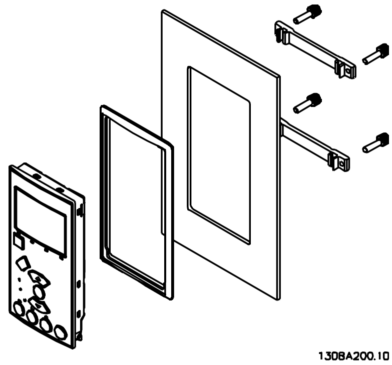
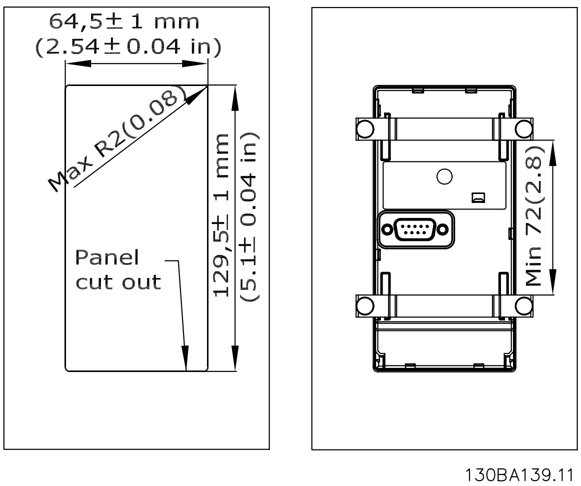


Illustration 8.5: LCP Kit with numerical LCP, fasternes and gasket.

LCP Kit without LCP is also available. Ordering number: 130B1117

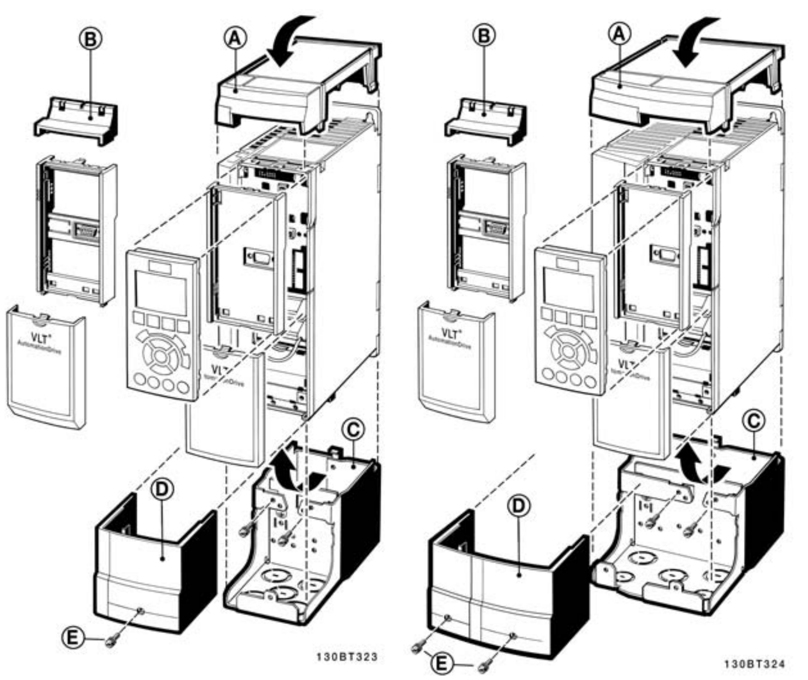


8.10. IP21/IP 4X/ TYPE 1 Enclosure Kit

IP 20/IP 4X top/ TYPE 1 is an optional enclosure element available for IP 20 Compact units.
If the enclosure kit is used, an IP 20 unit is upgraded to comply with enclosure IP 21/ 4X top/TYPE 1.

The IP 4X top can be applied to all standard IP 20 FC 30X variants.

A – Top cover
B – Brim
C – Base part
D – Base cover
E – Screw(s)
Place the top cover as shown. If an A or B option is used the brim must be fitted to cover the top inlet. Place the base part C at the bottom of the drive and use the clamps from the accessory bag to correctly fasten the cables. Holes for cable glands:
Size A2: 2x M25 and 3xM32
Size A3: 3xM25 and 3xM32



8.11. Sine-wave Filters

When a motor is controlled by a frequency converter, resonance noise will be heard from the motor. This noise, which is the result of the design of the motor, arises every time an inverter switch in the frequency converter is activated. The frequency of the resonance noise thus corresponds to the switching frequency of the frequency converter.

For the FC 300 Series, Danfoss can supply a Sine-wave filter to dampen the acoustic motor noise.

The filter reduces the ramp-up time of the voltage, the peak load voltage U_{PEAK} and the ripple current ΔI to the motor, which means that current and voltage become almost sinusoidal. Consequently, the acoustic motor noise is reduced to a minimum.

The ripple current in the Sine-wave Filter coils, will also cause some noise. Solve the problem by integrating the filter in a cabinet or similar.

9. RS-485 Installation and Set-up

9.1. RS-485 Installation and Set-up

9.1.1. Overview

RS-485 is a two-wire bus interface compatible with multi-drop network topology, i.e. 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.
Network segments are divided up by repeaters. Please note that each repeater functions as a node within the segment in which it is installed. Each node connected within a given network must have a unique node address, across all segments.
Terminate each segment at both ends, using either the termination switch (S801) of the frequency converters or a biased termination resistor network. Always use screened twisted pair (STP) cable for bus cabling, and always follow good common installation practice.
Low-impedance ground connection of the screen at every node is very important, including at high frequencies. This can be achieved by connecting a large surface of the screen to ground, for example by means of a cable clamp or a conductive cable gland. It may be necessary to apply potential-equalizing cables to maintain the same ground potential throughout the network, particularly in installations where there are long lengths of cable.
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: 120 Ohm
Cable length: Max. 1200 m (including drop lines)
Max. 500 m station-to-station

9.1.2. Network Connection

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

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.

NB!
Screened, twisted-pair cables are recommended in order to reduce noise between conductors.

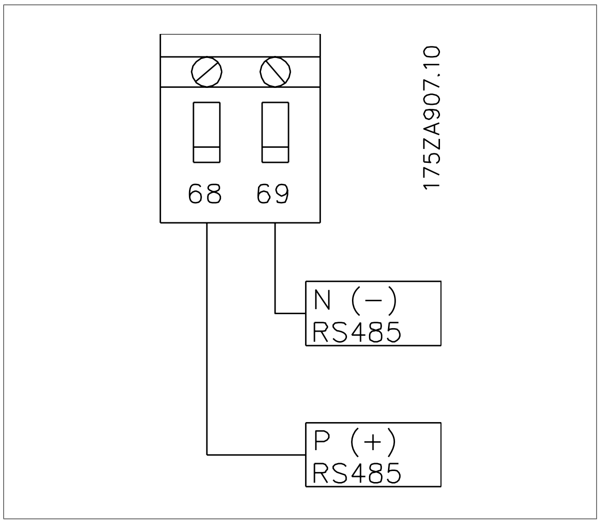
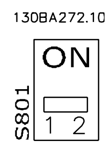


Illustration 9.1: Network Terminal Connection

9.1.3. RS 485 Bus Termination

Use the terminator dip switch on the main control board of the frequency converter to terminate the RS-485 bus.

NB!
The factory setting for the dip switch is OFF.

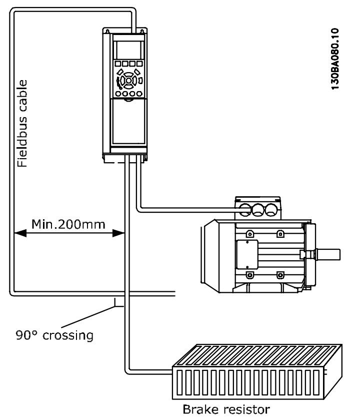


Terminator Switch Factory Setting

9.1.4. EMC Precautions

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

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



The FC protocol, also referred to as FC bus or Standard bus, is the Danfoss Drives standard fieldbus. It defines an access technique according to the master-slave principle for communications via a serial bus.
One master and a maximum of 126 slaves can be connected to the bus. The individual slaves are selected by the master via an address character in the telegram. A slave itself can never transmit without first being requested to do so, and direct message transfer between the individual slaves 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 utilizing 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, and a long format of 16 bytes that also includes a parameter channel. A third telegram format is used for texts.

9.3. Network Configuration

9.3.1. FC 300 Frequency Converter Set-up

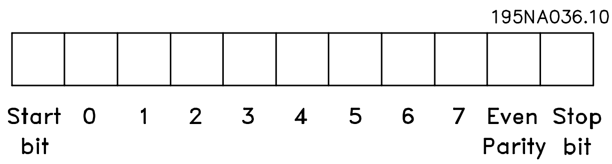
Set the following parameters to enable the FC protocol for the frequency converter.

Parameter Number	Parameter name	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)

9.4. FC Protocol Message Framing Structure - FC 300

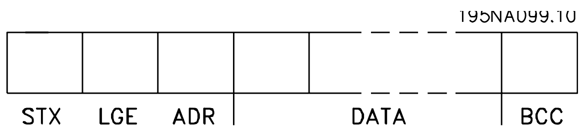
9.4.1. Content of a Character (byte)

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, which is set at "1" when it reaches parity (i.e. when there is an equal number of 1's in the 8 data bits and the parity bit in total). A character is completed by a stop bit, thus consisting of 11 bits in all.



9.4.2. Telegram Structure

Each telegram begins with a start character (STX)=02 Hex, followed by a byte denoting the telegram length (LGE) and a byte denoting the frequency converter address (ADR). A number of data bytes (variable, depending on the type of telegram) follows. The telegram is completed by a data control byte (BCC).



9.4.3. Telegram Length (LGE)

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

The length of telegrams with 4 data bytes is	LGE = 4 + 1 + 1 = 6 bytes
The length of telegrams with 12 data bytes is	LGE = 12 + 1 + 1 = 14 bytes
The length of telegrams containing texts is	10[1)]+n bytes

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

9.4.4. Frequency Converter Address (ADR)

Two different address formats are used.
The address range of the frequency converter is either 1-31 or 1-126.

1. Address format 1-31:
Bit 7 = 0 (address format 1-31 active)
Bit 6 is not used
Bit 5 = 1: Broadcast, address bits (0-4) are not used
Bit 5 = 0: No Broadcast

Bit 0-4 = Frequency converter address 1-31

2. 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 slave returns the address byte unchanged to the master in the response telegram.

9.4.5. Data Control Byte (BCC)

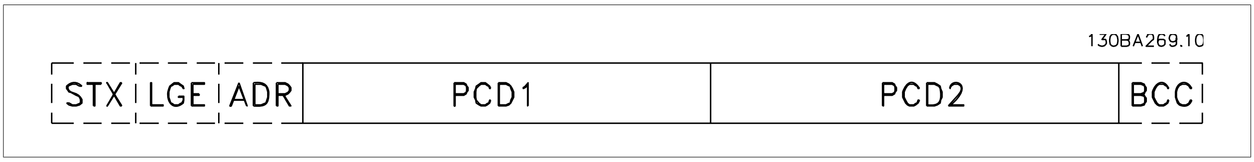
The checksum is calculated as an XOR-function. Before the first byte in the telegram is received, the Calculated Checksum is 0.

9.4.6. The Data Field

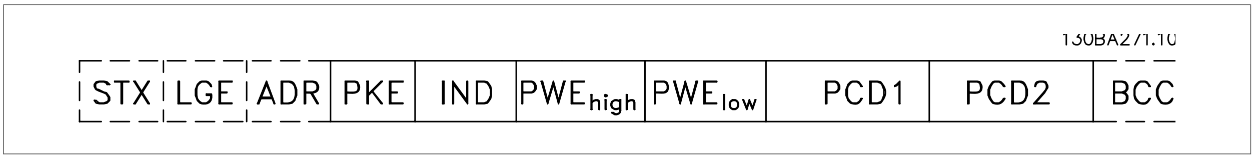
The structure of data blocks depends on the type of telegram. There are three telegram types, and the type applies for both control telegrams (master=>slave) and response telegrams (slave=>master).

The three types of telegram are:

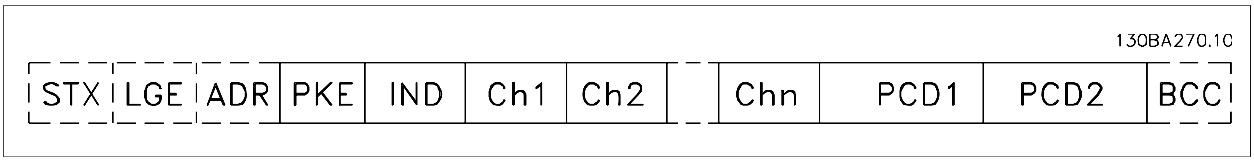
Process block (PCD):
The PCD is made up of a data block of four bytes (2 words) and contains:
- Control word and reference value (from master to slave)
- Status word and present output frequency (from slave to master).



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

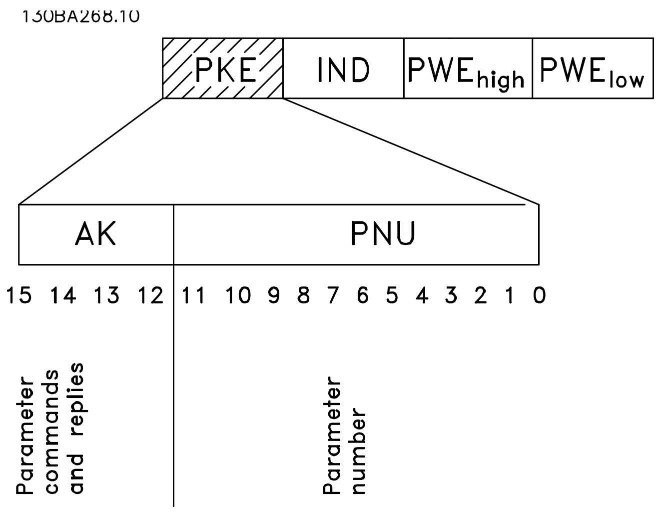


Text block:
The text block is used to read or write texts via the data block.



9.4.7. The PKE Field

The PKE field contains two sub-fields: Parameter command and response AK, and Parameter number PNU:



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

Parameter commands master ⇒ slave

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/write text

Response slave ⇒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

If the command cannot be performed, the slave sends this response:

0111 Command cannot be performed

- and issues the following fault report in the parameter value (PWE):

PWE low (Hex)	Fault Report
0	The parameter number used does not exit
1	There is no write access to the defined parameter
2	Data value exceeds the parameter's limits
3	The sub index used does not exit
4	The parameter is not the array type
5	The data type does not match the defined parameter
11	Data change in the defined parameter is not possible in the frequency converter's present mode. Certain parameters can only be changed when the motor is turned off
82	There is no bus access to the defined parameter
83	Data change is not possible because factory setup is selected

9.4.8. Parameter Number (PNU)

Bits no. 0-11 transfer parameter numbers. The function of the relevant parameter is defined in the parameter description in the Programming Guide.

9.4.9. Index (IND)

The index is used together with the parameter number to read/write-access parameters with an index, e.g. par. 15-30 *Error Code*. The index consists of 2 bytes, a low byte and a high byte.

NB!
Only the low byte is used as an index.

9.4.10. Parameter Value (PWE)

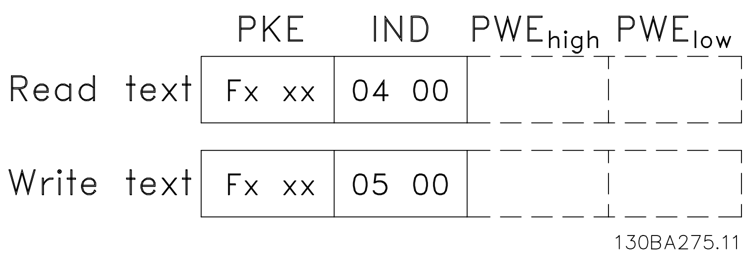
The parameter value block consists of 2 words (4 bytes), and the value depends on the defined command (AK). The master prompts for a parameter value when the PWE block contains no value. To change a parameter value (write), write the new value in the PWE block and send from the master to the slave.

When a slave 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 not a numerical value but several data options, e.g. par. 0-01 Language where [0] corresponds to English, and [4] corresponds to Danish, select the data value by entering the value in the PWE block. See Example - Selecting a data value. Serial communication is only capable of reading parameters containing data type 9 (text string).

Parameters 15-40 to 15-53 contain data type 9.
For example, read the unit size and mains voltage range in par. 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".

Some parameters contain text that can be written to via the serial bus. To write a text via the PWE block, set the parameter command (AK) to 'F' Hex. The index characters high-byte must be "5".



9.4.11. Data Types Supported by FC 300

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
10	Byte string
13	Time difference
33	Reserved
35	Bit sequence

9.4.12. Conversion

The various attributes of each parameter are displayed in the section Factory Settings. Parameter values are transferred as whole numbers only. Conversion factors are therefore used to transfer decimals.

Par. 4-12 *Motor Speed, Low Limit* 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 table

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

9.4.13. Process Words (PCD)

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

PCD 1	PCD 2
Control telegram (master⇒slave Control word)	Reference-value
Control telegram (slave ⇒master) Status word	Present outp. frequency

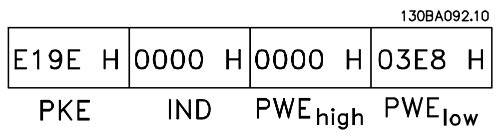
9.5. Examples

9.5.1. Writing a parameter value

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

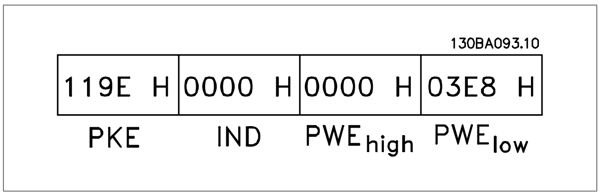
PKE = E19E Hex - Write single word in par. 4-14 *Motor Speed High Limit [Hz]*
IND = 0000 Hex
PWEHIGH = 0000 Hex
PWELOW = 03E8 Hex - Data value 1000, corresponding to 100 Hz, see Conversion.

The telegram will look like this:



Note: Parameter 4-14 is a single word, and the parameter command for write in EEPROM is "E". Parameter number 414 is 19E in hexadecimal.

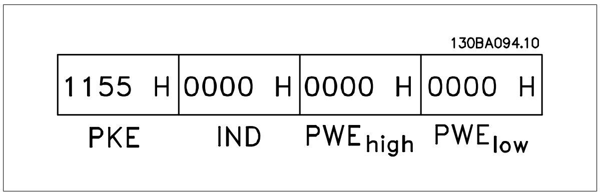
The response from the slave to the master will be:



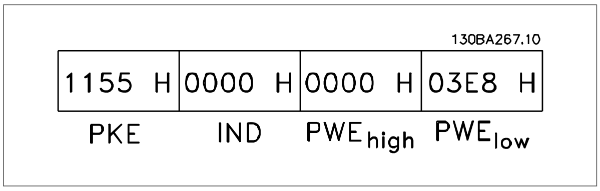
9.5.2. Reading a parameter value

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

PKE = 1155 Hex - Read parameter value in par. 3-41 *Ramp 1 Up Time*
IND = 0000 Hex
PWEHIGH = 0000 Hex
PWELOW = 0000 Hex



If the value in par. 3-41 *Ramp 1 Up Time* is 10 s, the response from the slave to the master will be:

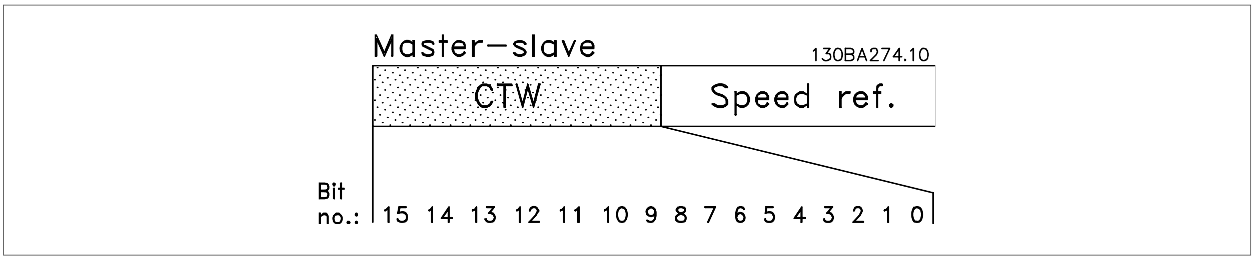


NB!
3E8 Hex corresponds to 1000 decimal. The conversion index for par. 3-41 is -2, i.e. 0.01.

9

9.6. Danfoss FC Control Profile

9.6.1. Control Word According to FC Profile(Par. 8-10 = 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	No function	Relay 01 active
12	No function	Relay 02 active
13	Parameter set-up	selection lsb
14	Parameter set-up	selection msb
15	No function	Reverse

Explanation of the Control Bits

Bits 00/01

Bits 00 and 01 are used to choose between the four reference values, which are pre-programmed in par. 3-10 *Preset reference* according to the following table:

Programmed ref. value	Par.	Bit 01	Bit 00
1	3-10 [0]	0	0
2	3-10 [1]	0	1
3	3-10 [2]	1	0
4	3-10 [3]	1	1

NB!

Make a selection in par. 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 par. 2-01 *DC Brake Current* and 2-02 *DC Braking Time* . Bit 02 = '1' leads to ramping.

Bit 03, Coasting:

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

NB!

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

Bit 04, Quick stop:

Bit 04 = ’0’: Makes the motor speed ramp down to stop (set in par. 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 by means of the digital inputs (par. 5-10 to 5-15) programmed to *Speed up* and *Slow down*.

NB!

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 (par. 5-10 to 5-15) programmed to *DC braking*, *Coasting stop*, or *Reset* and *coasting stop*.

Bit 06, Ramp stop/start:

Bit 06 = ’0’: Causes a stop and makes the motor speed ramp down to stop via the selected ramp down par. Bit 06 = ’1’: Permits the frequency converter to start the motor, if the other starting conditions are met.

NB!

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

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

Bit 08, Jog:

Bit 08 = ’1’: The output frequency is determined by par. 3-19 *Jog Speed*.

Bit 09, Selection of ramp 1/2:

Bit 09 = "0": Ramp 1 is active (par. 3-40 to 3-47). Bit 09 = "1": Ramp 2 (par. 3-50 to 3-57) 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. Thus, you can turn off the control word if you do not want 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* is chosen in par. 5-40 *Function relay*.

Bit 12, Relay 04:

Bit 12 = "0": Relay 04 is not activated. Bit 12 = "1": Relay 04 is activated provided that *Control word bit 12* is chosen in par. 5-40 *Function relay*.

Bit 13/14, Selection of set-up:

Use bits 13 and 14 to choose from the four menu set-ups according to the shown table: .

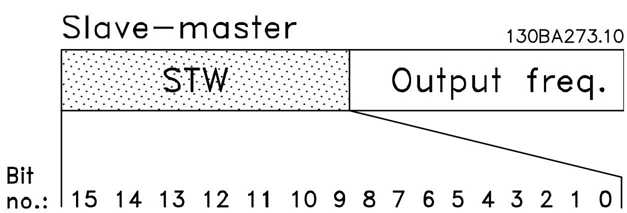
Set-up	Bit 14	Bit 13
1	0	0
2	0	1
3	1	0
4	1	1

The function is only possible when *Multi Set-Ups* is selected in par. 0-10 *Active Set-Up*

NB!
Make a selection in par. 8-55 *Set-up select* to define how Bit 13/14 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 par. 8-54 *Reversing Select*. Bit 15 causes reversing only when Ser. communication, Logic or or Logic and is selected.

9.6.2. Status Word According to FC Profile (STW) (Par. 8-10 = FC profile)



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

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

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

Bit 03, No error/trip:
Bit 03 = '0' : The frequency converter is not in fault mode. Bit 03 = '1': The frequency converter trips. To re-establish operation, enter [Reset].

Bit 04, No error/error (no trip):

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

Bit 05, Not used:

Bit 05 is not used in the status word.

Bit 06, No error / triplock:

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

Bit 07, No warning/warning:

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

Bit 08, Speed≠ reference/speed = reference:

Bit 08 = '0': The motor is running but the present speed is different from the preset speed reference. It might e.g. be the case when the speed ramps up/down during start/stop. Bit 08 = '1': The motor speed matches the preset speed reference.

Bit 09, Local operation/bus control:

Bit 09 = '0': [STOP/RESET] is activate on the control unit or *Local control* in par. 3-13 *Reference Site* is selected. You cannot 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 par. 4-11 *Motor Speed Low Limit* or par. 4-13 *Motor Speed High Limit*. Bit 10 = "1": The output frequency is within the defined limits.

Bit 11, No operation/in operation:

Bit 11 = '0': The motor is not running. Bit 11 = '1': The frequency converter 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 will resume operation once the over temperature stops.

Bit 13, Voltage OK/limit exceeded:

Bit 13 = '0': There are no voltage warnings. Bit 13 = '1': The DC voltage in the frequency converter's intermediate circuit is too low or too high.

Bit 14, Torque OK/limit exceeded:

Bit 14 = '0': The motor current is lower than the torque limit selected in par. 4-18 *Current Limit*. Bit 14 = '1': The torque limit in par. 4-18 *Current Limit* is exceeded.

Bit 15, Timer OK/limit exceeded:

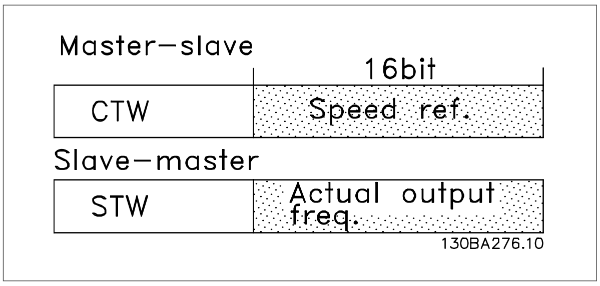
Bit 15 = '0': The timers for motor thermal protection and thermal protection are not exceeded 100%. Bit 15 = '1': One of the timers exceeds 100%.

NB!

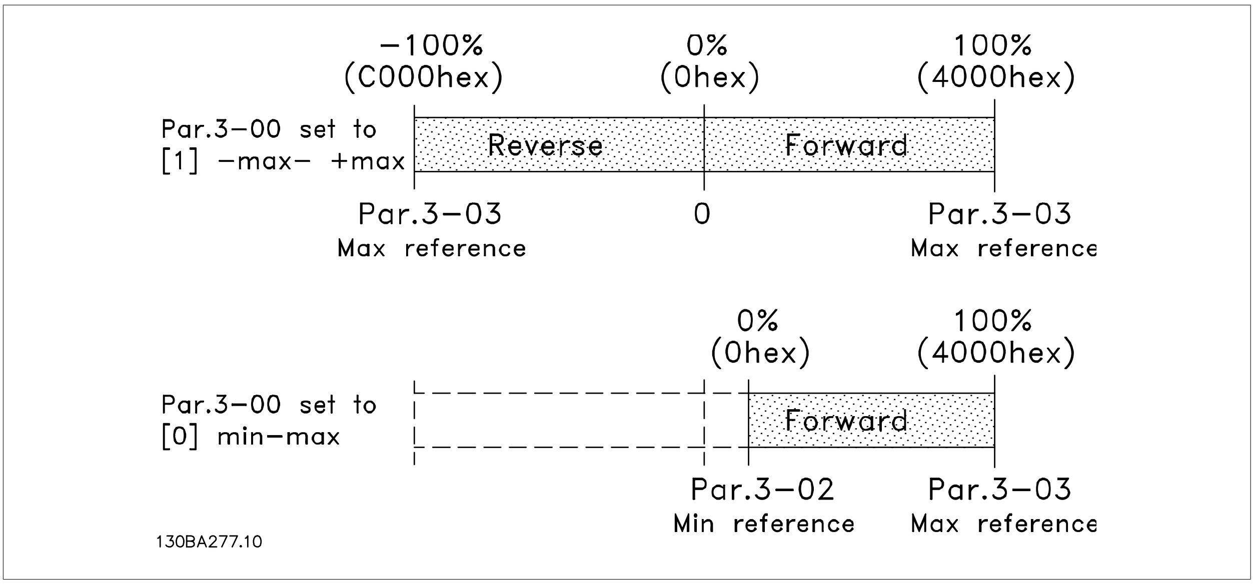
All bits in the STW are set to '0' if the connection between the Interbus option and the frequency converter is lost, or an internal communication problem has occurred.

9.6.3. 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.



The reference and MAV are scaled as follows:



9

9.6.4. PROFIdrive Control Profile

This section describes the functionality of the control word and status word in the PROFIdrive profile. Select this profile by setting par. 8-10 *Control word profile to PROFIdrive*.

9.6.5. Control Word according to PROFIdrive Profile (CTW)

The Control word is used to send commands from a master (e.g. a PC) to a slave.

Bit	Bit = 0	Bit = 1
00	OFF 1	ON 1
01	OFF 2	ON 2
02	OFF 3	ON 3
03	Coasting	No coasting
04	Quick stop	Ramp
05	Hold frequency output	Use ramp
06	Ramp stop	Start
07	No function	Reset
08	Jog 1 OFF	Jog 1 ON
09	Jog 2 OFF	Jog 2 ON
10	Data invalid	Data valid
11	No function	Slow down
12	No function	Catch up
13	Parameter set-up	Selection lsb
14	Parameter set-up	Selection msb
15	No function	Reverse

Explanation of the Control Bits

Bit 00, OFF 1/ON 1
Normal ramp stop using the ramp times of the actual selected ramp.
Bit 00 = "0" leads to the stop and activation of the output relay 1 or 2 if the output frequency is 0 Hz and if [Relay 123] has been selected in par. 5-40 *Function relay*.
When bit 00 = "1", the frequency converter is in State 1: "Switching on inhibited".
Please refer to the PROFIdrive State Transition Diagram, at the end of this section.

Bit 01, OFF 2/ON 2
Coasting stop
When bit 01 = "0", a coasting stop and activation of the output relay 1 or 2 occurs if the output frequency is 0 Hz and if [Relay 123] has been selected in par. 5-40 *Function relay*.
When bit 01 = "1", the frequency converter is in State 1: "Switching on inhibited". Please refer to the PROFIdrive State Transition Diagram, at the end of this section.

Bit 02, OFF 3/ON 3
Quick stop using the ramp time of par. 3-81 *Quick stop ramp time*. When bit 02 = "0", a quick stop and activation of the output relay 1 or 2 occurs if the output frequency is 0 Hz and if [Relay 123] has been selected in par. 5-40 *Function relay*.
When bit 02 = "1", the frequency converter is in State 1: "Switching on inhibited".
Please refer to the PROFIdrive State Transition Diagram, at the end of this section.

Bit 03, Coasting/No coasting
Coasting stop Bit 03 = "0" leads to a stop. When bit 03 = "1", the frequency converter can start if the other start conditions are satisfied.

NB!
The selection in par. 8-50 Coasting select determines how bit 03 is linked with the corresponding function of the digital inputs.

Bit 04, Quick stop/Ramp
Quick stop using the ramp time of par. 3-81 *Quick stop ramp time*.
When bit 04 = "0", a quick stop occurs.
When bit 04 = "1", the frequency converter can start if the other start conditions are satisfied.

NB!
The selection in par. 8-51 *Quick stop select* determines how bit 04 is linked with the corresponding function of the digital inputs.

Bit 05, Hold frequency output/Use ramp
When bit 05 = "0", the current output frequency is being maintained even if the reference value is modified.
When bit 05 = "1", the frequency converter can perform its regulating function again; operation occurs according to the respective reference value.

Bit 06, Ramp stop/Start
Normal ramp stop using the ramp times of the actual ramp as selected. In addition, activation of the output relay 01 or 04 if the output frequency is 0 Hz if Relay 123 has been selected in par. 5-40 *Function relay*. Bit 06 = "0" leads to a stop. When bit 06 = "1", the frequency converter can start if the other start conditions are satisfied.

NB!
The selection in par. 8-53 *Start select* determines how bit 06 is linked with the corresponding function of the digital inputs.

Bit 07, No function/Reset
Reset after switching off.
Acknowledges event in fault buffer.
When bit 07 = "0", no reset occurs.
When there is a slope change of bit 07 to "1", a reset occurs after switching off.

Bit 08, Jog 1 OFF/ON
Activation of the pre-programmed speed in par. 8-90 *Bus Jog 1 speed*. JOG 1 is only possible if bit 04 = "0" and bit 00 - 03 = "1".

Bit 09, Jog 2 OFF/ON
Activation of the pre-programmed speed in par. 8-91 *Bus Jog 2 speed*. JOG 2 is only possible if bit 04 = "0" and bit 00 - 03 = "1".

Bit 10, Data invalid/valid
Is used to tell the frequency converter whether the control word is to be used or ignored. Bit 10 = "0" causes the control word to be ignored, Bit 10 = "1" causes the control word to be used. This function is relevant, because the control word is always contained in the telegram, regardless of which type of telegram is used, i.e. it is possible to turn off the control word if you do not wish to use it in connection with updating or reading parameters.

Bit 11, No function/Slow down

Is used to reduce the speed reference value by the amount given in par. 3-12 *Catch up/slow down* value. When bit 11 = "0", no modification of the reference value occurs. When bit 11 = "1", the reference value is reduced.

Bit 12, No function/Catch up

Is used to increase the speed reference value by the amount given in par. 3-12 *Catch up/slow down value*.
When bit 12 = "0", no modification of the reference value occurs.
When bit 12 = "1", the reference value is increased.
If both - slowing down and accelerating - are activated (bit 11 and 12 = "1"), slowing down has priority, i.e. the speed reference value will be reduced.

Bits 13/14, Set-up selection

Bits 13 and 14 are used to choose between the four parameter set-ups according to the following table:

Set-up	Bit 13	Bit 14
1	0	0
2	1	0
3	0	1
4	1	1

The function is only possible if *Multi Set-up* has been chosen in par. 0-10 Active set-up. The selection in par. 8-55 *Set-up select* determines how bits 13 and 14 are linked with the corresponding function of the digital inputs. Changing set-up while running is only possible if the set-ups have been linked in par. 0-12 *This set-up linked to*.

Bit 15, No function/Reverse

Bit 15 = "0" causes no reversing.
Bit 15 = "1" causes reversing.
Note: In the factory setting reversing is set to *digital* in par. 8-54 *Reversing select*.

NB!
Bit 15 causes reversing only when *Ser. communication, Logic or* or *Logic and* is selected.

9.6.6. Status Word according to PROFIdrive Profile (STW)

The Status word is used to notify a master (e.g. a PC) about the status of a slave.

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	OFF 2	ON 2
05	OFF 3	ON 3
06	Start possible	Start not possible
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, autostart
13	Voltage OK	Voltage exceeded
14	Torque OK	Torque exceeded
15	Timer OK	Timer exceeded

Explanation of the Status Bits

Bit 00, Control not ready/ready

When bit 00 = "0", bit 00, 01 or 02 of the Control word is "0" (OFF 1, OFF 2 or OFF 3) - or the frequency converter is switched off (trip).

When bit 00 = "1", the frequency converter control is ready, but there is not necessarily power supply to the unit present (in the event of external 24 V supply of the control system).

Bit 01, VLT not ready/ready

Same significance as bit 00, however, there is a supply of the power unit. The frequency converter is ready when it receives the necessary start signals.

Bit 02, Coasting/Enable

When bit 02 = "0", bit 00, 01 or 02 of the Control word is "0" (OFF 1, OFF 2 or OFF 3 or coasting) - or the frequency converter is switched off (trip).

When bit 02 = "1", bit 00, 01 or 02 of the Control word is "1"; the frequency converter has not tripped.

Bit 03, No error/Trip

When bit 03 = "0", no error condition of the frequency converter exists.

When bit 03 = "1", the frequency converter has tripped and requires a reset signal before it can start.

Bit 04, ON 2/OFF 2

When bit 01 of the Control word is "0", then bit 04 = "0".

When bit 01 of the Control word is "1", then bit 04 = "1".

Bit 05, ON 3/OFF 3

When bit 02 of the Control word is "0", then bit 05 = "0".
When bit 02 of the Control word is "1", then bit 05 = "1".

Bit 06, Start possible/Start not possible

If PROFIdrive has been selected in par. 8-10 *Control word profile*, bit 06 will be "1" after a switch-off acknowledgement, after activation of OFF2 or OFF3, and after switching on the mains voltage. Start not possible will be reset, with bit 00 of the Control word being set to "0" and bit 01, 02 and 10 being set to "1".

Bit 07, No warning/Warning

Bit 07 = "0" means that there are no warnings.
Bit 07 = "1" means that a warning has occurred.

Bit 08, Speed ≠ reference / Speed = reference

When bit 08 = "0", the current speed of the motor deviates from the set speed reference value. This may occur, for example, when the speed is being changed during start/stop through ramp up/down.
When bit 08 = "1", the current speed of the motor corresponds to the set speed reference value.

Bit 09, Local operation/Bus control

Bit 09 = "0" indicates that the frequency converter has been stopped by means of the stop button on the control panel, or that [Linked to hand] or [Local] has been selected in par. 3-13 *Reference site*.
When bit 09 = "1", the frequency converter can be controlled through the serial interface.

Bit 10, Out of frequency limit/Frequency limit OK

When bit 10 = "0", the output frequency is outside the limits set in par. 4-11 *Motor speed low limit (rpm)* and par. 4-13 *Motor speed high limit (rpm)*.
When bit 10 = "1", the output frequency is within the indicated limits.

9

Bit 11, No operation/Operation

When bit 11 = "0", the motor does not turn.
When bit 11 = "1", the frequency converter has a start signal, or the output frequency is higher than 0 Hz.

Bit 12, Drive OK/Stopped, autostart

When bit 12 = "0", there is no temporary overloading of the inverter.
When bit 12 = "1", the inverter has stopped due to overloading. However, the frequency converter has not switched off (trip) and will start again after the overloading has ended.

Bit 13, Voltage OK/Voltage exceeded

When bit 13 = "0", the voltage limits of the frequency converter are not exceeded.
When bit 13 = "1", the direct voltage in the intermediate circuit of the frequency converter is too low or too high.

Bit 14, Torque OK/Torque exceeded

When bit 14 = "0", the motor torque is below the limit selected in par. 4-16 *Torque limit motor mode* and par. 4-17 *Torque limit generator mode*. When bit 14 = "1", the limit selected in par. 4-16 *Torque limit motor mode* or par. 4-17 *Torque limit generator mode* is exceeded.

Bit 15, Timer OK/Timer exceeded

When bit 15 = "0", the timers for the thermal motor protection and thermal frequency converter protection have not exceeded 100%.
When bit 15 = "1", one of the timers has exceeded 100%.

Index

A

B

C

D

E

F

G

H

I

J

L

M

N

O

P

R

S

T

U

V

W