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 VLT® FC Series Drive; 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	s
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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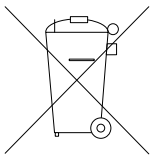
2.1 Safety Precautions



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 - 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.

Warnings

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

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

ACAUTION
Before servicing the filter, wait at least the voltage discharge time stated in the Design Guide for the corresponding VLT® 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 Drives 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-series frequency converters.
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 the 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 Drives frequency converters. It is divided into three sections:

- Protection of Motor Insulation
- Reduction of Motor Acoustic Noise
- Reduction of High Frequency Electromagnetic Noise in Motor Cable

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 following illustration. 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.
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 IEC61800-8.

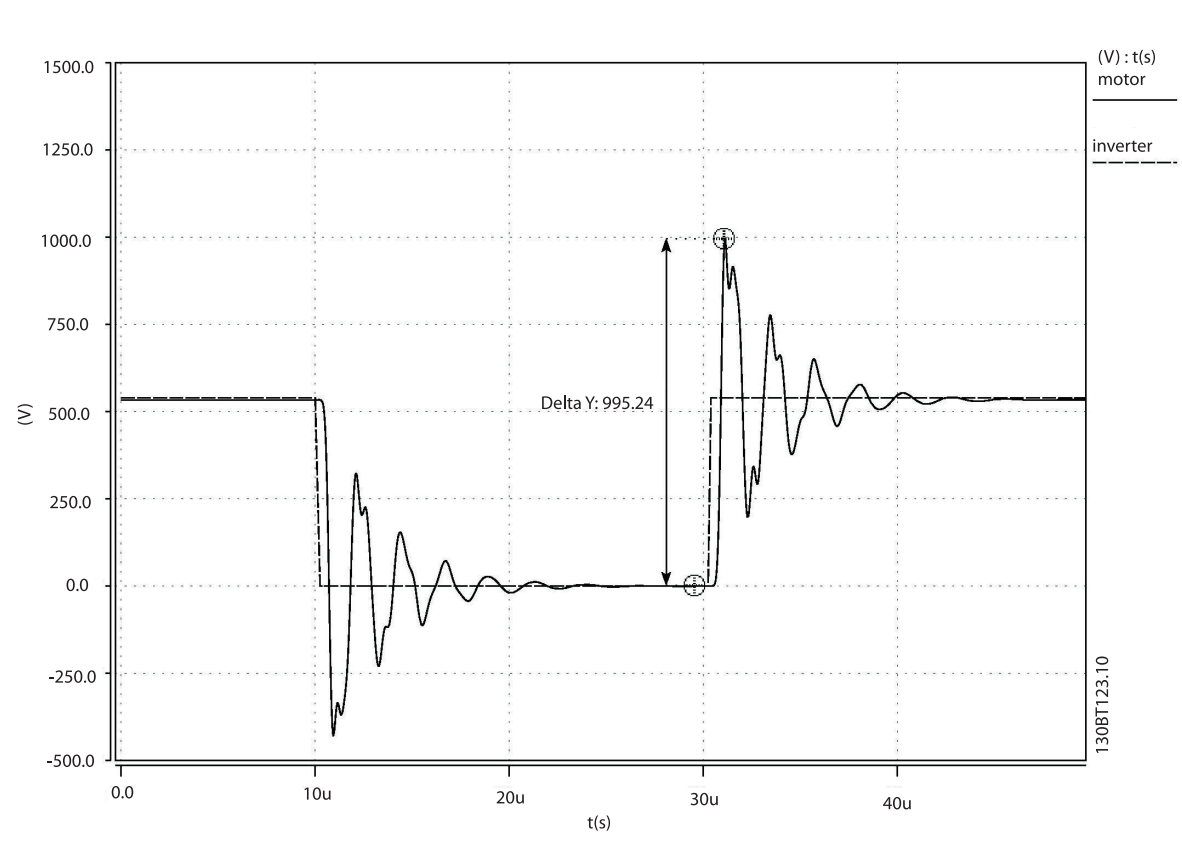


Illustration 3.1 Example of converter output voltage (dotted line) and motor terminal voltage after 200 meters of cable (solid line).

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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 following illustrations.

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, Upeak 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 (IEC61800-8).

The IEC and NEMA definitions of risetime t_r

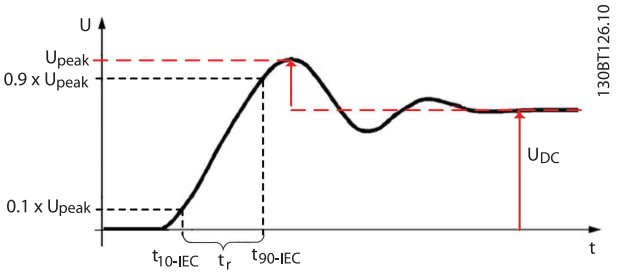


Illustration 3.2 IEC

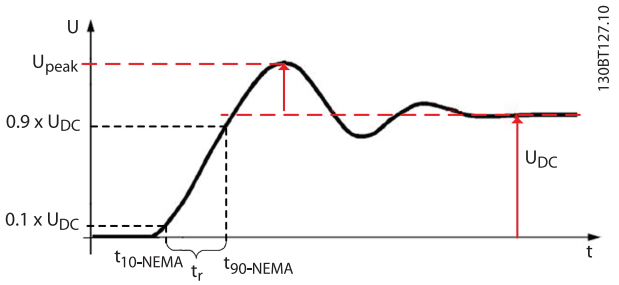


Illustration 3.3 NEMA

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 the figure below:

- IEC60034-17 – limit line for general purpose motors when fed by frequency converters, 500V motors.
- IEC60034-25 – 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.

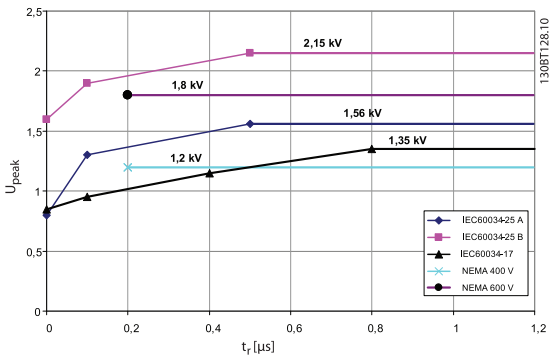


Illustration 3.4 Limit lines for U_{peak} and risetime t_r.

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. This can be seen in the figure below that 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.

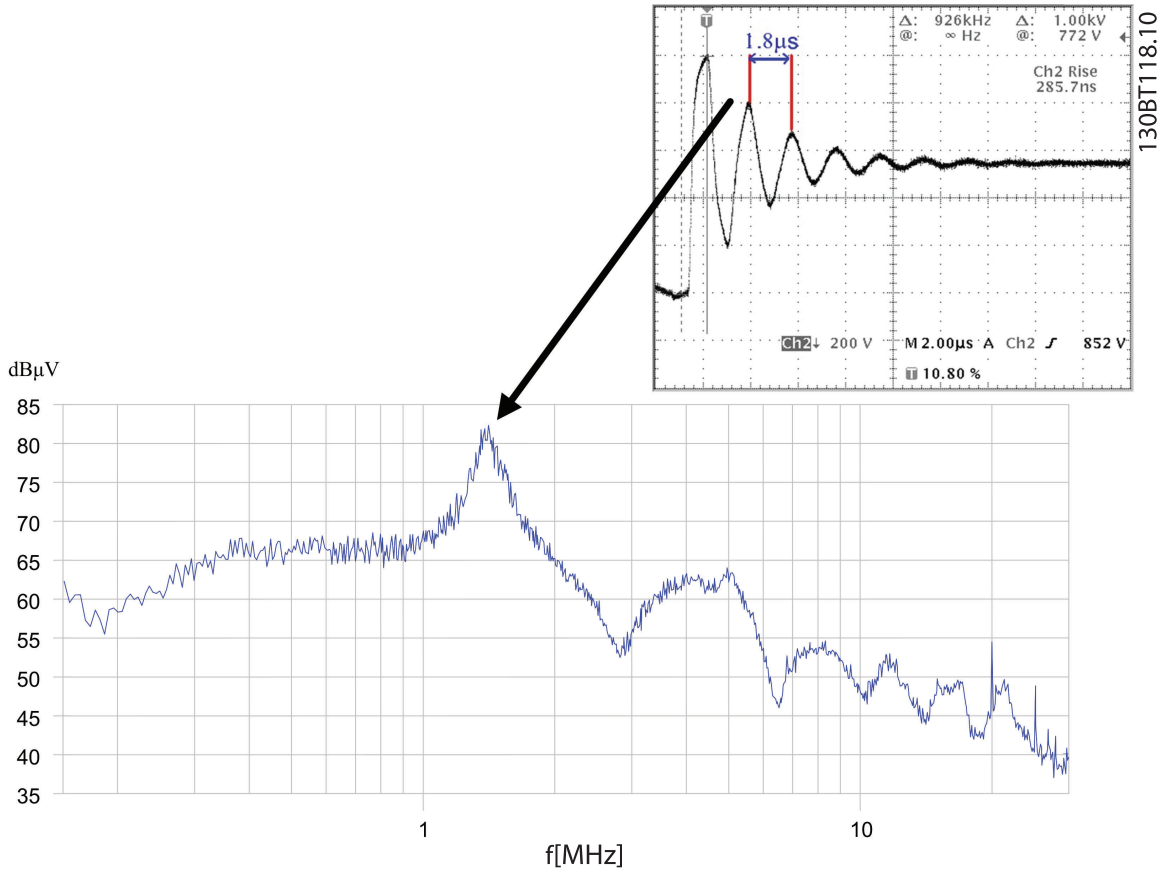


Illustration 3.5 Correlation between the frequency of the ringing voltage overshoot and the spectrum of noise emissions.

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. 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 isolated 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

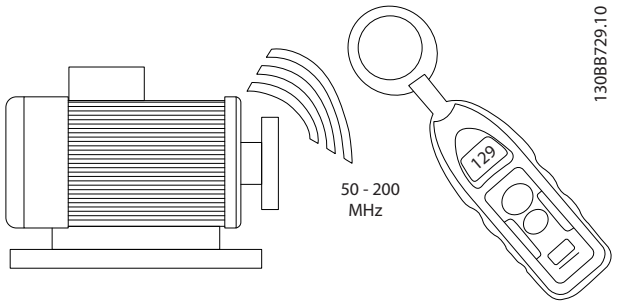
- Make sure that the motor and load are properly aligned.
- Make sure the loading of the bearing (axial and radial) is within the specifications.
- Check the vibration level in the bearing.
- Check the grease in the bearing and make sure the bearing is correctly lubricated for the given operating conditions.

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.

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). 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 electro-magnetic 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.



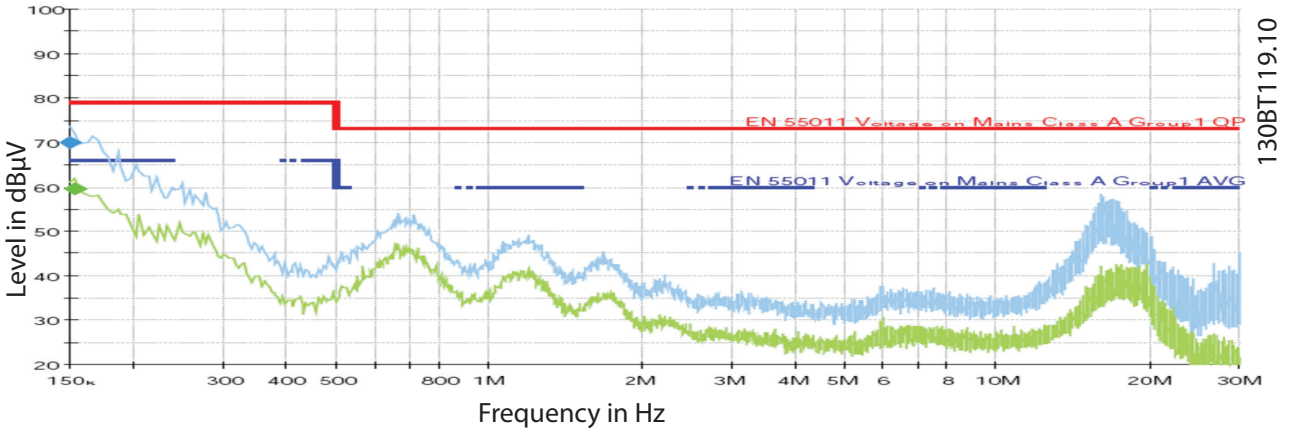


Illustration 3.6 Mains line conducted noise, no filter.

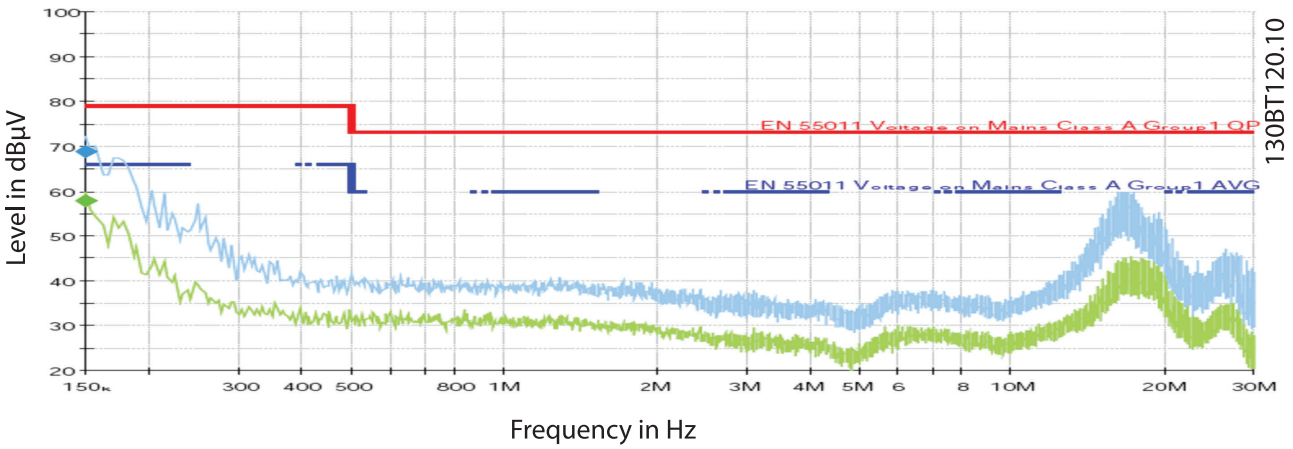


Illustration 3.7 Mains line conducted noise, sine-wave filter.

3.6 Which Filter for which Purpose

The table below shows a comparison of du/dt and Sine-wave filter performance. It can be used to determine which filter to use with your application.

3

Performance criteria	du/dt filters	Sine-wave filters	High-frequency common-mode filters
Motor insulation stress	Up to 150 m cable (screened/ unscreened) complies with the requirements of IEC60034-17 (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* 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 1 MHz). 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 ... 150 m 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)	150 m 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.

*) Not 690V.
**) 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 drive. The inductance (L) and capacitance (C) values are shown in the tables in the section *Electrical Data - du/dt Filters* in the chapter *Selection of Output 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 IEC600034-25
- 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 600034-25
- Applications with short motor cables (less than 15 meters)
- 690 V applications

Voltage and current with and without du/dt filter:

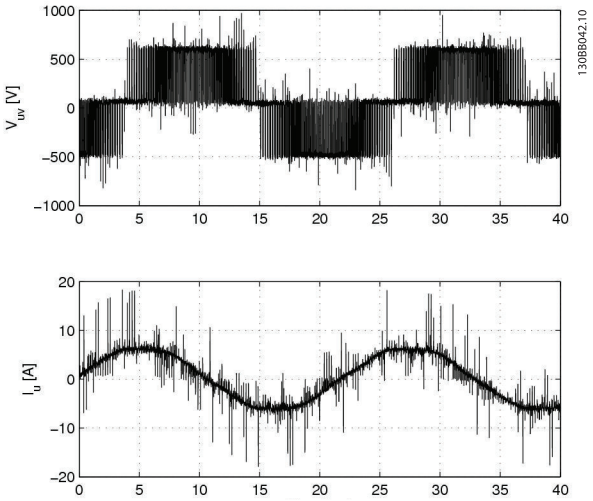


Illustration 3.8 Without filter

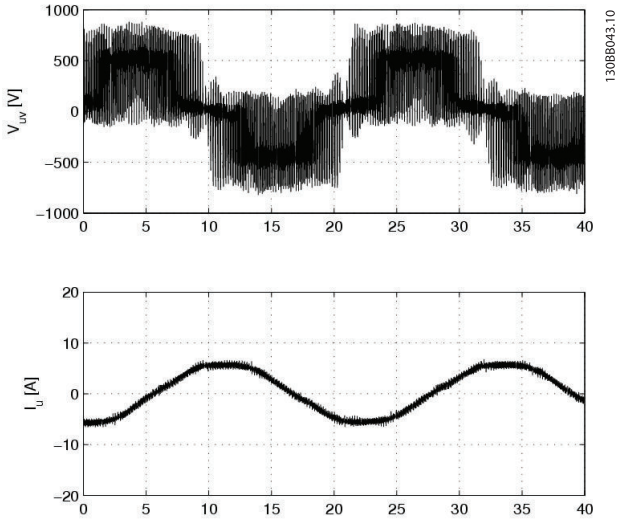


Illustration 3.9 With du/dt filter

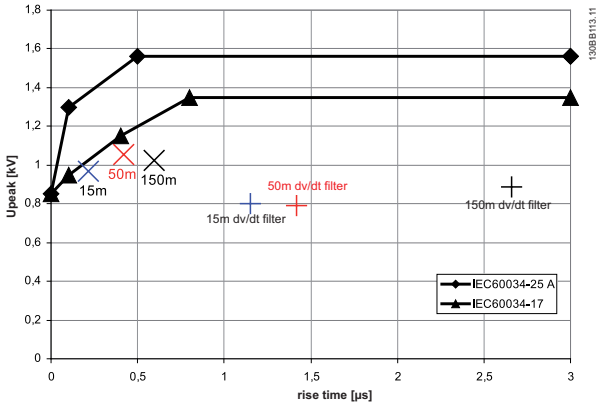


Illustration 3.10 Measured du/dt values (rise time and peak voltages) with and without du/dt filter using 15m, 50m and 150m cable lengths on a 400V, 37kW induction motor.

The du/dt value decreases with the motor cable length whereas the peak voltage increases (see illustration above). The Upeak value depends on the Udc from the drive and as Udc increases during motor braking (generative) Upeak can increase to values above the limits of IEC60034-17 and thereby stress the motor insulation. Danfoss therefore recommends du/dt filters in applications with frequent braking. Furthermore the illustration above shows how the Upeak 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 150 meters. Above 150m du/dt filters have no effect. If further reduction is needed, use a sine-wave filter.

3

Filter features:

- IP00 and IP20 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+
- Filters wall mounted up to 177A and floor mounted above that size

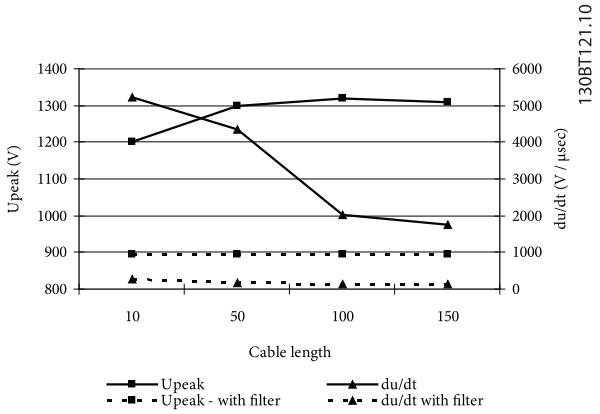


Illustration 3.11 525V - with and without du/dt filter

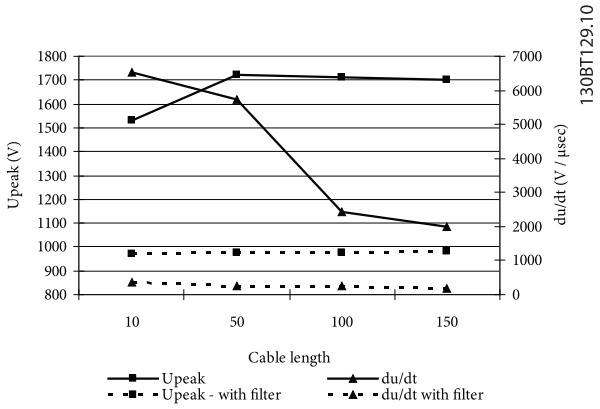


Illustration 3.12 690V - with and du/dt filter

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

The illustrations above show how Upeak 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 drive. 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 *Comparison of du/dt and sine-wave filters* in section *Which Filters for which Purpose*

The Danfoss Drives Sine-wave filters are designed to operate with the VLT® FC Series Drives. 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 the section *Electrical Data - Sine -wave Filters* in the chapter *Selection of Output 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 *525V - with du/dt filter.* 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:

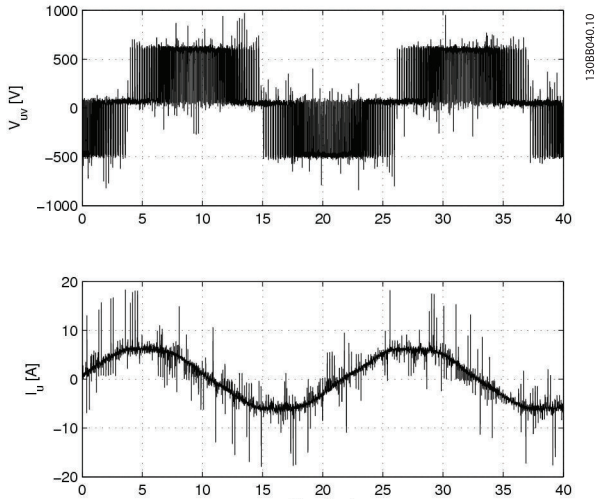


Illustration 3.13 Without filter

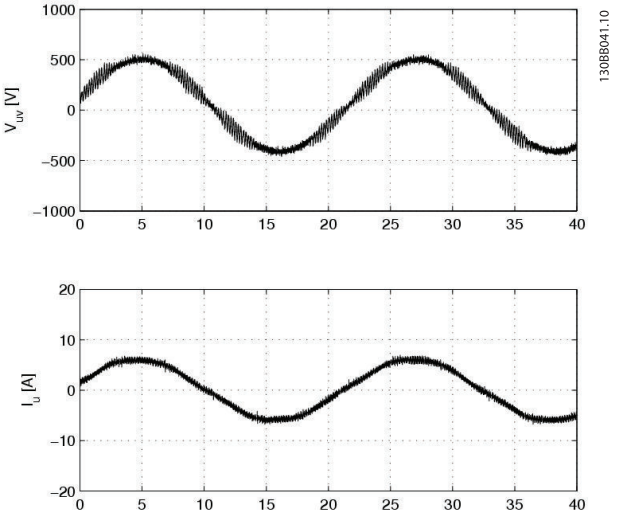
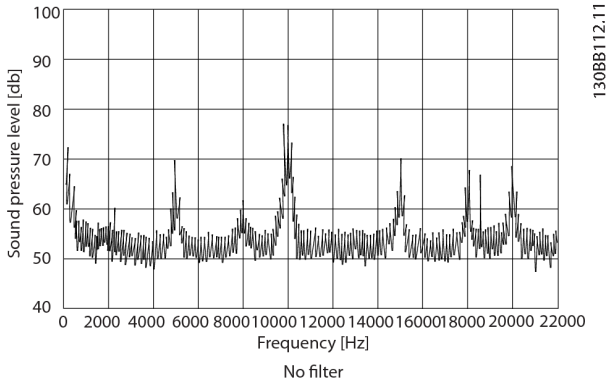


Illustration 3.14 With sine-wave filter

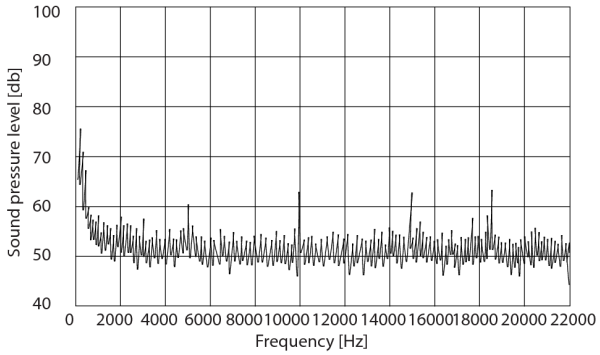
Application areas:
Danfoss recommends the use of Sine-wave filters in the following applications:

- 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 IEC60034-17
- 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



No filter



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 WC+
- Side by side mount with drive up to 75A
- Filter enclosure matching the drive enclosure
- Possibility of connection 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

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 below shows which Sine-wave filter to use with a specific drive. 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 50 Hz	Minimum switching frequency [kHz]	Maximum output frequency [Hz] With derating	Code number IP20	Code number IP00	Frequency converter size		
					200-240 V	380-440 V	441-500 V
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	130B2310	130B2284	P22K - P30K	P45K - P55K	P55K - P75K
180	3	100	130B2311	130B2285	P37K - P45K	P75K - P90K	P90K - P110
260	3	100	130B2312	130B2286		P110 - P132	P132
410	3	100	130B2313	130B2287		P160 - P200	P160 - P200
480	3	100	130B2314	130B2288		P250	P250
660	2	70	130B2315	130B2289		P315 - P355	P315 - P355
750	2	70	130B2316	130B2290		P400	P400 - P450
880	2	70	130B2317	130B2291		P450 - P500	P500 - P560
1200	2	70	130B2318	130B2292		P560 - P630	P630 - P710
1500	2	70	2X 130B2317	2X 130B2291		P710 - P800	P800

Table 4.1 Filter Selection

Mains supply 3 x 525 to 600/ 690V						
Rated filter current at 50 Hz	Minimum switching frequency [kHz]	Maximum output frequency [Hz] With derating	Code number IP20	Code number IP00	Frequency converter size	
					525-600 V	525-690 V
13	2	70	130B2341	130B2321	PK75 - P7K5	
28	2	100	130B2342	130B2322	P11K - P18K	
45	2	100	130B2343	130B2323	P22K - P30K	P37K
76	2	100	130B2344	130B2324	P37K - P45K	P45K - P55K
115	2	100	130B2345	130B2325	P55K - P75K	P75K - P90K
165	2	70	130B2346	130B2326		P110 - P132
260	2	100	130B2347	130B2327		P160 - P200
303	2	70	130B2348	130B2329		P250
430	1.5	60	130B2370	130B2341		P315 - P400
530	1.5	100	130B2371	130B2342		P500
660	1.5	100	130B2381	130B2337		P560 - P630
765	1.5	60	130B2382	130B2338		P710
940	1.5	100	130B2383	130B2339		P800 - P900
1320	1.5	60	130B2384	130B2340		P1M0

Table 4.2 Filter Selection

Generally the output filters are designed for the nominal switching frequency of the VLT FC-Series drives.

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

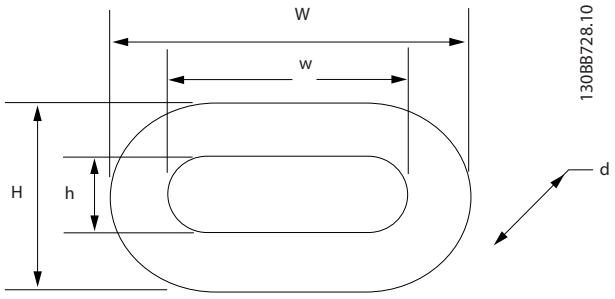
The cores can be installed at the frequency converter's output terminals (U, V, W) or in the motor terminal box.

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-frame + F	
	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 is 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 drives 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 200 m 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	235x190x140
E and F	130B3260	305	249	147	95	37	4.55	290x260x110

4.2 Electrical Data - du/dt Filters

du/dt Filter 3x380-500V IP00

Code number IP00/IP20(IP23)[1]	Filter current rating at given voltage and motor frequency [A][2]				VLT power and current rating								Maximum filter losses	Filter data	
	380V @ 60Hz and 400/440V @ 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	uH	nF
	44	40	32	27	11	24	11	21	7.5	14	11	13	37	150	10
130B2835					15	32	15	27	11	19	15	18			
130B2836					18.5	37.5	18.5	34	15	23	18.5	22			
					22	44	22	40	18.5	28	22	27			
	90	80	58	54	30	61	30	52	30	43	30	34	130	110	13.6
130B2838					37	73	37	65	37	54	37	41			
130B2839					45	90	55	80	45	65	45	52			
130B2841	106	105	94	86	55	106	75	105	55	87	55	62	145	95	15
130B2842											75	83			
130B2844	177	160	131	108	75	147	90	130	75	113	90	108	205	111	15
130B2845					90	177	110	160	90	137					
	315	303	242	192	110	212	132	190	110	162	110	131	315	50	20
130B2847					132	260	160	240	132	201	132	155			
130B2848					160	315	200	303			160	192			
1302849	480	443	344	290	200	395	250	361	160	253	200	242	398	30	43
130B3850					250	480	315	443	200	303	250	290			
	658	590	500	450	315	600	355	540	250	360	315	344	550	17	66
130B2851					355	658	400	590	300	395	355	380			
1302852									315	429	400	410			
	880	780	630	630	400	745	450	678	400	523	500	500	850	13	99
130B2853					450	800	500	730	450	596	560	570			
130B2854					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 60 Hz 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)[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 400/440V @ 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	uH	nF
2 x 130B2851 2 x 1302852 or 3 x 130B2849 3 x 130B3850	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											900	945			
3 x 130B2853					800	1460	1000	1380	850	1108	1000	1060			
3 x 130B2854					1000	1700	1100	1530	1000	1317	1200	1260			
2 x 130B2849 2 x 130B2852					450	800	500	730	500	659					
					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

4.3 Electrical Data - Sine-wave Filters

Sine-wave Filter 3x380-500 V IP00/IP20

Code Number	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]
IP00/IP20	A	A	A	kHz	kW	A	kW	A	kW	A	W	W	W	mH	uF
130B2404	2.5	2.5	2*	5	0.25	1.8	0.37	1.3	0.37	1.1	50	45	45	29	1
130B2439					0.37	2.4	0.55	1.8	0.55	1.6		50	50		
							0.75	2.4	0.75	2.1	60	60	60		
130B2406	4.5	4	3.5*	5			1.1	3	1.1	3		60	60	13	2.2
130B2441					0.55	3.5	1.5	4.1	1.5	3.4	65	70	65		
130B2408	8	7.5	5*	5	0.75	4.6					65			6.9	4.7
130B2443					1.1	6.6	2.2	5.6	2.2	4.8	75	70	70		
					1.5	7.5	3	7.2	3	6.3	80	80	80		
130B2409	10	9.5	7.5*	5			4	10	4	8.2		95	90	5.2	6.8
130B2444															
130B2411	17	156	13	5	2.2	10.6					90			3.1	10
130B2446					3	12.5	5.5	13	5.5	11	100	110	100		
					3.7	16.7	7.5	16	7.5	14.5	125	125	115		
130B2412	24	23	18	4	5.5	24.2	11	24	11	21	150	150	150	2.4	10
130B2447															
130B2413	38	36	28.5	4			15	32	15	27		170	160	1.6	10
130B2448					7.5	30.8	18.5	37.5	18.5	34	160	180	170		
130B2281	48	45.5	36	4	11	46.2	22	44	22	40	270	270	260	1.1	14.7
130B2307															
130B2282	62	59	46.5	3	15	59.4	30	61	30	52	300	310	280	0.85	30
130B2308															
130B2283	75	71	56	3	18.5	74.8	37	73	37	65	350	350	330	0.75	30
130B2309															
130B2284	115	109	86	3	22	88	45	90	55	80	450	460	430	0.5	60
130B2310					30	115	55	106	75	105	500	500	500		
130B2285	180	171	135	3	37	143	75	147	90	130	650	600	600	0.3	99
130B2311					45	170	90	177	110	160	680	700	680		
130B2286	260	247	195	3			110	212	132	190		820	800	0.2	141
130B2312							132	260	160	240		900	880		

*) 120Hz

[1]Equivalent STAR-connection value

Sine-wave Filter 3x380-500V IP00/IP20

Code Number IP00/IP20	Filter Current Rating @ 50Hz A	Filter Current Rating @ 60Hz A	Filter Current Rating @ 100Hz A	Switching Frequency kHz	VLT Power and Current Ratings @ 200-240V kW	VLT Power and Current Ratings @ 200-240V A	VLT Power and Current Ratings @ 380-440V kW	VLT Power and Current Ratings @ 380-440V A	VLT Power and Current Ratings @ 441-500V kW	VLT Power and Current Ratings @ 441-500V A	Filter Losses @ 200-240V W	Filter Losses @ 380-440V W	Filter Losses @ 441-500V W	L-value mH	C_y-Value[1] uF
130B2287	410	390	308	3			160	315	200	303		1050	1050	0.13	198
130B2313							200	395	250	361		1200	1100		
130B2288	480	456	360	3			250	480	315	443		1400	1350	0.11	282
130B2314															
130B2289	660	627	495	3			315	600	355	540		2000	1900	0.14	423
130B2315							355	658	400	590		2100	2000		
130B2290	750	712	562	2			400	745	450	678		2900	2800	0..2	495
130B2316															
130B2291	880	836	660	2			450	800	500	730		3400	3300	0.11	564
130B2317							500	880	560	780		3600	3400		
130B2292	1200	1140	900	2			560	990	630	890		3600	3600	0.075	846
130B2317							630	1120	710	1050		3800	3800		
2x130B2291	1500			2			710	1260	800	1160					
2X130B2317							800	1460	1000	1380					
2x130B2292	1700			2			1000	1700	1100	1530					
2X130B2318															

*) 120Hz

[1]Equivalent STAR-connection value

4

Code Number IP00/IP20	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	uF
130B2321 130B2341	13	12.35	9.75	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						120 125 125 130 130 140 160 170		11.7	47
130B2322 130B2342	28	26.5	21	2	11 15	18 22			11 15 18.5 22	13 18 22 27		230 250 280	180 230 250 280	5.5	10
130B2323 130B2343	45	42.5	33.5	2	22 30	34 41	30	46	30 37	34 46	360	300 330	300 360	3.4	20
130B2324 130B2344	76	72	57	2	37 45	52 62	37 45	56 76	45 55	54 73	450 500	420 450	450 500	2	33
130B2325 130B2345	115	109	86	2	55 75	83 100	55 75	90 113	75 90	86 108	800 850	750 800	750 850	1.3	47
130B2326 130B2346	165	157	123	2	90 110	131 155	90 110	137 162	110 132	131 155	1050 1150	1000 1100	1000 1100	0.9	66
130B2327 130B2347	260	247	195	2	150 180	192 242	132 160	201 253	160 200	192 242	1100 1250	1050 1200	1050 1200	0.6	94
130B2329 130B2348	303	287	227	2	220	290	200	303	250	290	1600	1600	1600	0.5	136

[1]Equivalent STAR-connection value

Sine-wave Filter 3x525-690V IP00/IP20

Code Number IP00/IP20	Filter Current Rating @ 50Hz			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]
	@ 50Hz	@ 60Hz	@ 100Hz												
	A	A	A	kHz	kW	A	kW	A	kW	A	W	W	W	mH	uF
130B2241	430	408	322	1.5	260	344	250	360	315	344	1850	1800	1800	0.35	272
130B2270					300	429	315	429	400	410	2100	2050	2000		
130B2242	530	503	397	1.5	375	523	400	523	500	500	2500	2500	2400	0.28	340
130B2271															
130B2337	660	627	495	1.5	450	596	450	596	560	570	2800	2800	2700	0.23	408
130B2381					480	630	500	659	630	630	2900	2850	2850		
130B2338	765	726	573	1.5	560	730	560	763	710	730	3850	3800	3800	0.2	476
130B2382															
130B2339	940	893	705	1.5	670	898	670		800	986	3350	3300	3350	0.16	612
130B2383							750	939	900	898	3400		3350		
130B2340	1320	1250	990	1.5	820	1060	850	1108	1000	1060	4500	4300	4300	0.12	816
130B2384					970	1260	1000	1317	1200	1317	4700	4600	4700		

[1]Equivalent STAR-connection value

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

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	uF
130B2542	10	10	8	5			4	10	4	8.2		60	60	5.3	1.36
					2.2	10.6									
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

4.4 Sine-Wave Filters

Surroundings:	
Isolation class:	
EIS 155	2.5A up to 75A
EIS 180	115A up to 2300A
Max. allowed ambient temperature	45°C

Electrical data:	
Over voltage test [voltage/time]	2.5kV / 1min. AC and DC
Overload capacity	1.6x rated current for 1 minute, every 10 minutes

Voltage drop (phase to phase):	
Sine- wave filter 500V:	
2.5A	40V
4.5A - 480A	30V
660A- 1200A	50V
Sine-wave filter 690V:	
4.5A - 480A	83V

Technical Specifications	
Voltage rating	3 x 200-500V AC and 3 x 525-690V AC
Nominal current I¬N @ 50Hz	2,5 – 1200A for higher power, modules can be paralleled
Motor frequency	0-60Hz without derating. 100/120Hz with derating (only 500V up to 10A)
Ambient temperature	-25° to 45°C side by side mount, without derating
Min. switching frequency	f_{min} 1,5kHz – 5kHz, depending on filter type
Max. switching frequency	no limit
Overload capacity	160% for 60 sec. every 10 min.
Enclosure degree	IP00 and IP20 (IP23 all floor standing filters)
Approval	CE, UL and cUL(up to and including 115A), RoHS

The voltage drop 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

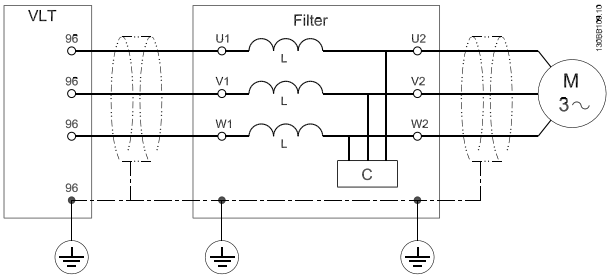
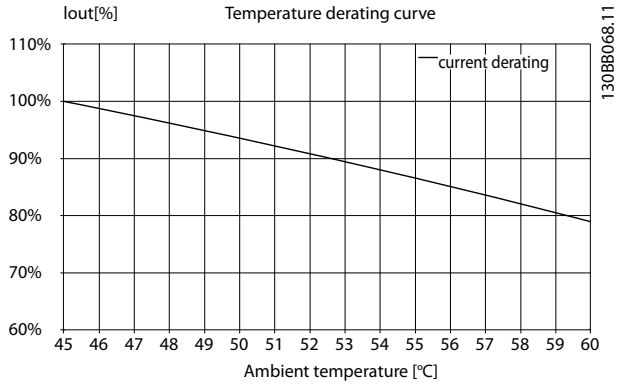


Illustration 4.1 Filter Diagram



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 min.
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 EN61800-5-1	II
Overvoltage category EN61800-5-1	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	fmin 5kHz
Max. switching frequency	fmax 16kHz
Overload capacity	160% for 60 sec. every 10 min.
Enclosure degree	IP20
Approval	CE, RoHS

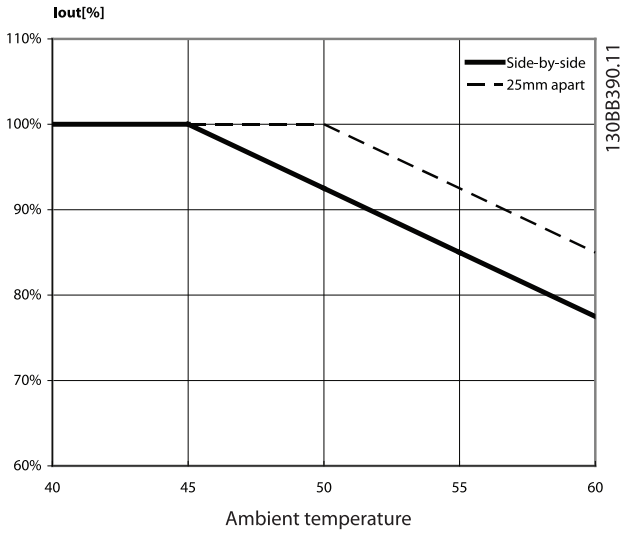


Illustration 4.2 Temperature derating

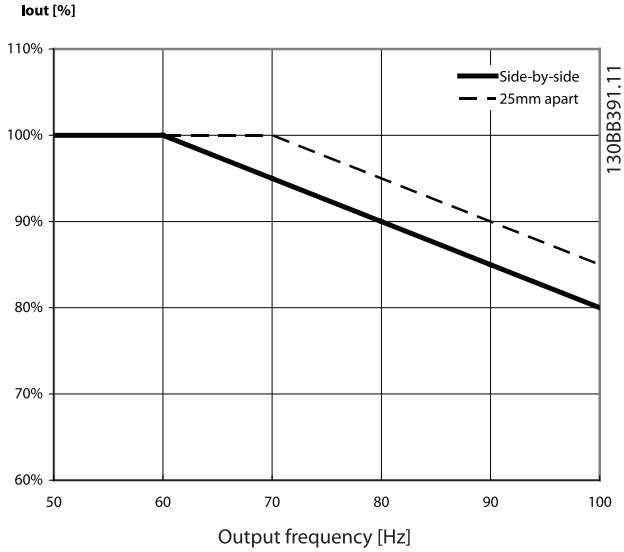


Illustration 4.3 Output frequency derating

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.

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.

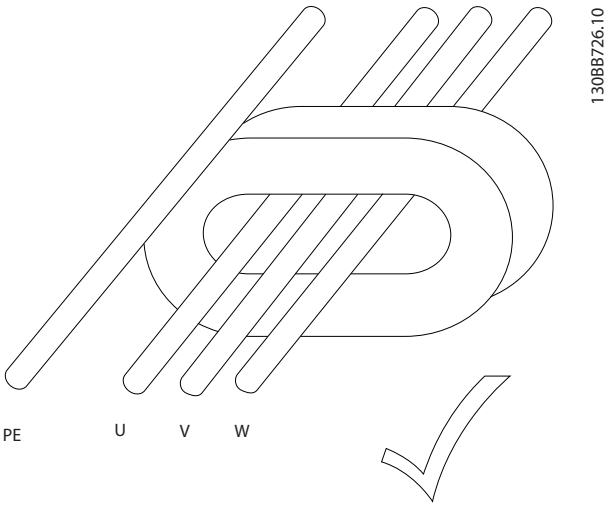


Illustration 5.1 Correct installation

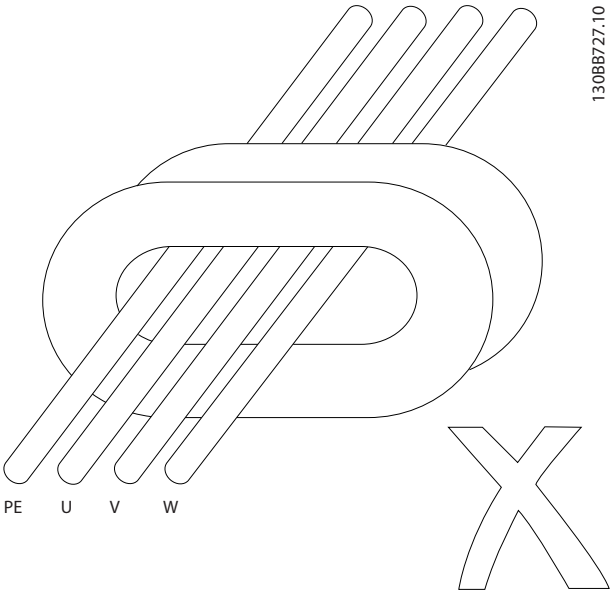


Illustration 5.2 Wrong installation. The PE should not go through the core.

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.

5.1.3 Earthing

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 VLT 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)

5.1.4 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).
- When 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.
- For maximum cable length between VLT 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.

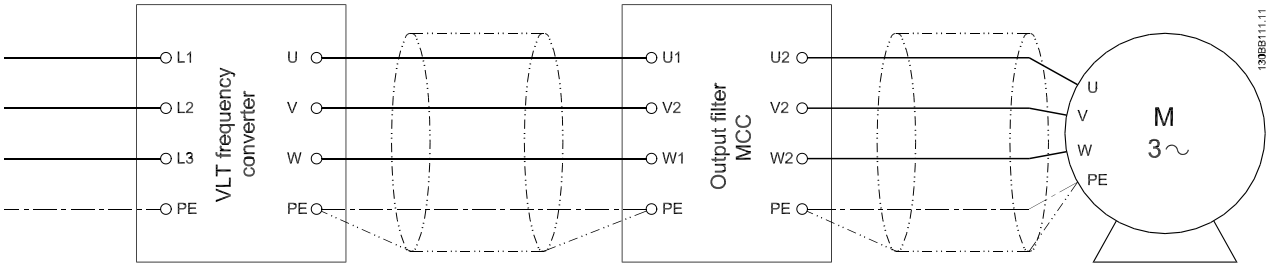


Illustration 5.3 Wiring diagram

For F-frame drives 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, either at the filters' terminals or at the motor terminals.

5.2 Mechanical Dimensions

5.2.1 Sketches

Wall Mounted Sine-wave filters

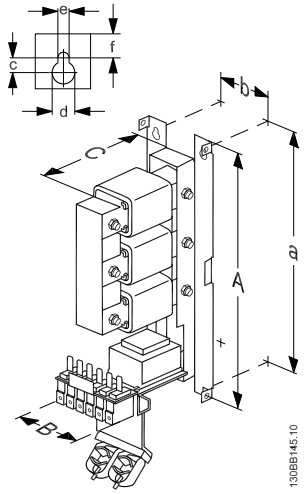


Illustration 5.4 IP00 Wall mounted

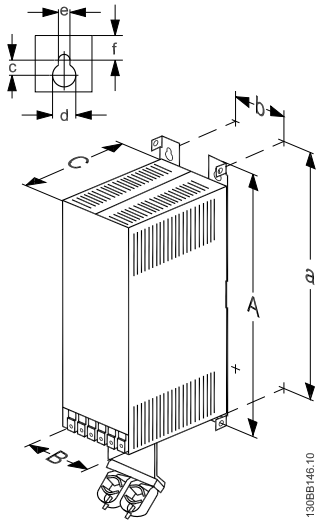


Illustration 5.5 IP20 Wall mounted

Floor Mounted Sine-wave filters

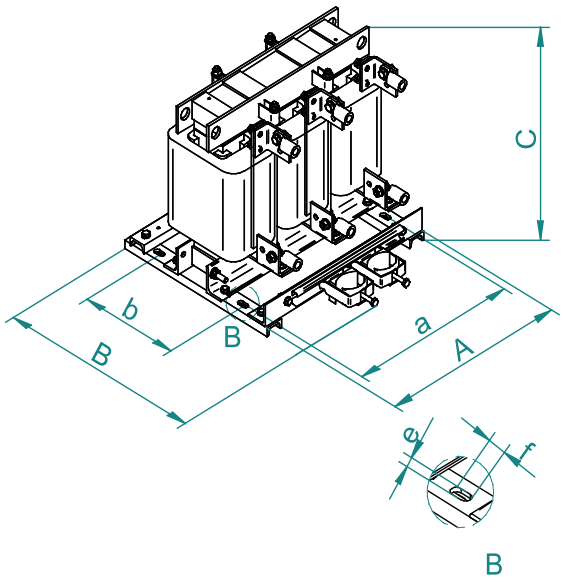


Illustration 5.6 IP00 Floor mounted

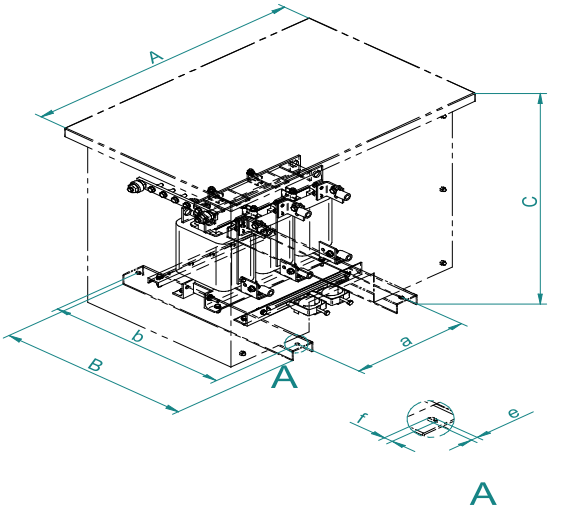


Illustration 5.7 IP23 Floor mounted

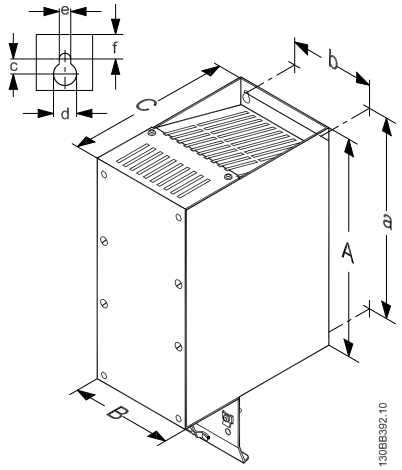


Illustration 5.8 IP20 Wall mounted foot print filters

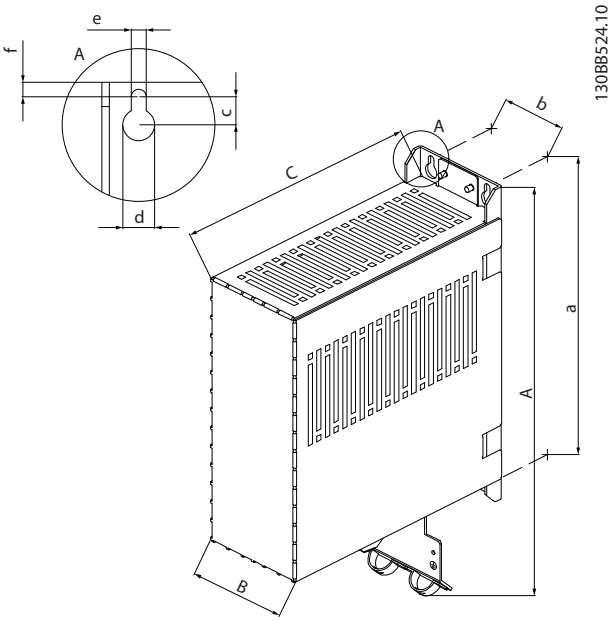


Illustration 5.10 IP20 wall mounted

Wall mounted du/du filters

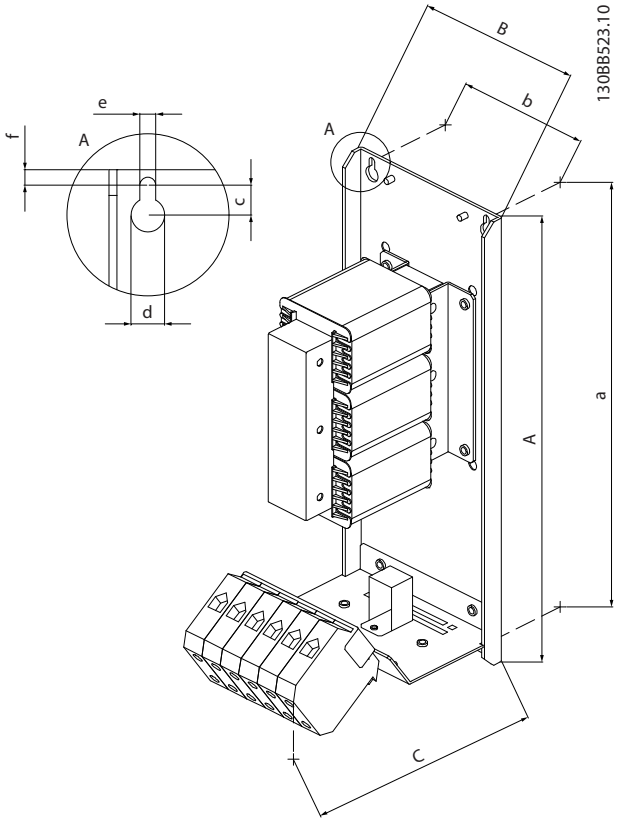


Illustration 5.9 IP00 wall mounted

5

Floor mounted du/du filters

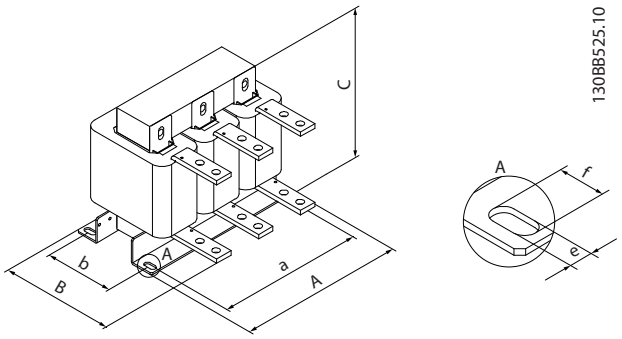


Illustration 5.11 IP00 floor mounted

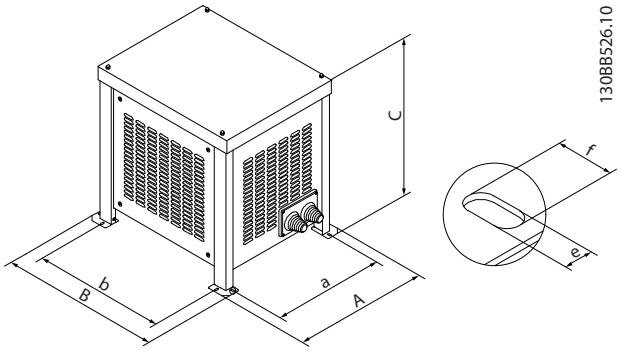


Illustration 5.12 IP23 floor mounted

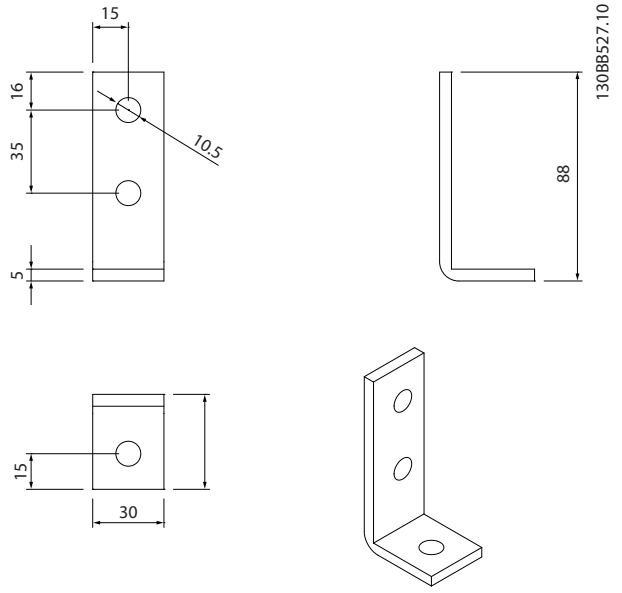


Illustration 5.13 L-shaped terminal kit 130B3137
(Only for du/dt filters)

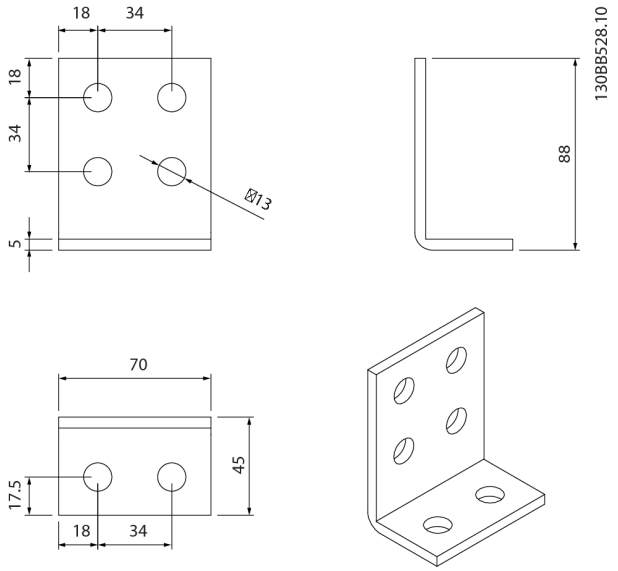


Illustration 5.14 L-shaped terminal kit 130B3138
(Only for du/dt filters)

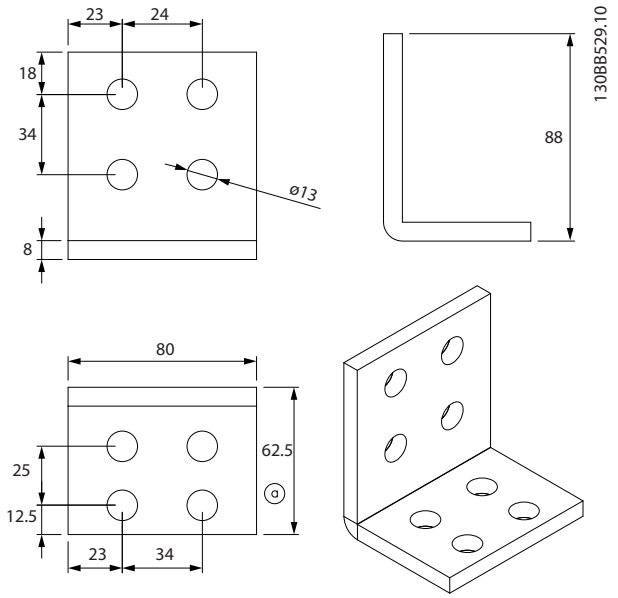


Illustration 5.15 L-shaped terminal kit 130B3139
(Only for du/dt filters)

5.2.2 Physical Dimensions

Code number	Enclosure	Dimensions [mm]									Weight	Mounting	Wire cross section		Terminal screw torque	L-shaped terminal kit[1)]
IP00/ IP20(IP23)		A	a	B	b	C	c	d	e	f	kg		mm^2	AWG	Nm/ft-lb	Partnumber
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
1302853	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 case of installation. Please see the L-shaped terminal kit sketches.
The kit is not included in the filter delivery and should be ordered separately.

500V Sine-wave Filter - Physical dimensions															
Code number	Enslosure	Measurements / Dimensions									Weight	Mounting direction	Max. wire cross section		Terminal screw torque
		A	a	B	b	C	c	d	e	f	kg	Wall/Floor	mm^2	AWG	Nm/ft-lb
130B2404	IP00	200	190	75	60	205	7	8	4.5	5	2.5	wall	4	24 - 10	0.6/0.44
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
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
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
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
130B2446	IP20										9.1				
130B2412	IP00	330	312	150	120	260	12	19	9	9	14.4	wall	16	20 - 4	2/1.5
130B2447	IP20										16.9				
130B2413	IP00	430	412	150	120	260	12	19	9	9	17.7	wall	16	20 - 4	2/1.5
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
130B2307	IP20					260					39				
130B2282	IP00	610	580	170	125	260	12	19	9	20	36	wall	50	6 - 1/0	8/5.9
130B2308	IP20										41				
130B2283	IP00	610	580	170	135	260	12	19	9	20	50	wall	50	6 - 1/0	15/11.1
130B2309	IP20										54				
130B2284	IP00	330	290	430	380	450			13	26	68	floor	M8	1 - 2/0	15/11.1
130B2310	IP23	670		500	460	522			11	15	87				
130B2285	IP00	450	400	524	235	402			13	26	87	floor	M8	1 - 2/0	15/11.1
130B2311	IP23	940		650	610	782			11	15	113		M10		18/13.3
130B2286	IP00	450	400	536	445	506			13	26	125	floor	M12	3/0	30/22.1
130B2312	IP23	940		650	610	782			11	15	190		M10		
130B2287	IP00	480	430	560	330	675			13	25	190	floor	M12	3/0	30/22.1
130B2313	IP23	940		650	610	782			11	15	245				
130B2288	IP00	600	430	630	310	650			13	26	235	floor	2xM12	4/0	30/22.1
130B2314	IP23	1050		760	720	742			11	15	310				
130B2289	IP00	620	570	683	435	764			13	26	310	floor	2xM12	5/0	30/22.1
130B2315	IP23	1290		800	760	1152			11	15	445				

Table 5.1 500V Sine-wave Filter - Physical dimensions

500V Sine-wave Filter - Physical dimensions															
Code number	Enclosure	Measurements / Dimensions									Weight	Mounting direction	Max. wire cross section		Terminal screw torque
		A	a	B	b	C	c	d	e	f	kg	Wall/Floor	mm^2	AWG	Nm/ft-lb
130B2290	IP00	660	610	680	370	684			13	26	470	floor	2xM12	6/0	30/22.1
130B2316	IP23	1290		800	760	1152			11	15	605				
130B2291	IP00	760	610	682	380	893			13	26	640	floor	2xM12	6/0	30/22.1
130B2317	IP23	1290		800	760	1152			11	15	810				
130B2292	IP00	740	690	682	360	936			13	25	680	floor	2xM12	For field wiring use cooper bus bars only	30/22.1
130B2318	IP23	1290	690	800	760	1152			11	15	815				

Table 5.2 500V Sine-wave Filter - Physical dimensions

690V Sine-wave filter - Physical Dimensions															
Code number	Enclosure	Measurements / Dimensions									Weight	Mounting direction	Max. wire cross section		Terminal screw torque
		A	a	B	b	C	c	d	e	f	kg	wall/floor	mm^2	AWG	Nm/ft-lb
130B2321	IP00	430	412	150	120	260	12	19	9	9	14.5	wall	16	20 - 8	2/1.5
130B2341	IP20										16.7				
130B2322	IP00	270	220	410	240	368			13	26	30	floor	M8	20 - 8	15/11.1
130B2342	IP23	670		500	460	522			11	15	55				
130B2323	IP00	310	260	410	320	378			13	26	45	floor	M8	8 - 6	15/11.1
130B2343	IP23	670		500	460	522			11	15	70				
130B2324	IP00	360	310	410	320	440			13	26	75	floor	M8	6 - 4	15/11.1
130B2344	IP23	670		500	460	522			11	15	105				
130B2325	IP00	430	380	400	280	478			13	25	120	floor	M8	4 - 2	15/11.1
130B2345	IP23	670		500	460	522			11	15	150				
130B2326	IP00	480	430	490		542			13	26	165	floor	M8	2 - 1/0	15/11.1
130B2346	IP23	910		650	610	782			11	15	220				
130B2327	IP00	550	500	540	295	493			13	26	220	floor	M10	2/0 - 4/0	18/13.3
130B2347	IP23	910		650	610	782			11	15	285				
130B2329	IP00	540	490	660		641			13	26	228	floor	M10	2/0 - 4/0	18/13.3
130B2348	IP23	1290		800	760	1152			11	15	370				
130B2241	IP00	590	540	680	505	643			13	26	330	floor	M12	4/0 - 5/0	18/13.3
130B2270	IP23	1290		800	760	1152			11	15	550				
130B2242	IP00	680	630	650	350	794			13	26	430	floor	2xM12	4/0 - 5/0	30/22.1
130B2271	IP23	1260		800	760	1152			11	15	610				
130B2337	IP00	790	640	677	365	794			13	26	540	floor	2xM12	5/0	30/22.1
130B2381	IP23	1290	638	790	764	1152			11	15	675				
130B2338	IP00	900	640	684	430	884			13	26	540	floor	2xM12	5/0 - 6/0	30/22.1
130B2382	IP23	1290	418	800	760	1152			11	15	670				
130B2339	IP00	1140	660	584	453	928			13	26	700	floor	2xM12	6/0	30/22.1
130B2383	IP23	1260		800	760	1152			11	15	775				
130B2340	IP00	880	800	740	620	1054			13	26	1020	floor	2xM12	6/0	30/22.1
130B2384	IP23	1304	800	860		1302			11	15	1020				

Table 5.3 690V Sine-wave filter - Physical Dimensions

Foot Print Sine-Wave Filter - Technical Data													
Code Number	Foot Print	Dimensions									Weight	Mounting Direction	Max. Wire Cross Section
		A	a	B	b	C	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 5.4 Foot Print Sine-Wave Filter - Technical Data

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

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	Sine-wave: Choose value du/dt: Choose max. value
14-55	Output Filter	Choose Sine-wave filter fixed
14-56	Capacitance Output Filter	Set the capacitance*
14-57	Inductance Output Filter	Set the inductance*
*) For FLUX control principle only. Values can be found in the chapter *Selection of output filter* section *Electrical Data - du/dt Filters* and section *Electrical Data - Sine-wave Filters*		

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