MAKING MODERN LIVING POSSIBLE

Output Filters Design Guide

VLT® AutomationDrive FC 300
VLT® AQUA Drive FC 200
VLT® HVAC Drive FC 100

THE REAL DRIVE

Contents

1 How to Read this Design Guide

This Design Guide will introduce all aspects of output filters for your frequency converter; from choosing the right output filter for the application to instructions about how to install it and how to program the frequency converter.

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

1.1.1 Symbols

Symbols used in this manual

NOTE

Indicates something to be noted by the reader.

⚠CAUTION

Indicates a general warning.

⚠WARNING

Indicates a high-voltage warning.

★	Indicates default setting

1.1.2 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
Rated Inverter Output Current	I_{INV}
Revolutions Per Minute	RPM
Second	sec.
Synchronous Motor Speed	n_s
Torque limit	T_{LIM}
Volts	V
$I_{VLT,MAX}$	The maximum output current.
$I_{VLT,N}$	The rated output current supplied by the frequency converter.

2 Safety and Conformity

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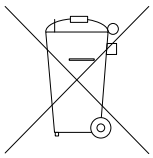
2.1 Safety Precautions



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.

MCC 101/102
Design Guide

2.1.1 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.
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 - 1000V AC and the 75 - 1500V DC voltage ranges. Danfoss CE-labels in accordance with the directive and issues a declaration of conformity upon request.

Warnings

⚠CAUTION

When in use the filter surface temperature rises. DO NOT touch the filter during operation.

⚠WARNING

Never work on a filter in operation. Touching the electrical parts may be fatal - even after the equipment has been disconnected from the frequency converter or motor.

⚠WARNING

Before servicing the filter, wait at least the voltage discharge time stated in the Design Guide for the corresponding frequency converter to avoid electrical shock hazard.

NOTE

Never attempt to repair a defect filter.

NOTE

The filters presented in this design guide are specially designed and tested for Danfoss frequency converters (FC 102/202/301 and 302). Danfoss takes no resposibility for the use of third party output filters.

NOTE

The phased out LC-filters that were developed for the VLT5000 series and are not compatible with the VLT FC 100/200/300.
However, the new filters are compatible with both FC-series and VLT 5000-series

NOTE

690V applications:
For motors not specially designed for frequency converter operation or without double insulation, Danfoss highly recommend the use of either dU/dt or Sine-Wave filters.

NOTE

Sine-wave filters can be used at switching frequencies higher than the nominal switching frequency, but should never be used at switching frequencies with less than 20% lower than the nominal switching frequency.

NOTE

dU/dt filters, unlike Sine-wave filters, can be used at lower switching frequency than the nominal switching frequency, but higher switching frequency will cause overheating of the filter and should be avoided.

3 Introduction to Output Filters

3.1 Why use Output Filters

This chapter describes why and when to use Output Filters with Danfoss frequency converters. It is divided into 4 sections:

- Protection of Motor Insulation
- Reduction of Motor Acoustic Noise
- Reduction of High Frequency Electromagnetic Noise in Motor Cable
- Bearing currents and shaft voltage

3.2 Protection of Motor Insulation

3.2.1 The Output Voltage

The output voltage of the frequency converter is a series of trapezoidal pulses with a variable width (pulse width modulation) characterized by a pulse rise-time t_r.

When a transistor in the inverter switches, the voltage across the motor terminal increases by a dU/dt ratio that depends on:

- the motor cable (type, cross-section, length, screened or unscreened, inductance and capacitance)
- the high frequency surge impendance of the motor

Because of the impedance mismatch between the cable characteristic impedance and the motor surge impedance a wave reflection occurs, causing a ringing voltage overshoot at the motor terminals - see *Illustration 3.1*. The motor surge impedance decreases with the increase of motor size resulting in reduced mismatch with the cable impedance. The lower reflection coefficient (Γ) reduces the wave reflection and thereby the voltage overshoot. Typical values are given in *Table 3.1*.
In the case of parallel cables the cable characteristic impedance is reduced, resulting in a higher reflection coefficient higher overshoot. For more information please see IEC 61800-8.

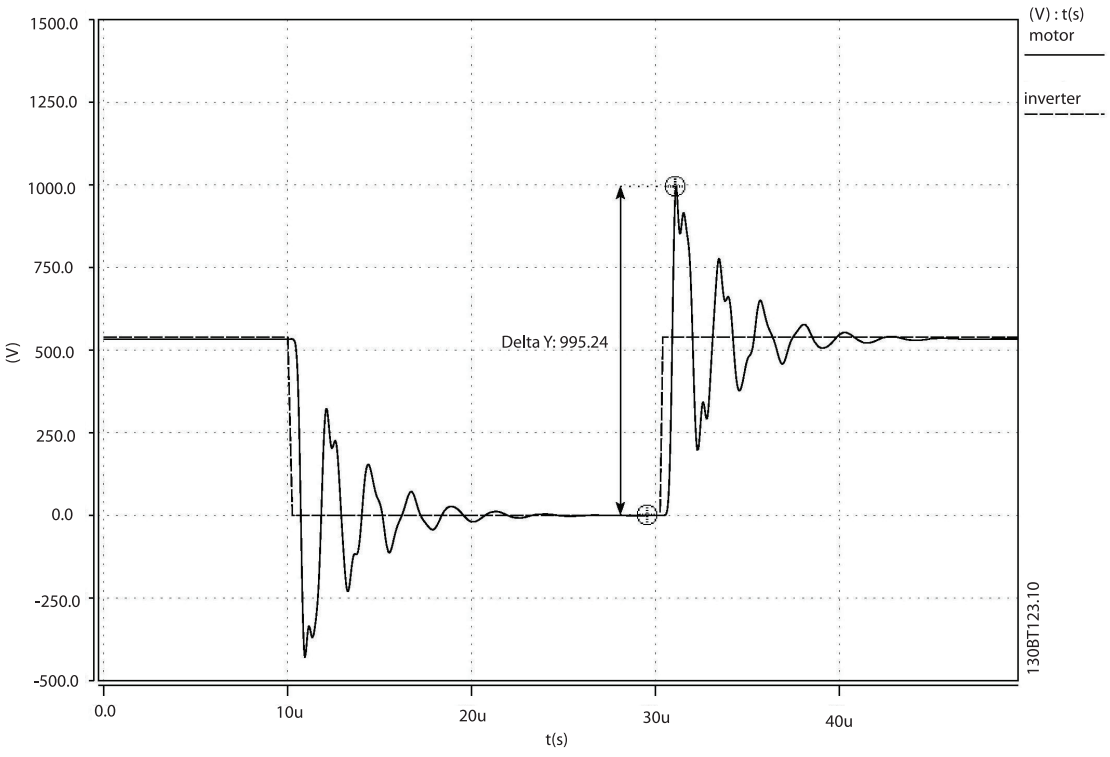


Illustration 3.1 Example of Converter Output Voltage (dotted line) and Motor Terminal Voltage After 200m of Cable (solid line)

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Typical values for the rise time and peak voltage U_{PEAK} are measured on the motor terminals between two phases.

Two different definitions for the risetime t_r are used in practice. The international IEC standards define the rise-time as the time between 10% to 90% of the peak voltage U_{peak}. The US National Electrical Manufacturers Association (NEMA) defines the rise-time as the time between 10% and 90% of the final, settled voltage, that is equal to the DC link voltage U_{DC}. See *Illustration 3.2* and *Illustration 3.3*.

To obtain approximate values for cable lengths and voltages not mentioned below, use the following rules of thumb:

1. Rise time increases with cable length.
2. U_{PEAK} = DC link voltage x (1+Γ); Γ represents the reflection coefficient and typical values can be found in table below
   (DC link voltage = Mains voltage x 1.35).
3. $dU/dt = \frac{0.8 \times U_{PEAK}}{t_r}$ (IEC)

   $dU/dt = \frac{0.8 \times U_{DC}}{t_r(NEMA)}$ (NEMA)

(For dU/dt, rise time, U_{peak} values at different cable lengths please consult the drive Design Guide)

Motor power [kW]	Zm [Ω]	Γ
<3.7	2000 - 5000	0.95
90	800	0.82
355	400	0.6

Table 3.1 Typical Values for Reflection Coefficients (IEC 61800-8).

The IEC and NEMA Definitions of Risetime t_r

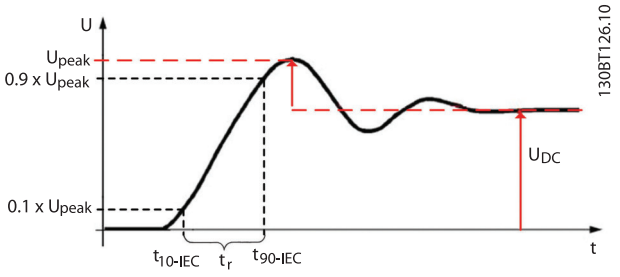

Illustration 3.2 IEC

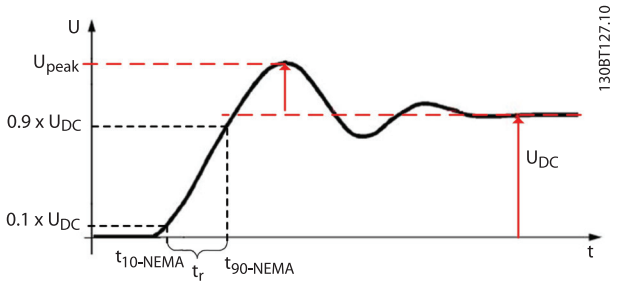

Illustration 3.3 NEMA

Various standards and technical specifications present limits of the admissible U_{peak} and t_r for different motor types. Some of the most used limit lines are shown in *Illustration 3.4*

- IEC 60034-17 – limit line for general purpose motors when fed by frequency converters, 500V motors.
- IEC 60034-25 – limit for converter rated motors: curve A is for 500V motors and curve B is for 690V motors.
- NEMA MG1 – Definite purpose Inverter Fed Motors.

If, in your application, the resulting U_{peak} and t_r exceed the limits that apply for the motor used, an output filter should be used for protecting the motor insulation.

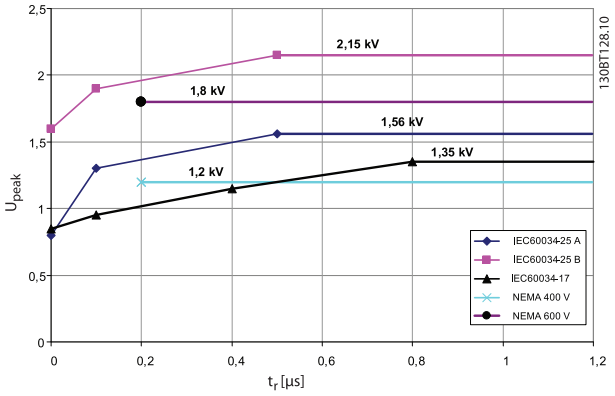

Illustration 3.4 Limit Lines for U_{peak} and Risetime t_r.

3.3 Reduction of Motor Acoustic Noise

The acoustic noise generated by motors has three main sources.

1. The magnetic noise produced by the motor core, through magnetostriction
2. The noise produced by the motor bearings
3. The noise produced by the motor ventilation

When a motor is fed by a frequency converter, the pulsewidth modulated (PWM) voltage applied to the motor causes additional magnetic noise at the switching frequency and harmonics of the switching frequency (mainly the double of the switching frequency). In some applications this is not acceptable. In order to eliminate this additional switching noise, a sine-wave filter should be used. This will filter the pulse shaped voltage from the frequency converter and provide a sinusoidal phase-to-phase voltage at the motor terminals.

3.4 Reduction of High Frequency Electromagnetic Noise in the Motor Cable

When no filters are used, the ringing voltage overshoot that occurs at the motor terminals is the main high-frequency noise source. *Illustration 3.5* shows the correlation between the frequency of the voltage ringing at the motor terminals and the spectrum of the high-frequency conducted interference in the motor cable.
Besides this noise component, there are also other noise components such as:

- The common-mode voltage between phases and ground at the switching frequency and its harmonics - high amplitude but low frequency.
- High-frequency noise (above 10MHz) caused by the switching of semiconductors - high frequency but low amplitude.

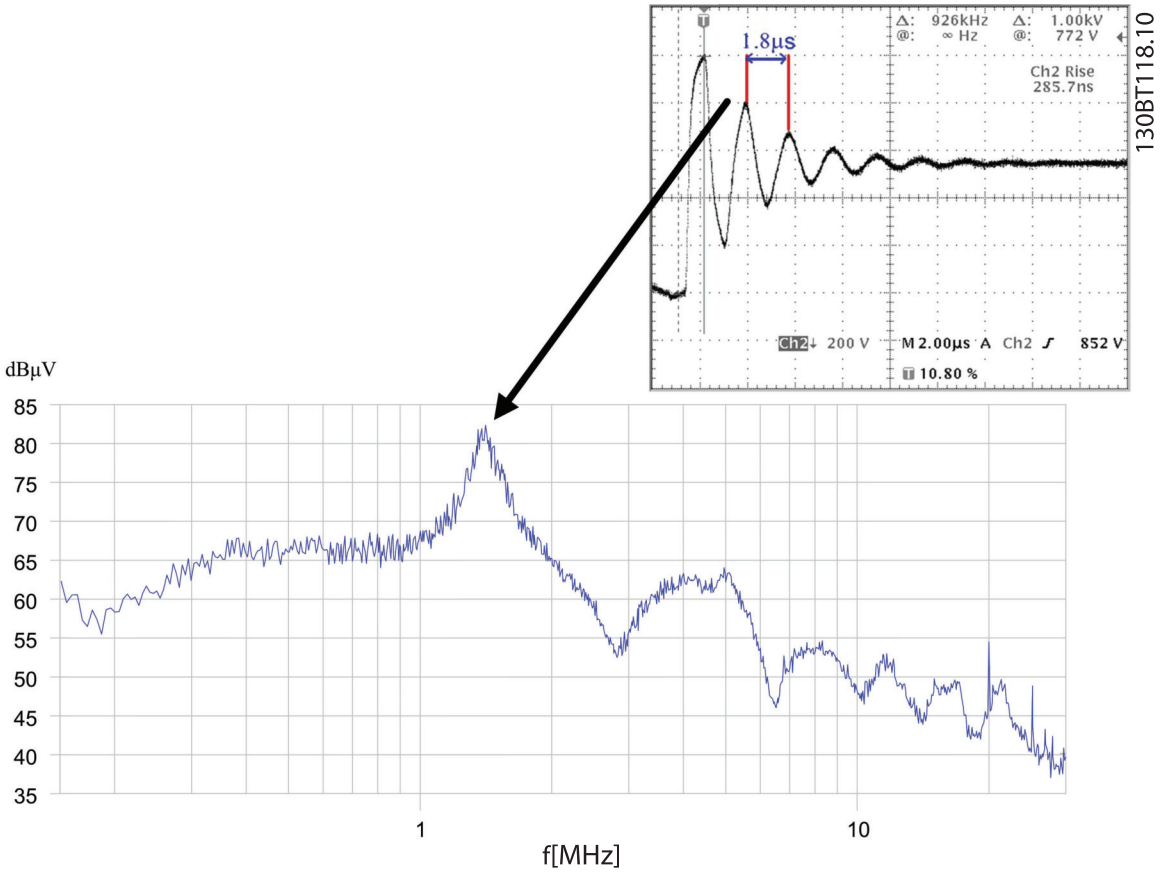

Illustration 3.5 Correlation Between the Frequency of the Ringing Voltage Overshoot and the Spectrum of Noise Emissions.

When an output filter is installed following effect is achieved:

- In the case of dU/dt filters the frequency of the ringing oscillation is reduced below 150kHz.
- In the case of sine-wave filters the ringing oscillation is completely eliminated and the motor is fed by a sinusoidal phase-to-phase voltage.

Remember, that the other two noise components are still present. This is illustrated in the conducted emission measurements shown in *Illustration 3.7* and *Illustration 3.8*. The use of unshielded motor cables is possible, but the layout of the installation should prevent noise coupling between the unshielded motor cable and the mains line or other sensitive cables (sensors, communication, etc.). This can be achieved by cable segregation and placement of the motor cable in a separate, continuous and grounded cable tray.

3.5 What are Bearing Currents and Shaft Voltages?

Fast switching transistors in the frequency converter combined with an inherent common-mode voltage (voltage between phases and ground) generate high-frequency bearing currents and shaft voltages. While bearing currents and shaft voltages can also occur in direct-on-line motors, these phenomena are accentuated when the motor is fed from a frequency converter. The majority of bearing damages in motors fed by frequency converters are because of vibrations, misalignment, excessive axial or radial loading, improper lubrication, impurities in the grease. In some cases, bearing damages are caused by bearing currents and shaft voltages. The mechanism that causes bearing currents and shaft voltages is quite intricate and beyond the scope of this Design Guide. Basically, two main mechanisms can be identified:

- Capacitive coupling: the voltage across the bearing is generated by parasitic capacitances in the motor.
- Inductive coupling: caused by circulating currents in the motor.

The grease film of a running bearing behaves like isolation. The voltage across the bearing can cause a breakdown of the grease film and produce a small electric discharge (a spark) between the bearing balls and the running track. This discharge produces a microscopic melting of the bearing ball and running track metal and in time it causes the premature wear-out of the bearing. This mechanism is called *Electrical Discharge Machining* or EDM.

3.5.1 Mitigation of Premature Bearing Wear-Out

There are a number of measures that can be taken for preventing premature wearing and damage of the bearings (not all of them are applicable in all cases – combinations can be used). These measures aim either to provide a low-impedance return path to the high-frequency currents or to electrically isolate the motor shaft for preventing currents through the bearings. Besides, there are also mechanical related measures.

Measures to provide a low-impedance return path

- Follow EMC installation rules strictly. A good high-frequency return path should be provided between motor and frequency converter, for example by using shielded cables.
- Make sure that the motor is properly grounded and the grounding has a low-impedance for high-frequency currents.
- Provide a good high-frequency ground connection between motor chassis and load.
- Use shaft grounding brushes.

Measures that isolate the motor shaft from the load

- Use isolated bearings (or at least one isolated bearing at the non-driving end NDE).
- Prevent shaft ground current by using isolated couplings.

Mechanical measures

- Make sure that the motor and load are properly aligned.
- Make sure the loading of the bearing (axial and radial) is within the specifications.
- Check the vibration level in the bearing.
- Check the grease in the bearing and make sure the bearing is correctly lubricated for the given operating conditions.

One of the mitigation measures is to use filters. This can be used in combination with other measures, such as those presented above. High-frequency common-mode (HF-CM) filters (core kits) are specially designed for reducing bearing stress. Sine-wave filters also have a good effect. dU/dt filters have less effect and it is recommended to use them in combination with HF-CM cores.

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3.5.2 Measuring Electric Discharges in the Motor Bearings

The occurrence of electric discharges in the motor bearings can be measured using an oscilloscope and a brush to pick up the shaft voltage. This method is difficult and the interpretation of the measured waveforms requires a deep understanding of the bearing current phenomena. An easy alternative is to use an electrical discharge detector (130B8000), as shown in *Illustration 3.6*. Such a device consists of a loop antenna that receives signals in the frequency range of 50MHz – 200MHz and a counter. Each electric discharge produces an electromagnetic wave that is detected by the instrument and the counter is incremented. If the counter displays a high number of discharges it means that there are many discharges occurring in the bearing and mitigation measures have to be taken to prevent the early wear out of the bearing. This instrument can be used for experimentally determining the exact number of cores needed to reduce bearing currents. Start with a set of 2 cores. If the discharges are not eliminated, or drastically reduced, add more cores. The number of cores presented in the table above is a guiding value that should cover most applications with a generous safety margin. If the cores are installed on the drive terminals and you experiment core saturation because of long motor cables (the cores have no effect on bearing currents), check the correctness of the installation. If cores keep saturating after the installation is made according to EMC best practice, consider moving the cores to the motor terminals.

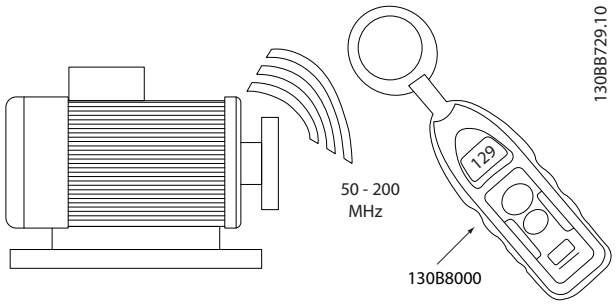

Illustration 3.6 Electrical Discharge Detector

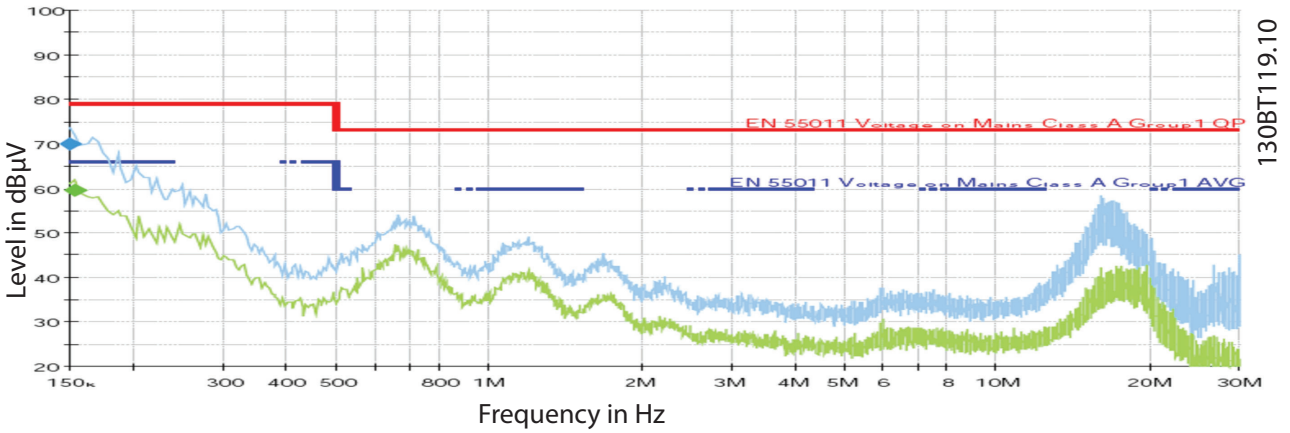

Illustration 3.7 Mains Line Conducted Noise, No Filter

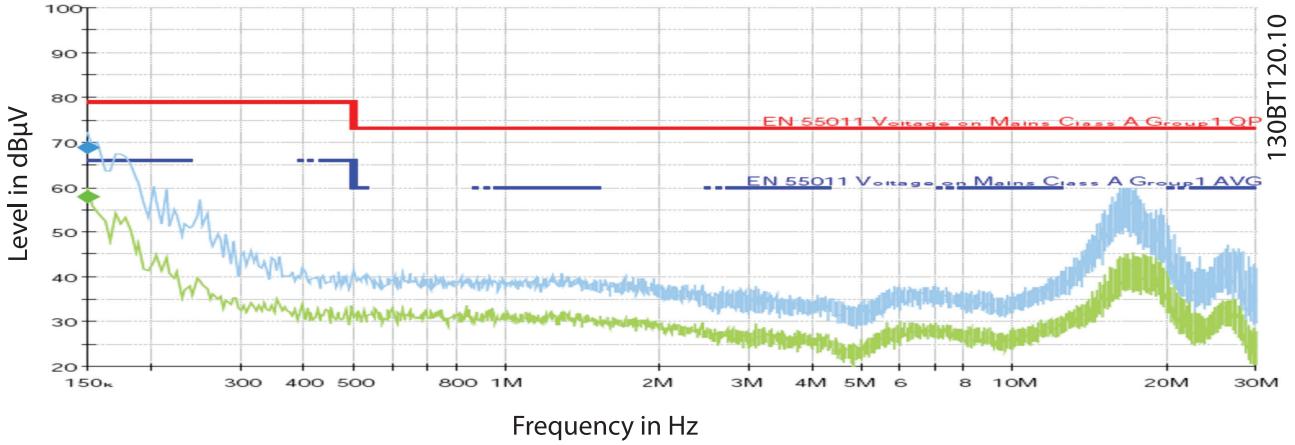

Illustration 3.8 Mains Line Conducted Noise, Sine-wave Filter

3.6 Which Filter for which Purpose

Table 3.2 shows a comparison of dU/dt, Sine-wave filter, and HF-CMperformance. It can be used to determine which filter to use with your application.

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Performance criteria	dU/dt filters	Sine-wave filters	High-frequency common-mode filters
Motor insulation stress	Up to 150m cable (screened/ unscreened) complies with the requirements of IEC 60034-17[1] (general purpose motors). Above this cable length the risk of "double pulsing" (two time mains network voltage) increases.	Provides a sinusoidal phase-to-phase motor terminal voltage. Complies with IEC 60034-17 [1] and NEMA-MG1 requirements for general purpose motors with cables up to 500m (1km for VLT frame size D and above).	Does not reduce motor insulation stress
Motor bearing stress	Slightly reduced, only in high-power motors.	Reduces bearing currents caused by circulating currents. Does not reduce common-mode currents (shaft currents).	Reduces bearing stress by limiting common-mode high-frequency currents
EMC performance	Eliminates motor cable ringing. Does not change the emission class. Does not allow longer motor cables as specified for the frequency converter's built-in RFI filter.	Eliminates motor cable ringing. Does not change the emission class. Does not allow longer motor cables as specified for the frequency converter's built-in RFI filter.	Reduces high-frequency emissions (above 1MHz). Does not change the emission class of the RFI filter. Does not allow longer motor cables as specified for the frequency converter.
Max. motor cable length	100m ... 150m With guaranteed EMC performance: 150m screened. Without guaranteed EMC performance: 150m unscreened.	With guaranteed EMC performance: 150m screened and 300m unscreened. Without guaranteed EMC performance: up to 500m (1km for VLT frame size D and above)	150m screened (frame size A, B, C), 300 m screened (frame size D, E, F), 300 m unscreened
Acoustic motor switching noise	Does not eliminate acoustic switching noise.	Eliminates acoustic switching noise from the motor caused by magneto-striction.	Does not eliminate acoustic switching noise.
Relative size	15-50% (depending on power size)	100%	5 - 15%
Voltage drop	0.5%	4-10%	none

Table 3.2 Comparison of dU/dt and Sine-wave Filters

1) Not 690V.
2) See general specification for formula.

3.6.1 dU/dt Filters

The dU/dt filters consist of inductors and capacitors in a low pass filter arrangement and their cut off frequency is above the nominal switching frequency of the frequency converter. The inductance (L) and capacitance (C) values are shown in the tables in *4.2 Electrical Data - dU/dt Filters*. Compared to Sine-wave filters they have lower L and C values, thus they are cheaper and smaller. With a dU/dt filter the voltage wave form is still pulse shaped but the current is sinusoidal - see following illustrations.

Features and benefits
dU/dt filters reduce the voltage peaks and dU/dt of the pulses at the motor terminals. The dU/dt filters reduce dU/dt to approx. 500V/µs.

Advantages

- Protects the motor against high dU/dt values and voltage peaks, hence prolongs the lifetime of the motor
- Allows the use of motors which are not specifically designed for converter operation, for example in retrofit applications

Application areas
Danfoss recommends the use of dU/dt filters in the following applications:

- Applications with frequent regenerative braking
- Motors that are not rated for frequency converter operation and not complying with IEC 600034-25
- Motors placed in aggressive environments or running at high temperatures
- Applications with risk of flash over

- Installations using old motors (retrofit) or general purpose motors not complying with IEC 600034-17
- Applications with short motor cables (less than 15m)
- 690V applications

Voltage and current with and without dU/dt filter:

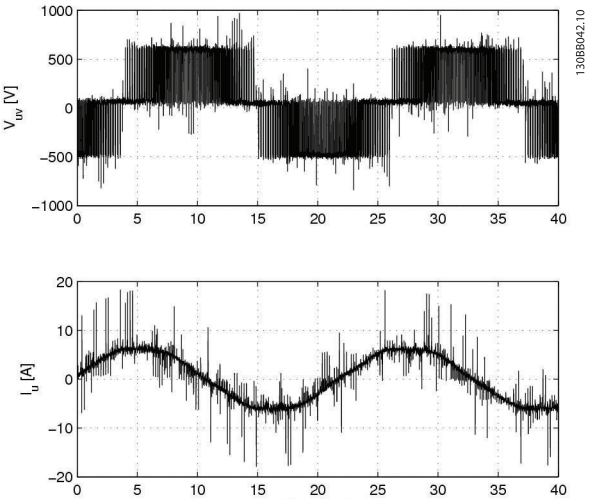

Illustration 3.9 Without Filter

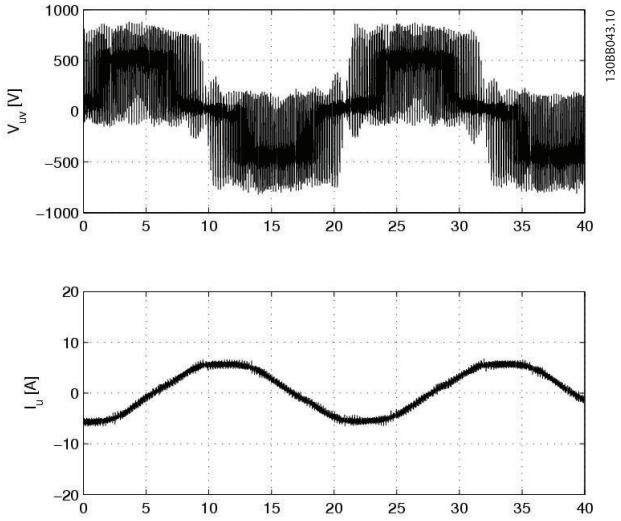

Illustration 3.10 With dU/dt Filter

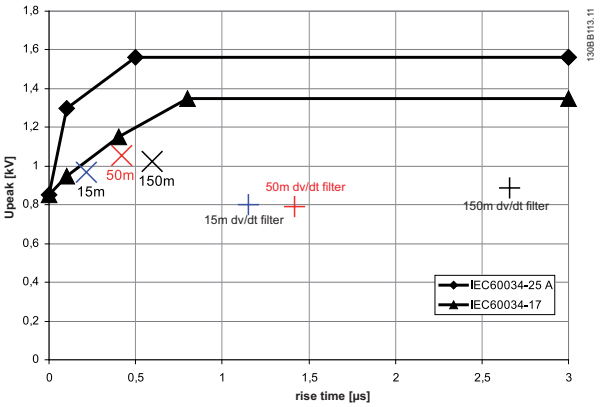

Illustration 3.11 Measured dU/dt values (rise time and peak voltages) with and without dU/dt filter using 15m, 50m and 150m cable lengths on a 400V, 37kW induction motor.

The dU/dt value decreases with the motor cable length whereas the peak voltage increases (see *Illustration 3.11*). The U_{peak} value depends on the U_{dc} from the frequency converter and as U_{dc} increases during motor braking (generative) U_{peak} can increase to values above the limits of IEC 60034-17 and thereby stress the motor insulation. Danfoss therefore recommends dU/dt filters in applications with frequent braking. Furthermore the illustration above shows how the U_{peak} increases with the cable length. As the cable length increases, the cable capacitance rises and the cable behaves like a low-pass filter. That means longer rise-time t_r for longer cables. Therefore it is recommended to use dU/dt filters only in applications with cable lengths up to 150m. Above 150m dU/dt filters have no effect. If further reduction is needed, use a sine-wave filter.

Filter features

- IP00 and IP20/23/54 enclosure in the entire power range
- Side by side mounting with the drive
- Reduced size, weight and price compared to the sine-wave filters
- Possibility of connecting screened cables with included decoupling plate
- Compatible with all control principles including flux and VVC^{PLUS}
- Filters wall mounted up to 177A and floor mounted above that size

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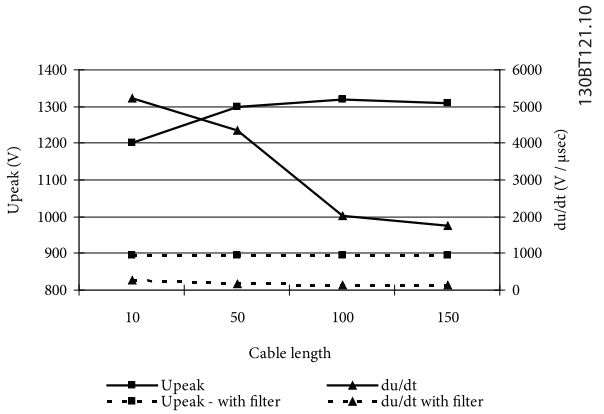


Illustration 3.12 525V - With and Without dU/dt Filter

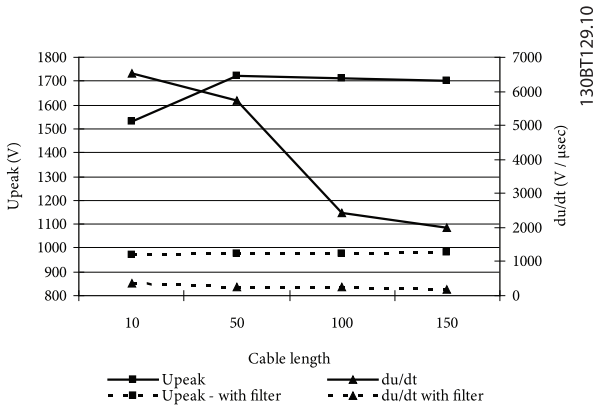


Illustration 3.13 690V - With and Without dU/dt Filter

Source: Test of 690V 30kW VLT FC 302 with MCC 102 dU/dt filter

Illustration 3.12 and *Illustration 3.13* show how U_{peak} and rise time behaves as a function of the motor cable length. In installations with short motor cables (below 5-10m) the rise time is short which causes high dU/dt values. The high dU/dt can cause a damaging high potential difference between the windings in the motor which can lead to breakdown of the insulation and flash-over. Danfoss therefore recommends dU/dt filters in applications with motor cable lengths shorter than 15m.

3.6.2 Sine-wave Filters

Sine-wave filters are designed to let only low frequencies pass. High frequencies are consequently shunted away which results in a sinusoidal phase to phase voltage waveform and sinusoidal current waveforms. With the sinusoidal waveforms the use of special frequency converter motors with reinforced insulation is no longer needed. The acoustic noise from the motor is also damped as a consequence of the sinusoidal wave condition. The sine-wave filter also reduces insulation stress and bearing currents in the motor, thus leading to prolonged motor lifetime and longer periods between services. Sine-wave filters enable use of longer motor cables in applications where the motor is installed far from the frequency converter. As the filter does not act between motor phases and ground, it does not reduce leakage currents in the cables. Therefore the motor cable length is limited - see *Table 3.2*.

The Danfoss Sine-wave filters are designed to operate with the VLT® FC 100/200/300. They replace the LC-filter product range and are backwards compatible with the VLT 5000-8000 Series Drives. They consist of inductors and capacitors in a low-pass filter arrangement. The inductance (L) and capacitance (C) values are shown in tables in *4.3 Electrical Data - Sine-wave Filters*.

Features and benefits

As described above, Sine-wave filters reduce motor insulation stress and eliminate switching acoustic noise from the motor. The motor losses are reduced because the motor is fed with a sinusoidal voltage, as shown in *Illustration 3.12*. Moreover, the filter eliminates the pulse reflections in the motor cable thus reducing the losses in the frequency converter.

Advantages

- Protects the motor against voltage peaks hence prolongs the lifetime
- Reduces the losses in the motor
- Eliminates acoustic switching noise from the motor
- Reduces semiconductor losses in the drive with long motor cables
- Decreases electromagnetic emissions from motor cables by eliminating high frequency ringing in the cable
- Reduces electromagnetic interference from unscreened motor cables
- Reduces the bearing current thus prolonging the lifetime of the motor

Voltage and current with and without Sine-wave filter

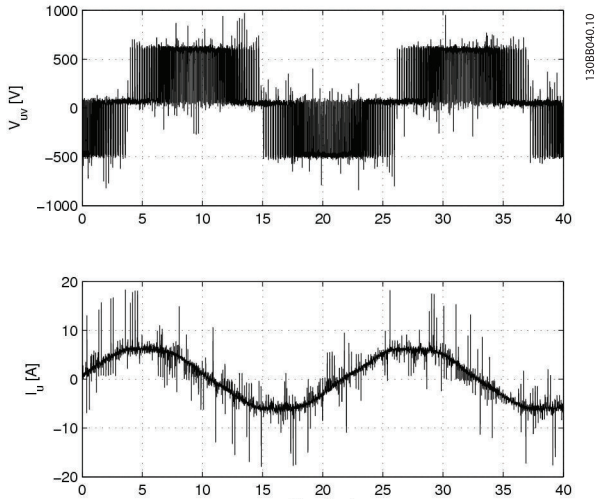


Illustration 3.14 Without Filter

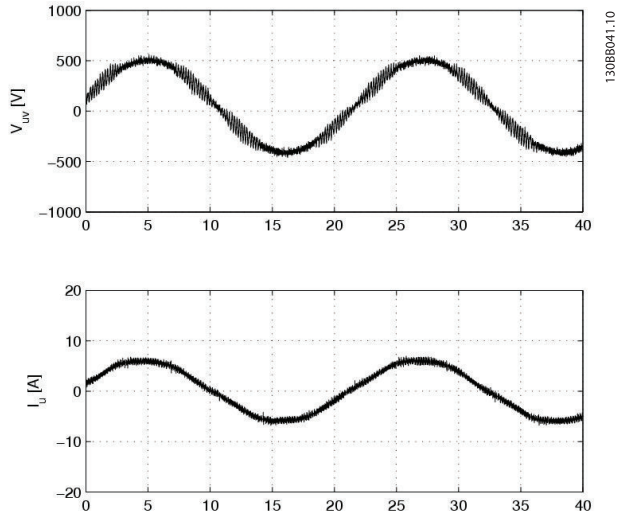


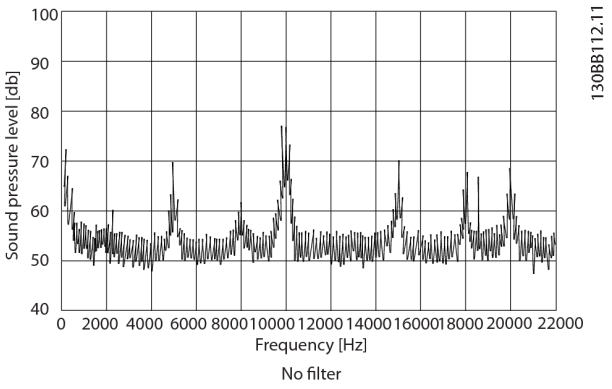
Illustration 3.15 With Sine-wave Filter

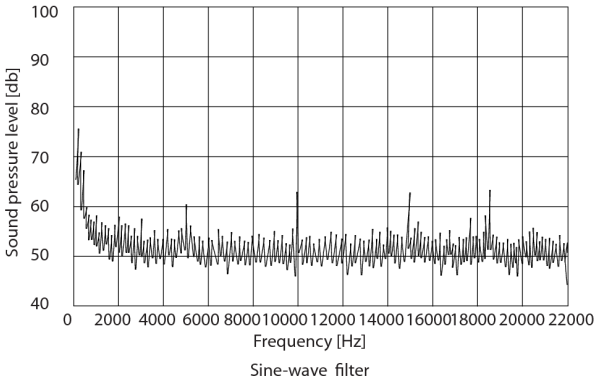
Application areas

Danfoss recommends the use of Sine-wave filters in the following applications.

- Applications where the acoustic switching noise from the motor has to be eliminated
- Retrofit installations with old motors with poor insulation
- Applications with frequent regenerative braking and motors that do not comply with IEC 60034-17
- Applications where the motor is placed in aggressive environments or running at high temperatures
- Applications with motor cables above 150m up to 300m (with both screened and unscreened cable). The use of motor cables longer than 300m depends on the specific application
- Applications where the service interval on the motor has to be increased
- 690V applications with general purpose motors
- Step up applications or other applications where the frequency converter feeds a transformer

Example of relative motor sound pressure level measurements with and without Sine-wave filter





Features

- IP00 and IP20 enclosure in the entire power range (IP23 for floor standing filters)
- Compatible with all control principle including flux and VVC^{PLUS}
- Side by side mount with the frequency converter up to 75A
- Filter enclosure matching the frequency converter enclosure
- Possibility of connecting unscreened and screened cables with included decoupling plate
- Filters wall mounted up to 75A and floor mount above

- Parallel filter installation is possible with applications in the high power range

3.6.3 High-Frequency Common-Mode Core Kits

3

High-frequency common-mode (HF-CM) core kits are one of the mitigation measures to reduce bearing wear. However, they should not be used as the sole mitigation measure. Even when HF-CM cores are used, the EMC-correct installation rules must be followed. The HF-CM cores work by reducing the high-frequency common-mode currents that are associated with the electric discharges in the bearing. They also reduce the high-frequency emissions from the motor cable which can be used, for example, in applications with unshielded motor cables.

4 Selection of Output Filters

4.1 How to Select the Correct Output Filter

An output filter is selected based on the nominal motor current. All filters are rated for 160% overload for 1 minute, every 10 minutes.

4.1.1 Product Overview

To simplify the Filter Selection *Table 4.1* shows which Sine-wave filter to use with a specific frequency converter. This is based on the 160% overload for 1 minute every 10 minutes and is to be considered guideline.

Mains supply 3 x 240 to 500V							
Rated filter current at 50Hz	Minimum switching frequency [kHz]	Maximum output frequency [Hz] With derating	Code number IP20	Code number IP00	Frequency converter size		
					200-240V	380-440V	441-500V
2.5	5	120	130B2439	130B2404	PK25 - PK37	PK37 - PK75	PK37 - PK75
4.5	5	120	130B2441	130B2406	PK55	P1K1 - P1K5	P1K1 - P1K5
8	5	120	130B2443	130B2408	PK75 - P1K5	P2K2 - P3K0	P2K2 - P3K0
10	5	120	130B2444	130B2409		P4K0	P4K0
17	5	120	130B2446	130B2411	P2K2 - P4K0	P5K5 - P7K5	P5K5 - P7K5
24	4	100	130B2447	130B2412	P5K5	P11K	P11K
38	4	100	130B2448	130B2413	P7K5	P15K - P18K	P15K - P18K
48	4	100	130B2307	130B2281	P11K	P22K	P22K
62	3	100	130B2308	130B2282	P15K	P30K	P30K
75	3	100	130B2309	130B2283	P18K	P37K	P37K
115	3	100	130B3181	130B3179	P22K - P30K	P45K - P55K	P55K - P75K
180	3	100	130B3183	130B3182	P37K - P45K	P75K - P90K	P90K - P110
260	3	100	130B3185	130B3184		P110 - P132	P132
410	3	100	130B3187	130B3186		P160 - P200	P160 - P200
510	3	100	130B3189	130B3188		P250	P250
660	2	70	130B3192	130B3191		P315 - P355	P315 - P355
800	2	70	130B3194	130B3193		P400	P400 - P450
1020	2	70	2 x 130B3189	2 x 130B3188		P450 - P500	P500 - P560
1320	2	70	2 x 130B3192	2 x 130B3191		P560 - P630	P630 - P710
1530	2	70	3 x 130B3189	3 x 130B3188		P710 - P800	P800
1980	2	70	3 x 130B9192	3 x 130B3191			P1M0

Table 4.1 Filter Selection

Mains supply 3 x 525 to 600/690V						
Rated filter current at 50Hz	Minimum switching frequency [kHz]	Maximum output frequency [Hz] With derating	Code number IP20	Code number IP00	Frequency converter size	
					525-600V	525-690V
13	2	70	130B3196	130B3195	PK75 - P7K5	
28	2	100	130B4113	130B4112	P11K - P18K	
45	2	100	130B4115	130B4114	P22K - P30K	P37K
76	2	100	130B4117	130B4116	P37K - P45K	P45K - P55K
115	2	100	130B4119	130B4118	P55K - P75K	P75K - P90K
165	2	70	130B4124	130B4121		P110 - P132
260	2	100	130B4126	130B4125		P160 - P200
303	2	70	130B4151	130B4129		P250
430	1.5	60	130B4153	130B4152		P315 - P400
530	1.5	100	130B4155	130B4154		P500
660	1.5	100	130B4157	130B4156		P560 - P630
868	1.5	60	2 x 130B4153	2 x 130B4152		P710
1060	1.5	100	2 x 130B4155	2 x 130B4154		P800 - P900
1590	1.5	60	3 x 130B4155	3 x 130B4154		P1M0

Table 4.2 Filter Selection

Generally the output filters are designed for the nominal switching frequency of the frequency converter.

NOTE

Sine-wave filters can be used at switching frequencies higher than the nominal switching frequency, but should never be used at switching frequencies with less than 20% lower than the nominal switching frequency.

NOTE

dU/dt filters, unlike Sine-wave filters, can be used at lower switching frequency than the nominal switching frequency, but higher switching frequency will cause the overheating of the filter and should be avoided.

4.1.2 HF-CM Selection

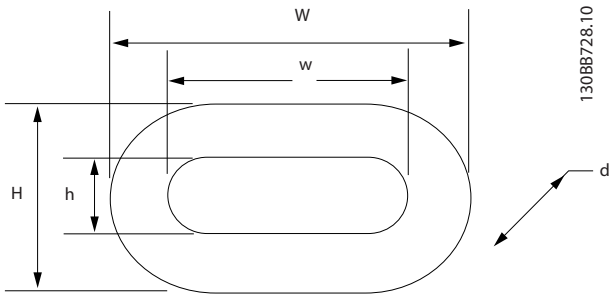
The cores can be installed at the frequency converter's output terminals (U, V, W) or in the motor terminal box.

When installed at the frequency converter's terminals the HF-CM kit reduces both bearing stress and high-frequency electromagnetic interference from the motor cable. The number of cores depends on the motor cable length and frequency converter voltage and a selection table is shown below.

Cable length [m]	A- and B frame		C frame		D frame		E- F frame	
	T5	T7	T5	T7	T5	T7	T5	T7
50	2	4	2	2	2	4	2	2
100	4	4	2	4	4	4	2	4
150	4	6	4	4	4	4	4	4
300	4	6	4	4	4	6	4	4

When installed in the motor terminal box the HF-CM kit reduces only bearing stress and has no effect on the electro-magnetic interference from the motor cable. Two cores are sufficient in most cases, independent of the motor cable length.

Danfoss provides the HF-CM cores in kits of two pieces/kit. The cores are oval shaped for the ease of installation and are available in four sizes: for A and B frames, for C frames, for D frames, for E and F frames. For F frame frequency converters, one core kit shall be installed at each inverter module terminals. Mechanical mounting can be made with cable ties. There are no special requirements regarding mechanical mounting.



In normal operation the temperature is below 70°C. However, if the cores are saturated they can get hot, with temperatures above 70°C. Therefore it is important to use the correct number of cores to avoid saturation. Saturation can occur if the motor cable is too long, motor cables are paralleled or high capacitance motor cables, not suitable for frequency converter operation, are used. Always avoid motor cables with sector-shaped cores. Use only cables with round-shaped cores.

⚠CAUTION

Check the core temperature during commissioning. A temperature above 70°C indicates saturation of the cores. If this happens add more cores. If the cores still saturate it means that the cable capacitance is too large because of: too long cable, too many parallel cables, cable type with high capacitance.

Applications with parallel cables

When parallel cables are used the total cable length has to be considered. For example 2 x 100m cables are equivalent with one 200m cable. If many paralleled motors are used a separate core kit should be installed for each individual motor.

The ordering numbers for the core kits (2 cores/package) are given in the following table.

VLT frame size	Danfoss part no.	Core dimension [mm]					Weight	Packaging dimension
		W	w	H	h	d	[kg]	[mm]
A and B	130B3257	60	43	40	25	22	0.25	130x100x70
C	130B3258	102	69	61	28	37	1.6	190x100x70
D	130B3259	189	143	126	80	37	2.45	235x190x 140
E and F	130B3260	305	249	147	95	37	4.55	290x260x 110

Code number	IP00 IP20/IP23[1] IP54[4]	Filter current rating at given voltage and motor frequency [A][2]				VLT power and current rating										Maximum filter losses	Filter data	
		380V @ 60Hz and 200/440V @ 50Hz	460/480V @ 60Hz and 500/525V @ 50Hz[3]	575/600V @ 60Hz	690V @ 50HzkW	200 - 240v		380 - 440V		441 - 500V		525 - 550V		551 - 690V			µH	C
						kW	A	kW	A	kW	A	kW	A	kW	A	W	uH	nF
130B2835	IP00	44	40	32	27	5.5	24.2	11	24	11	21	7.5	14	11	13	37	150	10
130B2836	IP20					7.5	30.8	15	32	15	27	11	19	15	18			
130B2837	IP54							18.5	37.5	18.5	34	15	23	18.5	22			
								22	44	22	40	18.5	28	22	27			
130B2838	IP00	90	80	58	54	11	46.2	30	61	30	52	30	43	30	34	130	110	13.6
130B2839	IP20					15	59.4	37	73	37	65	37	54	37	41			
130B2840	IP54					18.5	74.8	45	90	55	80	45	65	45	52			
						22	88											
130B2841	IP00	106	105	94	86			55	106	75	105	55	87	55	62	145	95	15
130B2842	IP20													75	83			
130B2843	IP54																	
130B2844	IP00	177	160	131	108	30	115	75	147	90	130	75	113	90	108	205	111	15
130B2845	IP20					37	143	90	177	110	160	90	137					
130B2846	IP54					45	170											
130B2847	IP00	315	303	242	192			110	212	132	190	110	162	110	131	315	50	20
130B2848	IP23							132	260	160	240	132	201	132	155			
								160	315	200	303			160	192			
130B2849	IP00	480	443	344	290			200	395	250	361	160	253	200	242	398	30	43
130B2850	IP23							250	480	315	443	200	303	250	290			
130B2851	IP00	658	590	500	450			315	600	355	540	250	360	315	344	550	17	66
130B2852	IP23							355	658	400	590	300	395	355	380			
												315	429	400	410			
130B2853	IP00	880	780	630	630			400	745	450	678	400	523	500	500	850	13	99
130B2854	IP23							450	800	500	730	450	596	560	570			
								500	880	560	780	500	659	630	630			

[1] The filter enclosure is IP20 for wall-mounted filters and IP23 for floor-mounted filters

[2] For derating with motor frequency consider 60Hz rating=0.94 x 50Hz rating and 100Hz rating= 0.75 x 50Hz rating

[3] 525V operation requires a T7 drive

[4] IP54 is available up to 177A

Table 4.3 dU/dt Filter 3x200-690V IP00/IP20/IP23/IP54

Code number	IP00 IP20/IP23[1]	Filter current rating at given voltage and motor frequency [A][2]				VLT power and current size								Maximum filter losses	Filter data	
		380V @ 60Hz and 200/440V @ 50Hz	460/480V @ 60Hz and 500/525V @ 50Hz[3]	575/600V @ 60Hz	690V @ 50Hz	380 - 440V		441 - 500V		525 - 550V		551 - 690V			L	C
						kW	A	kW	A	kW	A	kW	A	W	µH	nF
2 x 130B2851 2 x 1302852 or 3 x 130B2849 3 x 130B3850	IP00 IP23 IP00 IP23	For F frame drives, parallel filters shall be used, one filter for each inverter module.				710	1260	800	1160	750	988					
2 x 130B2853 2 x 130B2854 or 3 x 130B2851 3 x 130B2852	IP00 IP23 IP00 IP23											900	945			
3 x 130B2853	IP00					800	1460	1000	1380	850	1108	1000	1060			
3 x 130B2854	IP23					1000	1700	1100	1530	1000	1317	1200	1260			
2 x 130B2849	IP00					450	800	500	730	500	659					
2 x 130B2852	IP23					500	880	560	780							

[1] The filter enclosure is IP20 for wall-mounted filters and IP23 for floor-mounted filters

[2] For derating with motor frequency consider 60Hz rating=0.94 x 50Hz rating and 100Hz rating= 0.75 x 50Hz rating

[3] 525V operation requires a T7 drive

Code Number	IP00 IP20 (IP23)[2]	Filter Current Rating @ 50Hz	@ 60Hz	@ 100Hz	Switching Frequency	VLT Power and Current Ratings @ 200-240V		@ 380-440V		@ 441-500V		Filter Losses @ 200-240V	@ 380-440V	@ 441-500V	L-value	C_y-Value[1]
		A	A	A	kHz	kW	A	kW	A	kW	A	W	W	W	mH	µF
130B2404	IP00	2.5	2.5	2*	5			0.37	1.3	0.37	1.1		45	45		
130B2439	IP20					0.25	1.8	0.55	1.8	0.55	1.6	50	50	50	29	1
						0.37	2.4	0.75	2.4	0.75	2.1	60	60	60		
130B2406	IP00	4.5	4	3.5*	5			1.1	3	1.1	3		60	60	13	2.2
130B2441	IP20					0.55	3.5	1.5	4.1	1.5	3.4	65	70	65		
						0.75	4.6					65				
130B2408	IP00	8	7.5	5*	5	1.1	6.6	2.2	5.6	2.2	4.8	75	70	70	6.9	4.7
130B2443	IP20					1.5	7.5	3	7.2	3	6.3	80	80	80		
130B2409	IP00	10	9.5	7.5*	5			4	10	4	8.2		95	90	5.2	6.8
130B2444	IP20															
						2.2	10.6					90				
130B2411	IP00	17	156	13	5	3	12.5	5.5	13	5.5	11	100	110	100	3.1	10
130B2446	IP20					3.7	16.7	7.5	16	7.5	14.5	125	125	115		
130B2412	IP00	24	23	18	4	5.5	24.2	11	24	11	21	150	150	150	2.4	10
130B2447	IP20															
130B2413	IP00	38	36	28.5	4			15	32	15	27		170	160	1.6	10
130B2448	IP20					7.5	30.8	18.5	37.5	18.5	34	160	180	170		
130B2281	IP00	48	45.5	36	4	11	46.2	22	44	22	40	270	270	260	1.1	14.7
130B2307	IP20															
130B2282	IP00	62	59	46.5	3	15	59.4	30	61	30	52	300	310	280	0.85	30
130B2308	IP20															
130B2283	IP00	75	71	56	3	18.5	74.8	37	73	37	65	350	350	330	0.75	30
130B2309	IP20															
130B3179	IP00	115	109	86	3	22	88	45	90	55	80		470		0.51	15
130B3181	IP23					30	115	55	106	75	105					
130B3182	IP00	180	170	135	3	37	143	75	147	90	130		650		0.33	25
130B3183	IP23					45	170	90	177	110	160					
130B3184	IP00	260	246	195	3			110	212	132	190		850		0.34	25
130B3185	IP23							132	260	160	240					

*) 120Hz

[1]Equivalent STAR-connection value

[2]IP23 - All floor mounted filters

Table 4.4 Sine-wave Filter 3x380-500 V IP00/IP20/IP23

Code Number	IP00 IP20 (IP23)[2]	Filter Current Rating @ 50Hz	@ 60Hz	@ 100Hz	Switching Frequency	VLT Power and Current Ratings @ 200-240V		@ 380-440V		@ 441-500V		Filter Losses @ 200-240V	@ 380-440V	@ 441-500V	L-value	Cy-Value[1]
		A	A	A	kHz	kW	A	kW	A	kW	A	W	W	W	mH	µF
130B3186	IP00	410	390	308	3			160	315	200	303		1150		0.25	33
130B3187	IP23							200	395	250	361					
130B3188	IP00	510	456	360	3			250	480	315	443		1450		0.14	66
130B3189	IP23															
130B3191	IP00	660	627	495	3			315	600	355	540		2000		0.15	106
130B3192	IP23							355	658	400	590					
130B3193	IP00	800	712	562	2			400	745	450	678		3000		0.1	153
130B3194	IP23															
2 x 130B3188	IP00	1020	912	720	2			450	800	500	730		2900			
2 x 130B3189	IP23							500	880	560	780					
2 x 130B3191	IP00	1320	1254	990	2			560	990	630	890		4000			
2 x 130B3192	IP23							630	1120	710	1050					
3 x 130B3188	IP00	1530	1368	1080	2			710	1260	800	1160		4350			
3 x 130B3189	IP23							800	1460	1000	1380					
3 x 130B3191	IP00	1980	1881	1485	2			1000	1700	1100	1530		6000			
3 x 130B3192	IP23															

*) 120Hz

[1]Equivalent STAR-connection value

[2]IP23 - All floor mounted filters

Table 4.5 Sine-wave Filter 3x380-500V IP00/IP20/IP23

Code Number	IP00 IP20(IP23)[2]	Filter Current Rating @ 50Hz	@ 60Hz	@ 100Hz	Switching Frequency	VLT Power and Current Ratings @ 525-550V		@ 525-600V		@ 690V		Filter losses @ 525-550V	@ 525-600V	@ 690V	L-value	C_y-Value[1]
		A	A	A	kHz	kW	A	kW	A	kW	A	W	W	W	mH	µF
130B3195 130B3196	IP00 IP20	13	12	9	2	0.75 1.1 1.5 2.2 3 4 5.5 7.5	1.7 2.4 2.7 4.1 5.2 6.4 9.5 11.5						115		8.1	4.7
130B4112 130B4113	IP00 IP23	28	26	21	2	11 15 18.5	18 22 27			11 15 18.5 22	13 18 22 27		150		5	10
130B4114 130B4115	IP00 IP23	45	42	33	2	22 30	34 41	30	46	30 37	34 46		250		2.5	15
130B4116 130B4117	IP00 IP23	76	72	57	2	37 45	52 62	37 45	56 76	45 55	54 73		475		1.6	33
130B4118 130B4119	IP00 IP23	115	109	86	2	55 75	83 100	55 75	90 113	75 90	86 108		750		0.91	33
130B4121 130B4124	IP00 IP23	165	156	124	2	90 110	131 155	90 110	137 162	110 132	131 155		1100		0.765	66
130B4125 130B4126	IP00 IP23	260	246	195	2	150 180	192 242	132 160	201 253	160 200	192 242		1300		0.48	66
130B4129 130B4151	IP00 IP23	360	314	270	2	220 260	290 344	200 315	303 344	250 250	290 360		1800		0.42	66
130B4152 130B4153	IP00 IP23	430	407	323	1.5	300	429	400	410	315	429		2150		0.285	99
130B4154 130B4155	IP00 IP23	530	502	398	1.5	375	523	500	500	400	523		2400		0.215	120
130B4156 130B4157	IP00 IP23	660	625	496	1.5	450 480	596 630	560 630	570 630	500	596		3000		0.19	153

[1]Equivalent STAR-connection value

[2]IP23 - All floor mounted filters

Table 4.6 Sine-wave Filter 3x525-690V IP00/IP20/IP23

MG.90.N5.02 - VLT® is a registered Danfoss trademark

Code Number	IP00 IP20(IP23)[2]	Filter Current Rating @ 50Hz	@ 60Hz	@ 100Hz	Switching Frequency	VLT Power and Current Ratings @ 525-550V		@ 525-600V		@ 690V		Filter losses @ 525-550V	@ 525-600V	@ 690V	L-value	C_y-Value[1]
		A	A	A	kHz	kW	A	kW	A	kW	A	W	W	W	mH	µF
2 x 130B4142	IP00	860	814	646	1.5	970	1260	1200	1260	1000	1317		4300			
2 x 130B4153	IP23					560	730	710	730	460	630					
2 x 130B4154	IP00	1060	1004	796	1.5	670	898	800	850	630	763		4800			
2 x 130B4155	IP23							900	945	710	939					
3 x 130B4154	IP00	1590	1506	1194	1.5	820	1060	1000	1060	800	1108		7200			
3 x 130B4155	IP23					970	1260	1200	1260	1000	1317					

[1]Equivalent STAR-connection value

[2]IP23 - All floor mounted filters

Code Number	Filter Current Rating			Switching Frequency	VLT Power and Current Rating						Filter losses			L-value	C_y-Value[1]
	@ 50Hz	@ 60Hz	@ 100Hz		@ 200-240V		@ 380-440V		@ 441-500V		@ 200-240V	@ 380-440V	@ 441-500V		
	A	A	A	kHz	kW	A	kW	A	kW	A	W	W	W	mH	µF
130B2542	10	10	8	5	2.2	10.6	4	10	4	8.2		60	60	5.3	1.36
130B2543	17	17	13.6	5	3	12.5	5.5	13	5.5	11	100	100	100	3.1	2.04
					3.7	16.7	7.5	16	7.5	14.5	100	100	100	3.1	2.04

Table 4.7 Sine-wave Foot Print Filter 3x200-500V IP20

MG.90.N5.02 - VLT® is a registered Danfoss trademark

4.3.1 Spare Parts/Accessories

Protective earth (PE) grounding plate for IP00 and IP20 wall mounted filters. The accessory bag also includes all necessary screws and cable fixations.

Wall mounted Sine-wave filters		Accessory bag
IP00	IP20	
130B2404	130B2439	130B0385
130B2406	130B2441	
130B2408	130B2443	
130B2409	130B2444	
130B2411	130B2446	
130B2412	130B2447	130B0386
130B2413	130B2448	
130B2341	130B2321	
130B2281	130B2307	130B0387
130B2282	130B2308	
130B2283	130B2309	
130B2835	130B2836	130B4175
130B2838	130B2839	130B4176
130B2841	130B2842	130B4177

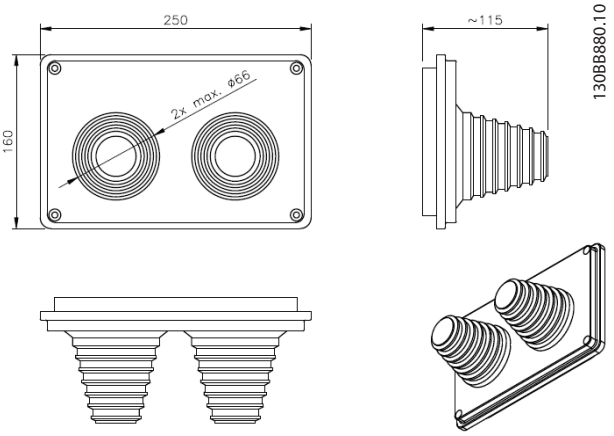
Nom. filter current rating (200-380/460/600/690V) [A]	Filter code number	Accessory bag
44/40/32/27	130B2835 130B2836	130B4175
90/80/58/54	130B2838 130B2839	130B4176
106/105/94/86	130B2841 130B2842	130B4176
177/160/131/108	130B2844 130B2845	130B4127

Accessories - L-shapes

Voltage	Current	IP	Danfoss part no.	L-shape
500	115	00	130B3179	---
	115	23	130B3181	---
	180	00	130B3182	---
	180	23	130B3183	---
	260	00	130B3184	130B3137
	260	23	130B3185	130B3137
	410	00	130B3186	130B3138
	410	23	130B3187	130B3138
	510	00	130B3188	130B3138
	510	23	130B3189	130B3138
	660	00	130B3191	130B3139
	660	23	130B3192	130B3139
	800	00	130B3193	130B3139
	800	23	130B3194	130B3139
690	13	00	130B3195	---
	13	20	130B3196	---
	28	00	130B4112	---
	28	20	130B4113	---
	45	00	130B4114	---
	45	20	130B4115	---
	76	00	130B4116	---
	76	23	130B4117	---
	115	00	130B4118	---
	115	23	130B4119	---
	165	00	130B4121	130B3137
	165	23	130B4124	130B3137
	260	00	130B4125	130B3137
	260	23	130B4126	130B3137
	360	00	130B4129	130B3138
	360	23	130B4151	130B3138
	430	00	130B4152	130B3138
	430	23	130B4153	130B3138
	530	00	130B4154	130B3138
	530	23	130B4155	130B3138
	660	00	130B4156	130B3139
	660	23	130B4157	130B3139

4.3.2 Cable Glands for Floor Standing Filters

Nom. filter current rating (200-380/460/600/690V) [A]	Filter code number	Spare part no.
315/303/242/192	130B2848	130B4178
480/443/344/290	130B2850	
658/590/500/450	130B2852	
880/780/630/630	130B2854	



4

4.3.3 Terminal Kits

Voltage	Current	IP	Danfoss part no.	Spare parts
500	115	00	130B3179	-
	115	23	130B3181	130B4178
	180	00	130B3182	-
	180	23	130B3183	130B4178
	260	00	130B3184	-
	260	23	130B3185	130B4178
	410	00	130B3186	-
	410	23	130B3187	130B4178
	510	00	130B3188	-
	510	23	130B3189	130B4178
	660	00	130B3191	-
	660	23	130B3192	130B4178
	800	00	130B3193	-
	800	23	130B3194	130B4178
690	13	00	130B3195	130B4175
	13	20	130B3196	130B4175
	28	00	130B4112	130B4175
	28	20	130B4113	130B4175
	45	00	130B4114	130B4176
	45	20	130B4115	130B4176
	76	00	130B4116	-
	76	23	130B4117	130B4178
	115	00	130B4118	-
	115	23	130B4119	130B4178
	165	00	130B4121	-
	165	23	130B4124	130B4178
	260	00	130B4125	-
	260	23	130B4126	130B4178
	360	00	130B4129	-
	360	23	130B4151	130B4178
	430	00	130B4152	-
	430	23	130B4153	130B4178
	530	00	130B4154	-
	530	23	130B4155	130B4178
	660	00	130B4156	-
	660	23	130B4157	130B4178

4.4 Sine-Wave Filters

Technical Specifications	
Voltage rating	3 x 200-500V and 500-690V AC
Nominal current @ 50Hz	up to 800A (500V) and 660A (690V). F frame current ratings are achieved by filter paralleling, one filter per inverter module.
Motor frequency derating	
50Hz	Inominal
60Hz	0.94 x Inominal
100Hz	0.75 x Inominal
Minimum switching frequency	nominal switching frequency of the respective FC 102, 202 or 302 x 0.80
Maximum switching frequency	8kHz
Overload capacity	160% for 60 seconds, every 10 minutes.
Enclosure degree	IP00, IP20 for wall-mounted, IP23 for floor mounted.
Ambient temperature	-10° to +45°C
Storage temperature	-25° to +60°C
Transport temperature	-25° to +70°C
Maximum ambient temperature (with derating)	55°C
Maximum altitude without derating	1000m
Maximum altitude with derating	4000m
Derating with altitude	5%/1000m
MTBF	1481842 h
FIT	1.5 106/h
Tolerance of the inductance	± 10%
Degree of pollution EN 61800-5-1	II
Overvoltage category EN 61800-5-1	III
Environmental Conditions Load	3K3
Environmental Conditions Storage	1K3
Environmental Conditions Transport	2K3
Noise level	< frequency converter
Approvals	CE (EN 61558, VDE 0570), RoHS, cULus file E219022 (pending)

The voltage drop across the inductor can be calculated using this formula:

$ud = 2 \times \pi \times f_m \times L \times I$

f_m = output frequency
L = filter inductions
I = current

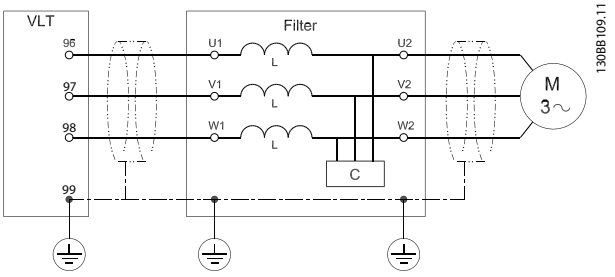
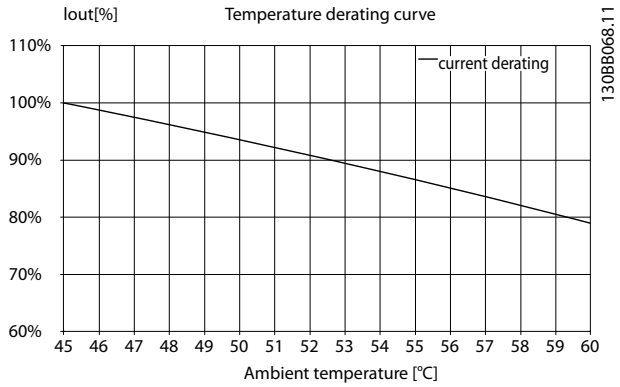


Illustration 4.1 Filter Diagram



4.4.1 dU/dt Filters

Technical Specifications	
Voltage rating	3 x 200-690V
Nominal current @ 50Hz	up to 880A. F frame current ratings are achieved by filter paralleling, one filter per inverter module.
Motor frequency derating	
50Hz	Inominal
60Hz	0.94 x Inominal
100Hz	0.75 x Inominal
Minimum switching frequency	no limit
Maximum switching frequency	nominal switching frequency of the respective FC 102, 202 or 302
Overload capacity	160% for 60 seconds, every 10 minutes.
Enclosure degree	IP00, IP 20 for wall-mounted, IP23 for floor mounted. IP21/NEMA 1 available for wall-mounted using separate kits.
Ambient temperature	-10° to +45°C
Storage temperature	-25° to +60°C
Transport temperature	-25° to +70°C
Maximum ambient temperature (with derating) Maximum altitude without derating	55°C
Maximum altitude without derating	1000m
Maximum altitude with derating	4000m
Derating with altitude	5%/1000m
MTBF	1481842 h
FIT	1.5 10^6 / h
Tolerance of the inductance	± 10%
Degree of pollution EN 61800-5-1	II
Overvoltage category EN 61800-5-1	III
Environmental Conditions Load	3K3
Environmental Conditions Storage	1K3
Environmental Conditions Transport	2K3
Noise level	< frequency converter
Approvals	CE (EN61558, VDE 0570), RoHS, cULus file E219022 (pending)

4.4.2 Sine-Wave Foot Print Filter

Technical Specification

Voltage rating	3 x 200-500V AC
Nominal current I⌐N @ 50Hz	10 – 17A
Motor frequency	0-60Hz without derating. 100/120Hz with derating (see derating curves below)
Ambient temperature	-25° to 45°C side by side mount, without derating (see derating curves below)
Min. switching frequency	f_{min} 5kHz
Max. switching frequency	f_{max} 16kHz
Overload capacity	160% for 60 sec. every 10 minutes.
Enclosure degree	IP20
Approval	CE, RoHS

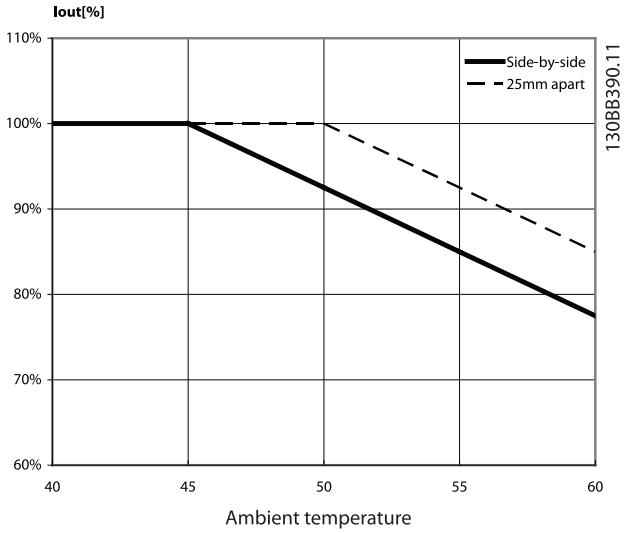


Illustration 4.2 Temperature Derating

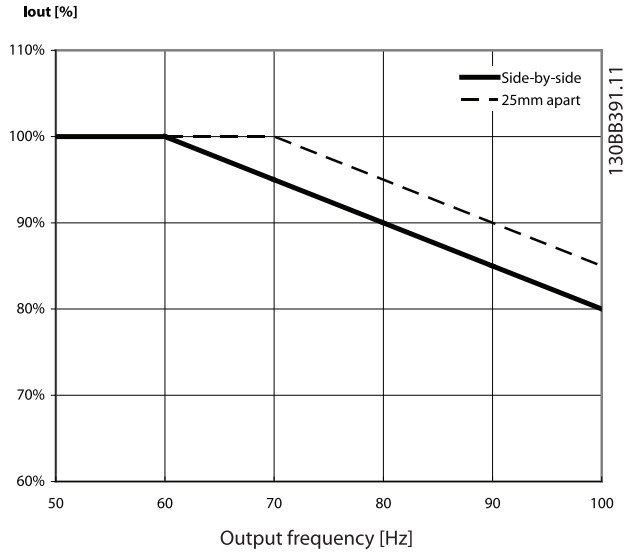


Illustration 4.3 Output Frequency Derating

5 How to Install

5.1 Mechanical Mounting

5.1.1 Safety Requirements for Mechanical Installation

⚠WARNING

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 filter is cooled by natural convection.
To protect the unit from overheating it must be ensured that the ambient temperature *does not exceed the maximum temperature stated for the filter*. Locate the maximum temperature in the paragraph *Derating for Ambient Temperature*.
If the ambient temperature is in the range of 45°C - 55°C, derating of the filter will become relevant.

5.1.2 Mounting

- All wall mounted filters must be mounted vertically with the terminals at the bottom.
- Do not mount the filter close to other heating elements or heat sensitive material (such as wood)
- The filter can be side-mounted with the frequency converter. There is no requirement for spacing between the filter and frequency converter.
- Top and bottom clearance is minimum 100mm (200mm for foot print filters).
- The surface temperature of IP20/23 units does not exceed 70°C.
- The surface temperature of IP00 filters can exceed 70°C and a hot surface warning label is placed on the filter.

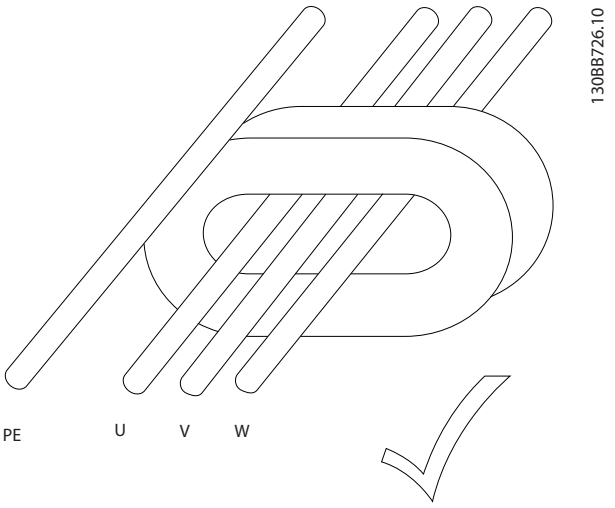


Illustration 5.1 Correct Installation

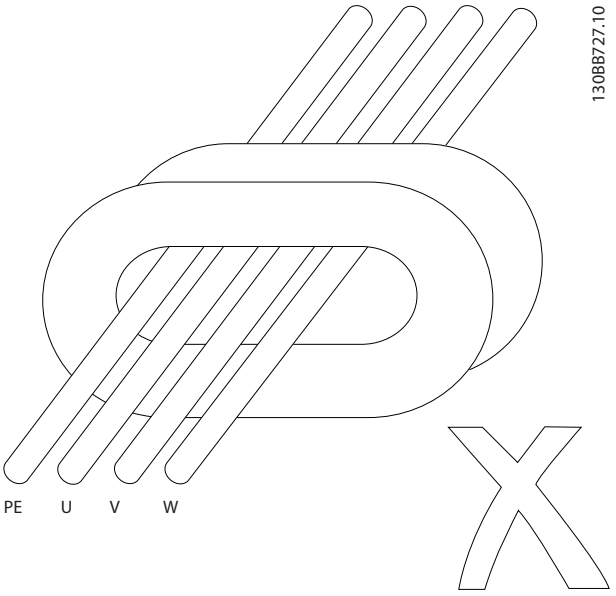


Illustration 5.2 Wrong Installation. The PE should not go through the core.

5.1.3 Mechanical Installation of HF-CM

The HF-CM cores have an oval shape to allow easier installation. They should be placed around the three motor phases (U, V and W). It is important to put all three motor phases through the core, else the core will saturate. It is also important not to put the PE or any grounding wires through the core, else the core will loose its effect. In most applications several cores have to be stacked.

The cores can vibrate due to the alternating magnetic field. When close to the cable's isolation or other parts, it is possible that the vibration causes the wearing of the core or cable isolation material. Use cable ties to secure the cores and cable.

5.1.4 Earthing of Sine-wave and dU/dt Filters

⚠WARNING

The filter must be earthed before switching the power on (high leakage currents).

Common mode interferences are kept small by ensuring that the current return path to the frequency converter has the lowest possible impedance.

- Choose the best earthing possibility (e.g. cabinet mounting panel)
- Use the enclosed (in accessory bag) protective earth terminal to ensure the best possible earthing
- Remove any paint present to ensure good electrical contact
- Ensure that the filter and frequency converter make solid electrical contact (high frequency earthing)
- The filter must be earthed before switching the power on (high leakage currents)

5.1.5 Screening

It is recommended to use screened cables to reduce the radiation of electromagnetic noise into the environment and prevent malfunctions in the installation.

- Cable between the frequency converter output (U, V, W) and filter input (U1, V1, W1) to be screened or twisted.
- Use preferably screened cables between the filter output (U2, V2, W2) and the motor. When unscreened cables are employed it should be ensured that the installation minimizes the possibility of cross-couplings with other cables carrying sensitive signals. This can be achieved by measures such as cable segregation and mounting in earthed cable trays.
- The cable screen must be solidly connected at both ends to the chassis (e.g. housing of filter and motor).
- If IP00 filters are installed in cabinets and screened cables are used, the screen of the motor cable should be terminated at the cabinet cable entry point.
- All screen connections must exhibit the smallest possible impedance, i.e. solid, large area connections, both ends of screened cable.
- Maximum cable length between frequency converter and output filter:
  Below 7.5kW: 2m
  Between 7.5 - 90kW: 5-10m
  Above 90kW: 10-15m

NOTE

The cable between frequency converter and filter should be kept as short as possible

NOTE

More than 10m is possible but Danfoss strongly discourge such installations, due to the risk of increased EMI and voltage spikes on the filter terminals.

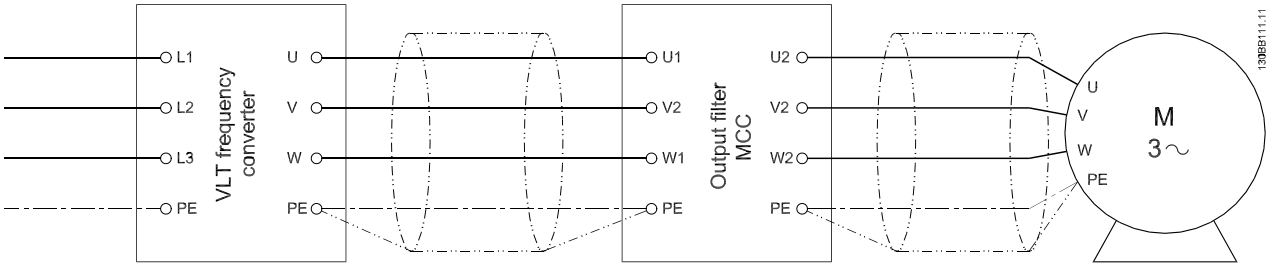


Illustration 5.3 Wiring Diagram

For F frame frequency converters parallel filters shall be used, one filter for each inverter module.
The cables or bus bars between inverter and filter should have the same length for each module.
The paralleling connection should be after the dU/dt filter/sine-wave filter, either at the filters' terminals or at the motor terminals.

5.2 Mechanical Dimensions

5.2.1 Sketches

Wall Mounted Sine-wave filters

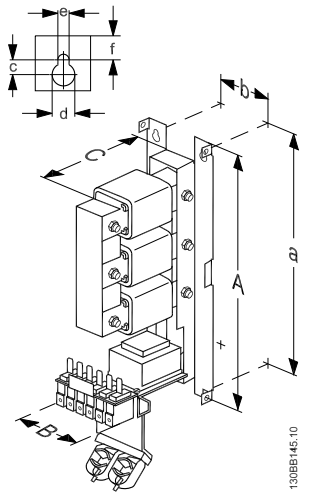


Illustration 5.4 IP00 Wall Mounted

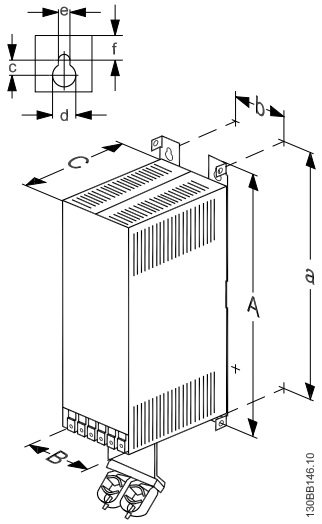


Illustration 5.5 IP20 Wall Mounted

Floor Mounted Sine-wave filters

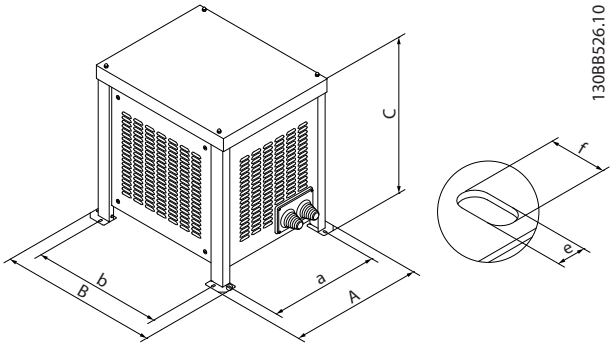


Illustration 5.6 IP23 Floor Mounted

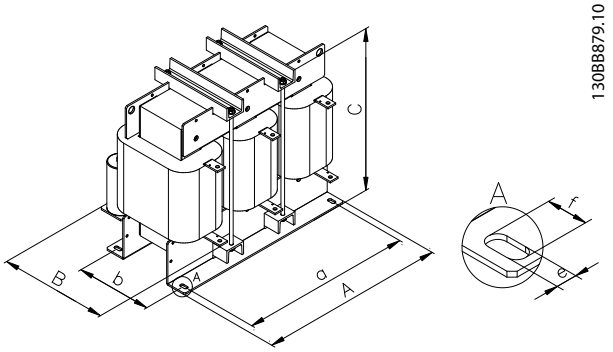


Illustration 5.7 IP00 Floor Mounted

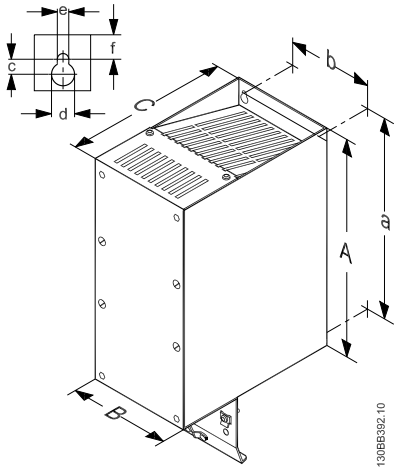


Illustration 5.8 IP20 Wall Mounted Foot Print Filters

Wall mounted dU/du filters

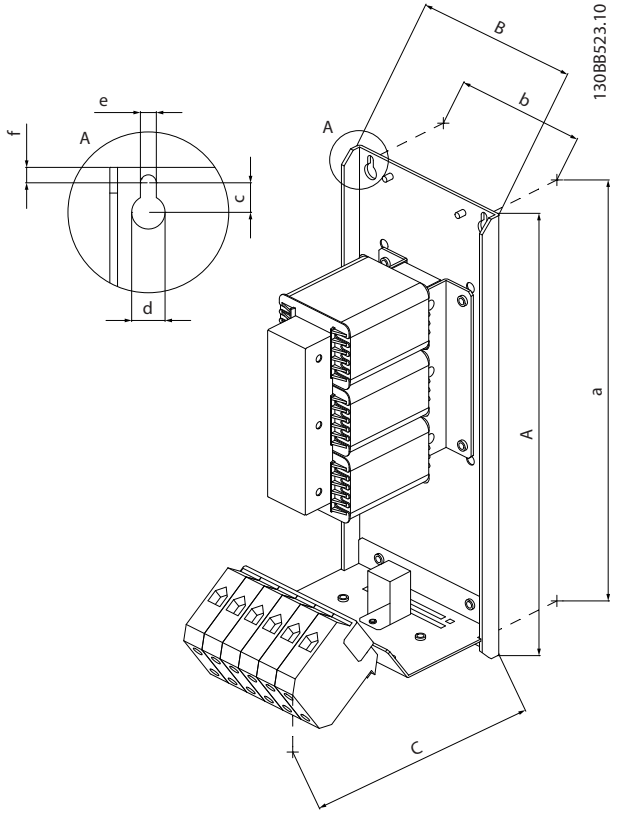


Illustration 5.9 IP00 Wall Mounted

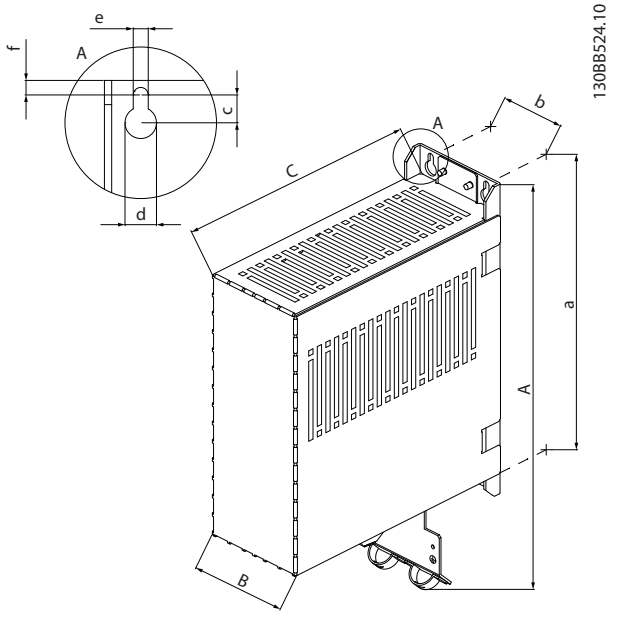


Illustration 5.10 IP20 Wall Mounted

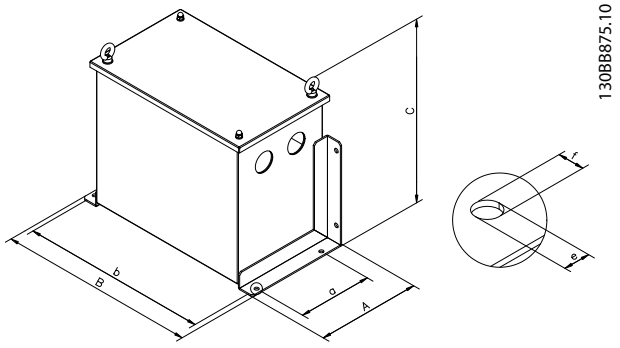


Illustration 5.11 IP54 Floor/Wall Mounted

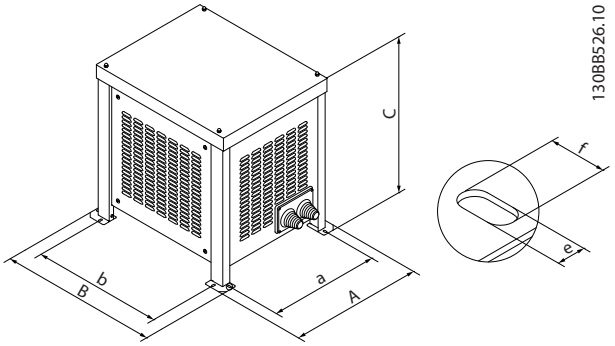


Illustration 5.12 IP23 Floor Mounted

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Floor mounted dU/du filters

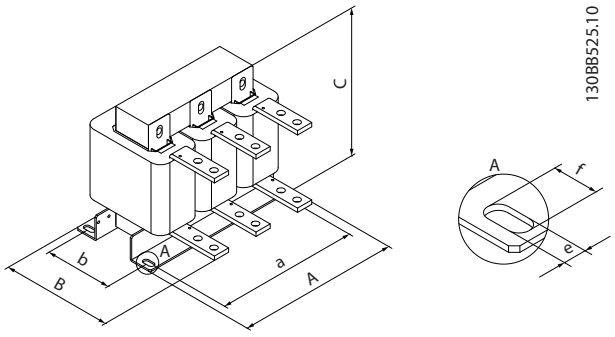

Illustration 5.13 IP00 Floor Mounted

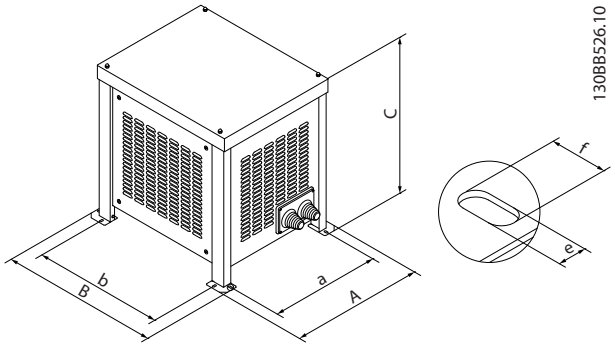

Illustration 5.14 IP23 Floor Mounted

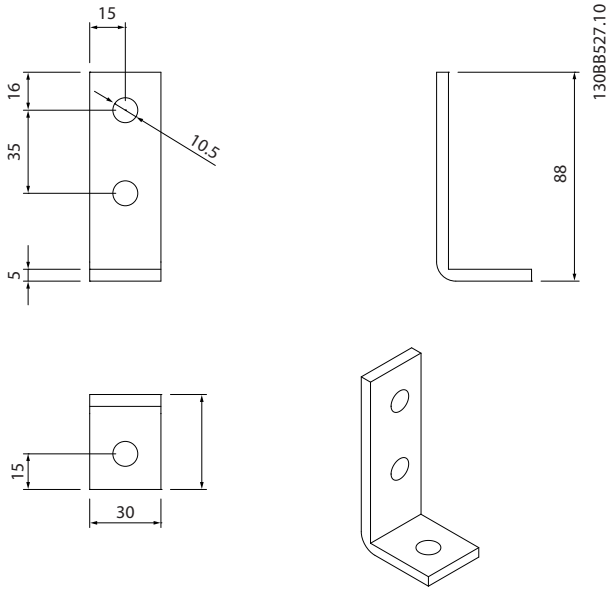

Illustration 5.15 L-shaped Terminal Kit 130B3137

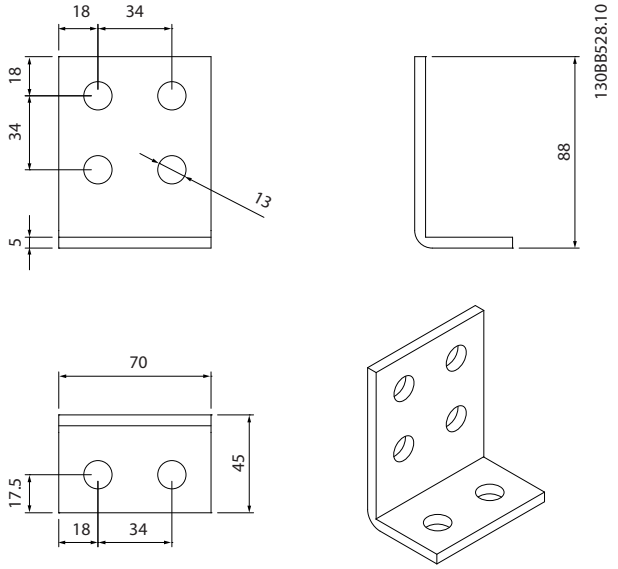

Illustration 5.16 L-shaped Terminal Kit 130B3138

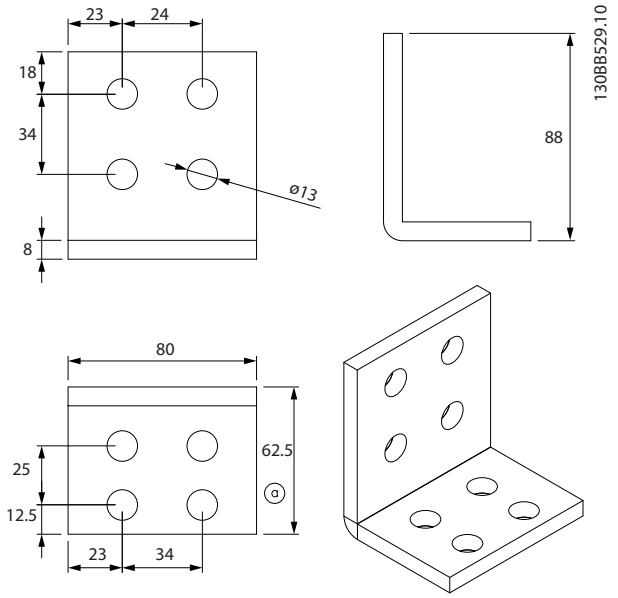

Illustration 5.17 L-shaped Terminal Kit 130B3139

5.2.2 Physical Dimensions

Code number	Enclosure	Dimensions [mm]									Weight	Mounting	Wire cross section		Terminal screw torque	L-shaped terminal kit[1)]
		A (height)	a	B (width)	b	C (depth)	c	d	e	f	kg		mm^2	AWG	Nm/ft-lb	Part no.
130B2835	IP00	295	279	115	85	170	11.5	13	6.2	6	4.6	wall	16	6	4/3	N/A
130B2836	IP20	370	279	118	85	242	11.5	13	6.2	6	6.3	wall	16	6	4/3	N/A
130B2838	IP00	395	379	155	125	220	11.5	13	6.2	6	12.7	wall	50	1	6/4.5	N/A
130B2839	IP20	475	379	157	125	248	11.5	13	6.2	6	16.2	wall	50	1	6/4.5	N/A
130B2841	IP00	395	379	155	125	220	11.5	13	6.2	6	22	wall	50	1	6/4.5	N/A
130B2842	IP20	475	379	158	125	248	11.5	13	6.2	6	25.5	wall	50	1	6/4.5	N/A
130B2844	IP00	445	429	185	155	235	11.5	13	6.2	6	27	wall	95	3/0	12/9	N/A
130B2845	IP20	525	429	188	155	335	11.5	13	6.2	6	30	wall	95	3/0	12/9	N/A
130B2847	IP00	300	275	190	100	235			11	22	33	floor	M10		18/13.3	130B3137
130B2848	IP23	425	325	700	660	620			13	17	64.5	floor	M10		18/13.3	130B3137
130B2849	IP00	300	275	250	125	235			11	22	36	floor	2 x M10		30/22.1	130B3138
130B3850	IP23	425	325	700	660	620			13	17	67.5	floor	2 x M10		30/22.1	130B3138
130B2851	IP00	350	325	250	123	270			11	22	47	floor	2 x M10		30/22.1	130B3138
130B2852	IP23	425	325	700	660	620			13	17	78.5	floor	2 x M10		30/22.1	130B3138
130B2853	IP00	400	375	290	159	283			11	22	72	floor	4 x M10		30/22.1	130B3139
130B2854	IP23	792	660.5	940	779	918			11	22	182	floor	4 x M10		30/22.1	130B3139

[1)] For floor mounted filters, an optional terminal connection kit is available for the ease of installation. Please see the L-shaped terminal kit sketches.
The kit is not included in the filter delivery and should be ordered separately.

Table 5.1 200-690V dU/dt Filters - Physical Dimensions

Code number	Enslosure	Measurements / Dimensions									Weight	Mounting direction	Max. wire cross section		Terminal screw torque	L-shaped terminal kit[1)]
		A (height	a	B (width)	b	C (depth)	c	d	e	f	kg	Wall/Floor	mm^2	AWG	Nm/ft-lb	Part no.
130B2404	IP00	200	190	75	60	205	7	8	4.5	5	2.5	wall	4	24 - 10	0.6/0.44	N/A
130B2439	IP20										3.3					
130B2406	IP00	200	190	75	60	205	7	8	4.5	5	3.3	wall	4	24 - 10	0.6/0.44	N/A
130B2441	IP20										4.2					
130B2408	IP00	268	257	90	70	205	8	11	6.5	6.5	4.6	wall	4	24 - 10	0.6/0.44	N/A
130B2443	IP20					206					5.8					
130B2409	IP00	268	257	90	70	205	8	11	6.5	6.5	6.1	wall	4	24 - 10	0.6/0.44	N/A
130B2444	IP20										7.1					
130B2411	IP00	268	257	130	90	205	8	11	6.5	6.5	7.8	wall	4	24 - 10	0.6/0.44	N/A
130B2446	IP20										9.1					
130B2412	IP00	330	312	150	120	260	12	19	9	9	14.4	wall	16	20 - 4	2/1.5	N/A
130B2447	IP20										16.9					
130B2413	IP00	430	412	150	120	260	12	19	9	9	17.7	wall	16	20 - 4	2/1.5	N/A
130B2448	IP20					259					19.9					
130B2281	IP00	530	500	170	125	258	12	19	9	20	34	wall	50	6 - 1/0	8/5.9	N/A
130B2307	IP20					260					39					
130B2282	IP00	610	580	170	125	260	12	19	9	20	36	wall	50	6 - 1/0	8/5.9	N/A
130B2308	IP20										41					
130B2283	IP00	610	580	170	135	260	12	19	9	20	50	wall	50	6 - 1/0	15/11.1	N/A
130B2309	IP20										54					
130B3179	IP00	520	-	470	400	334	175		13	26	95	floor			2.0-6.0	N/A
130B3181	IP23	918	898	904	779	792	661		11	22	205					
130B3182	IP00	580	-	470	400	311	150		13	26	127	floor				N/A
130B3183	IP23	918	898	904	779	792	661		11	22	237					
130B3184	IP00	520	-	500	450	350	200		13	26	197	floor				130B3137
130B3185	IP23	918	898	904	779	792	661		11	22	307					
130B3186	IP00	520	-	500	450	400	250		13	26	260	floor				130B3138
130B3187	IP23	918	898	904	779	792	661		11	22	370					
130B3188	IP00	520	-	500	450	400	250		13	26	265	floor				130B3138
130B3189	IP23	1161	1141	1260	1099	991	860		11	22	425					
130B3191	IP00	620	-	620	575	583	250		13	26	410	floor				130B3139
130B3192	IP23	1161	1141	1260	1099	991	860		11	22	570					

[1)] For floor mounted filters, an optional terminal connection kit is available for the ease of installation. Please see the L-shaped terminal kit sketches.
The kit is not included in the filter delivery and should be ordered separately.

Table 5.2 500V Sine-wave Filter - Physical dimensions

Code number	Enclosure	Measurements / Dimensions									Weight	Mounting direction	Max. wire cross section		Terminal screw torque	L-shaped terminal kit[1]
		A (height)	a	B (width)	b	C (depth)	c	d	e	f	kg	Wall/Floor	mm^2	AWG	Nm/ft-lb	Part no.
130B3193	IP00	620	-	620	575	583	250		13	26	410	floor				130B3139
130B3194	IP23	1161	1141	1260	1099	991	860		11	22	610					
2 x 130B3188	IP00															N/A
2 x 130B3189	IP23															
2 x 130B3191	IP00															N/A
2 x 130B3192	IP23															
3 x 130B3188	IP00															N/A
3 x 130B3189	IP23															
3 x 130B3191	IP00															N/A
3 x 130b3192	IP23															

[1] For floor mounted filters, an optional terminal connection kit is available for the ease of installation. Please see the L-shaped terminal kit sketches.
The kit is not included in the filter delivery and should be ordered separately.

Table 5.3 500V Sine-wave Filter - Physical Dimensions

Code number	Enclosure	Measurements / Dimensions									Weigh t	Mounting direction	Max. wire cross section		Terminal screw torque	L-shaped terminal kit[1)]
		A (height)	a	B width)	b	C depth)	c	d	e	f	kg	wall/floor	mm²	AWG	Nm/ft-lb	Part no.
130B3195	IP00	465	449	115	85	270	225	13	6.2	6.5	18	wall	16	20 - 8	2/1.5	N/A
130B3196	IP20	465	449	118	85	243	-	13	6.2	6.5	21					
130B4112	IP00	505	489	155	125	270	225	13	6.2	6.5	27	floor	16	20 - 8	15/11.1	N/A
130B4113	IP23	505	489	158	125	310	-	13	6.2	6.5	31					
130B4114	IP00	625	609	155	125	370	300	13	6.2	6.5	43	floor	50	8 - 6	15/11.1	N/A
130B4115	IP23	625	609	158	125	310	-	13	6.2	6.5	49					
130B4116	IP00	520	-	470	400	332	175		13	26	107	floor	95	6 - 4	15/11.1	N/A
130B4117	IP23	715	699	798	676	620	502		11	22	142					
130B4118	IP00	520	-	470	400	332	175		13	26	123	floor	95	4 - 2	15/11.1	N/A
130B4119	IP23	715	699	798	676	620	502		11	22	160					
130B4121	IP00	470	-	500	450	400	200		13	26	160	floor	Ø10.5	2 - 1/0	15/11.1	130B3137
130B4124	IP23	918	898	940	779	792	661		11	22	270					
130B4125	IP00	535	-	660	575	460	250		13	26	315	floor	Ø10.5	2/0 - 4/0	18/13.3	130B3137
130B4126	IP23	1161	1141	1260	1099	991	860		11	22	475					
130B4129	IP00	660	-	800	750	610	275		13	26	513	floor	2 x Ø13	2/0 - 4/0	18/13.3	130B3138
130B4151	IP23	1161	1141	1260	1099	991	860		11	22	673					
130B4152	IP00	660	-	800	750	610	275		13	26	485	floor	2 x Ø13	4/0 - 5/0	18/13.3	130B3138
130B4153	IP23	1161	1141	1260	1099	991	860		11	22	645					
130B4154	IP00	660	-	800	750	684	350		13	26	600	floor	2 x Ø13	4/0 - 5/0	30/22.1	130B3138
130B4155	IP23	1161	1141	1260	1099	991	860		11	22	760					
130B4156	IP00	490	-	800	750	713	375		13	26	745	floor	4 x Ø13	5/0	30/22.1	130B3139
130B4157	IP23	1161	1141	1260	1099	991	860		11	22	905					
2 x 130B4152	IP00													5/0 - 6/0	30/22.1	N/A
2 x 130B4153	IP23															
2 x 130B4154	IP00													6/0	30/22.1	N/A
2 x 130B4155	IP23															
3 x 130B4154	IP00													6/0	30/22.1	N/A
3 x 1304155	IP23															

[1)] For floor mounted filters, an optional terminal connection kit is available for the ease of installation. Please see the L-shaped terminal kit sketches.
The kit is not included in the filter delivery and should be ordered separately.

Table 5.4 690V Sine-wave filter - Physical Dimensions

MG.90.N5.02 - VLT® is a registered Danfoss trademark

Code Number	Foot Print	Dimensions									Weight	Mounting Direction	Max. Wire Cross Section
		A (height)	a	B (width)	b	C (depth)	c	d	e	f	[kg]		mm^2
130B2542	A2	282	257	90	70	202	10	11	6	15	8	wall	4
130B2543	A3	282	257	130	110	212	10	11	6	15	11.5	wall	4

Table 5.5 Foot Print Sine-Wave Filter - Technical Data

MG.90.N5.02 - VLT® is a registered Danfoss trademark

Part number	Enclosure	Dimensions [mm]									Weight	Mounting	Wire cross section		Terminal screw torque	L-shaped terminal kit[1]
IP54		A (heigth)	a	B (width)	b	C (depth)	c	d	e	f	kg		mm^2	AWG	Nm/ft-lb	partnumber
130B2837	IP54	200	130	320	304	250			9	9	15.7	floor	16	6	4/3	N/A
130B2840	IP54	230	160	420	400	355			9	9	39.8	floor	50	1	6/4.5	N/A
130B2843	IP54	275	200	470	446	460			11	14	59.6	floor	50	1	6/4.5	N/A
130B2846	IP54	275	200	470	446	460			11	14	61.8	floor	95	3/0	12/9	N/A

Table 5.6 200-690V dU/dt Filters - Physical Dimensions

6 How to Programme the Frequency Converter

- The VLT® switching frequency must be set to the value specified for the individual filter. Please consult the *VLT® Programming Guide* for the corresponding parameter values.
- With an output filter installed only a reduced Automatic Motor Adaption (AMA) can be used.

NOTE

Sine-wave filters can be used at switching frequencies higher than the nominal switching frequency, but should never be used at switching frequencies with less than 20% lower than the nominal switching frequency.

NOTE

du/dt filters, unlike Sine-wave filters, can be used at lower switching frequency than the nominal switching frequency, but higher switching frequency will cause the overheating of the filter and should be avoided.

6.1.1 Parameter Settings for Operation with Sine-wave Filter

Parameter no.	Name	Suggested setting
14-00	Switching Pattern	For Sine-wave filters choose SFAVM
14-01	Switching Frequency	Choose value for individual filter
14-55	Output Filter	Choose Sine-wave filter fixed
14-56	Capacitance Output Filter	Set the capacitance[1]
14-57	Inductance Output Filter	Set the inductance[1]
[1]) For FLUX control principle only. Values can be found in *4.2 Electrical Data - dU/dt Filters* and *4.3 Electrical Data - Sine-wave Filters*.		

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