

SISO LCL and LC Filters

VACON® Power Options

1 Overview

1.1 SISO Filters

SISO (Sine In – Sine Out) LCL and LC filters combine both differential (DM) and common-mode (CM) filtering. SISO filters enable installations without a transformer, for example, for marine and energy storage applications.

Two different types of the SISO filter are available:

- SISO-LCL-0525-5-0-AFTP
- SISO-LC-0525-5-0-AFTP

Table 1: Description of the Type Code

Code	Description
SISO	This part is same for all the products.
LCL	Filter type: • LCL filter • LC filter
0525	The current rating in amperes. For example, 0525 = 525 A
5	The mains voltage: • 5 = 380–500 V
0	The protection rating: • 0 = IP00
AF	Cooling method: • AF = Forced air cooling
TP	Temperature measurement type: • TP = Thermal relay and Pt100 temperature sensor

1.2 Contents of the Delivery

The filter consists of separate inductors and capacitor banks. The components are delivered separately.

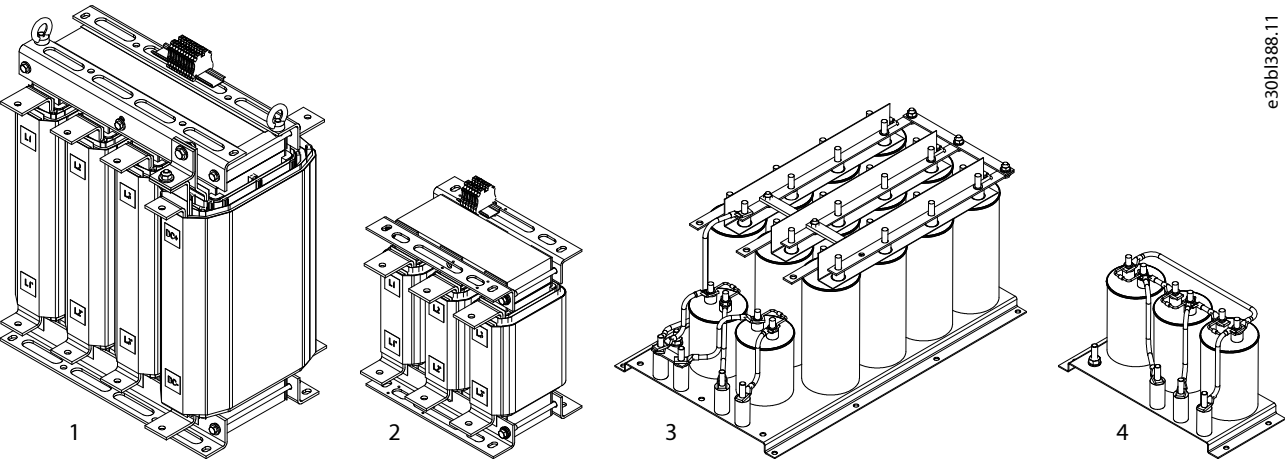


Figure 1: Items Included in the Delivery

1	Drive side inductor	2	Grid side inductor (only included in LCL filter)
3	$C_{DM}+C_{FB}$ capacitor bank	4	C_{Delta} capacitor bank

1.3 Checking the Shipment

Before delivery, the VACON® SISO LCL/LC Filter has been run through several demanding factory tests.

1. Examine the packaging and the filter components for transport damage.

➡ If the product was damaged during transport, contact the cargo insurance company or the carrier.

2. Make sure that the items supplied and the information on the product label correspond to the order confirmation.

➡ If the shipment does not match your order, contact the vendor immediately.

3. If the installation of the equipment is going to be in the future, cover and store the filter in a clean and dry location.

➡ After storage and before installation, make sure that there is no condensation on the internal components of the filter.

2 Mechanical Installation

2.1 Safety

⚠ DANGER

SHOCK HAZARD FROM THE CAPACITORS

The capacitors can have hazardous charge even if electric power is switched off. Contact with this voltage can lead to death or serious injury.

- After disconnecting the filter from the supply, wait 5 more minutes before doing any work on the filter. Do not open the doors or covers of the enclosure before this time has expired. After expiration of this time, use measuring equipment to ensure that no voltage is present. Always ensure the absence of voltage before starting any electrical work.

⚠ DANGER

SHOCK HAZARD

This IP00 filter does not provide protection against direct contact to hazardous live parts. Touching any of the power connectors during operation can lead to death or serious injury.

- Install the filter inside a supplementary enclosure or in a restricted-access area which provides appropriate protection against electric shock.

⚠ CAUTION

BURN HAZARD

The filter is hot during operation.

- Do not install the filter on a combustible surface.
- Do not touch the filter when hot.

This guide is intended for use by qualified personnel who are experienced in the operation and maintenance of power quality filters. The personnel involved in the operation and maintenance of this filter must be aware of the necessary safety precautions for this type of equipment because of the high voltages required by the application.

Follow the instructions in this guide and relevant local regulations.

2.2 Installation Requirements

The products described in this guide have the protection rating IP00/UL Open Type. Install the products in an enclosure that has a correct level of protection against the ambient conditions in the installation area. Make sure that the enclosure gives protection against water, humidity, dust, and other contaminations.

The enclosure must also be sufficiently strong for the weight of the filter components and other devices.

The protection rating of the enclosure must be at least IP21/UL Type 1. When preparing the installation, obey the local regulations.

2.3 Installing the SISO LCL or LC Filter into an Enclosure

For mechanical dimensions and the positions of the mounting holes, see [4.2 Dimensions](#).

1. Install the inductors on a horizontal surface.
2. Install the capacitor banks with the terminals upright.

If another mounting orientation is required, make sure that the capacitor bank is properly supported. If necessary, contact Danfoss for instructions.

3. Make sure that the inductors do not heat up the capacitors. For example, install the capacitors and inductors in separate sections.

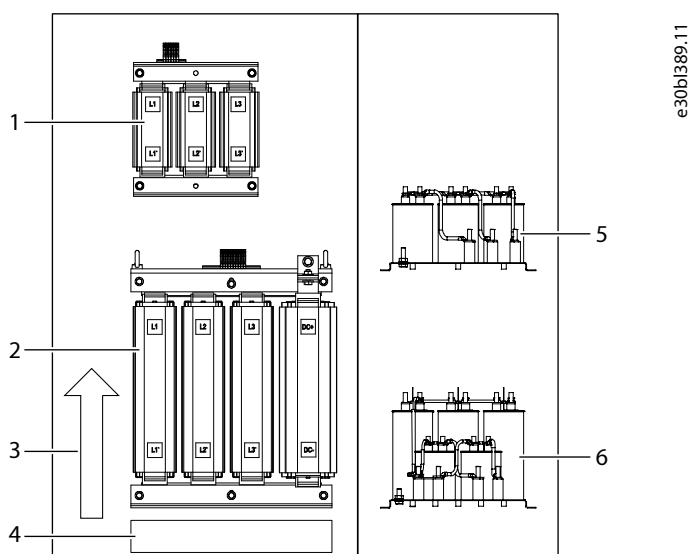


Figure 2: Example of the SISO LCL Filter Installed in an Enclosure

1	Grid side inductor (only included in LCL filter)	2	Drive side inductor
3	Airflow direction	4	Fan
5	C_{Δ} capacitor bank	6	$C_{DM}+C_{FB}$ capacitor bank

2.4 Cooling Requirements

For reliable operation, ensure sufficient cooling of the filter components. The product requires forced air cooling.

Make sure that the cooling airflow through the filter inductors is sufficient.

- The maximum temperature of the cooling air is 40 °C (104 °F).
- The minimum airflow is 3 m/s (10 ft/s).

Install air guides or ducts to guide the hot air from the inductors up, away from other components, and out of the enclosure.

3 Electrical Installation

3.1 Power Cabling

Install the SISO LCL or LC filter at the input of the drive. Connect the L_{CM} and C_{FB} to the DC link. To make sure that the filter functions correctly, follow the instructions in [3.4 Installing the Power Cables](#).

In [Figure 3](#), L_1 and L_{CM} are part of the 4-leg drive side inductor. C_{DM} and C_{FB} are part of the same capacitor bank. L_2 is the grid side inductor, which is only included in LCL filters.

The C_{CM} capacitor is optional and not included in the delivery by default. The C_{CM} capacitor is typically used in grounded networks, bypassing the excess high frequency noise from the load side. For further information, contact Danfoss.

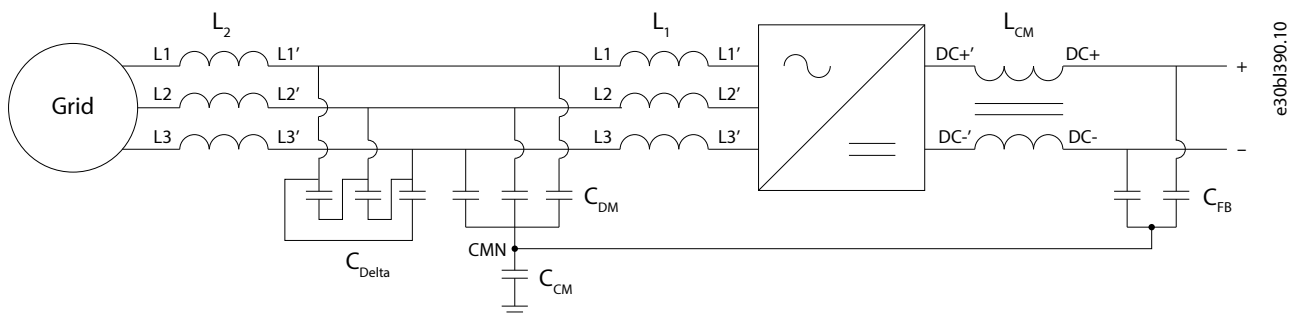


Figure 3: Wiring Diagram Example of the SISO LCL Filter Installation

3.2 Cable Requirements

For main power and PE cables, use cable sizes specified by local regulatory instructions and standards for nominal 525 A rms current.

Capacitor cables are not included in the delivery. The cable current ratings are shown in the following illustration as %-value from the rated RMS current of the filter.

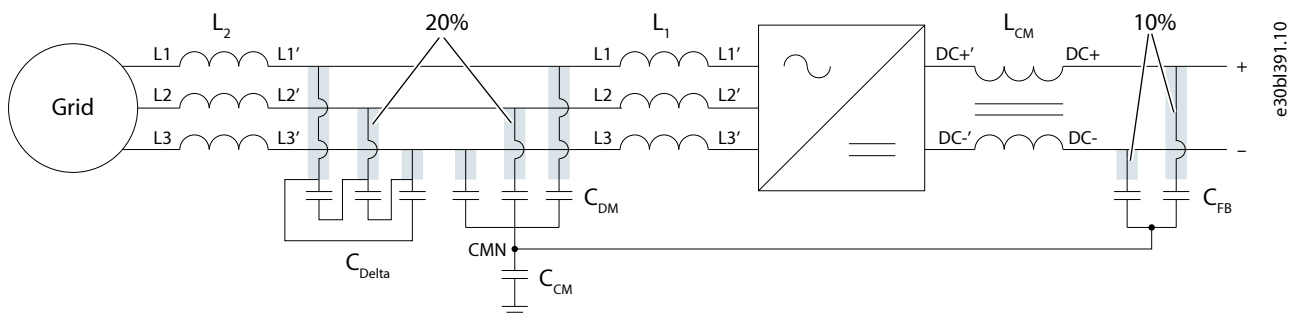


Figure 4: Cable Current Ratings for the Capacitor Banks

3.3 Grounding

Make sure that all filter components are connected to PE. Ground the filter in accordance with applicable standards and directives. The ground connection must be fixed.

Unless local wiring regulations state otherwise, the cross-sectional area of the protective earthing conductor must be at least $\frac{1}{2}$ times of the phase conductor and made of the same material when the phase conductor cross-section is above 35 mm^2 according to IEC 60364-5-54; 543.1.

3.4 Installing the Power Cables

NOTICE

Loose or improperly mounted connections can damage the performance of the filter.

- Make sure that all connections are tightened according to the instructions.

- Cabling between inductors and capacitor banks must not be longer than 2 m.
- Before connecting cables to the terminals, make sure that the surfaces of the terminals are properly cleaned.
- If 2 cables/phase are used, it is recommended to connect cables to both sides of the terminals.
- When routing the cables, avoid abrasion against sharp edges in inductor terminals and the frame of the enclosure.

1. Connect the cables to the drive side inductor L_1/L_{CM} .

The terminal size is Ø11 mm (0.43 in). Use tightening torque 30–44 Nm (266–389 in-lb). See the terminal locations in [Figure 5](#).

- a. Connect the grid side AC cables to terminals L1, L2, and L3.
- b. Connect the drive side AC cables to terminals L1', L2', and L3'.
- c. Connect the DC terminals of the drive to terminals DC+' and DC-'.
- d. Connect the DC link to terminals DC+ and DC-.

2. Connect the cables to the $C_{DM}+C_{FB}$ capacitor bank.

The terminal size is M10. Use tightening torque 12 Nm (106 in-lb). See the terminal locations in [Figure 7](#).

- a. Connect the terminals L1, L2, and L3 of the capacitor bank to the grid side (terminals L1, L2, and L3) of the drive side inductor L_1 .
- b. Connect the terminals +DC and -DC to the DC-link side (terminals DC+ and DC-) of inductor L_{CM} .

3. Connect the cables to the C_{Delta} capacitor bank.

The terminal size is M10. Use tightening torque 12 Nm (106 in-lb). See the terminal locations in [Figure 8](#).

- a. Connect the terminals L1, L2, and L3 to the grid side (terminals L1, L2, and L3) of the drive side inductor L_1 .

4. If included in the delivery, connect the grid side inductor L_2 to the grid side of the drive side inductor L_1 and the capacitor banks.

The terminal size is Ø11 mm (0.43 in). Use tightening torque 30–44 Nm (266–389 in-lb). See the terminal locations in [Figure 6](#).

- a. Connect the L_2 terminals L1, L2, and L3 to the grid side.
- b. Connect the L_2 terminals L1', L2', and L3' to terminals L1, L2, and L3 of the drive side inductor L_1 .

5. If included in the delivery, connect the C_{CM} capacitor between the star point of the C_{DM} capacitor and ground.

See the wiring diagram in [Figure 3](#).

6. Connect the ground terminals of all components to PE.

The ground terminal size on the inductors is Ø11 mm (0.43 in). Use tightening torque 55 Nm (486 in-lb).

The ground terminal size on the capacitor banks is M10. Use tightening torque 55 Nm (486 in-lb).

See the terminal locations in [3.5 Terminals](#).

3.5 Terminals

The markings on the inductor terminals are explained in the following table. The locations of the terminals are shown in the illustrations.

Table 2: Markings on the Terminals

Side	Marking
Grid	L1, L2, L3
Drive AC	L1', L2', L3'
Drive DC	+DC', -DC'
C _{FB}	+DC, -DC

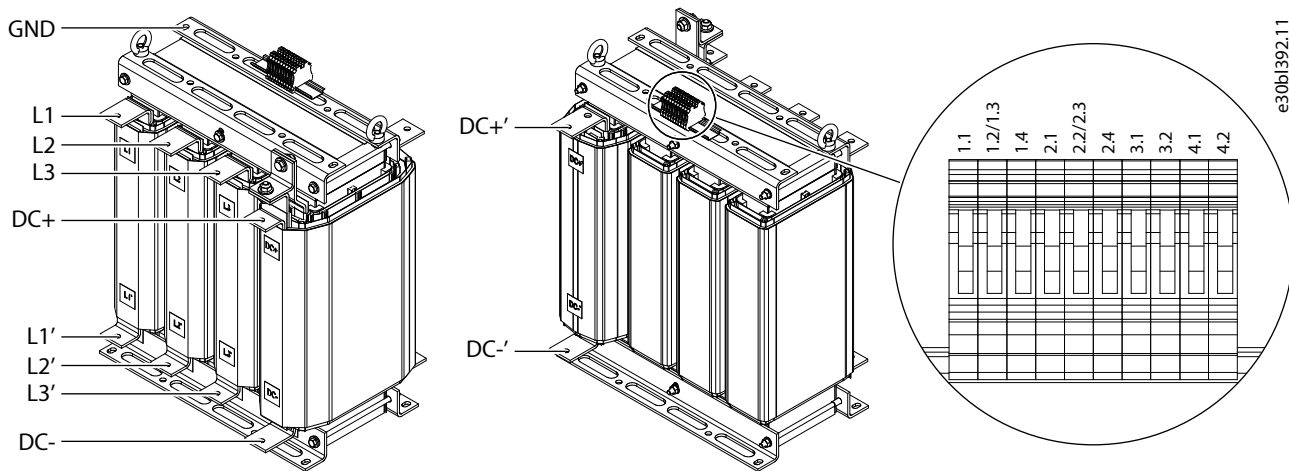


Figure 5: Terminals on the Drive Side Inductor

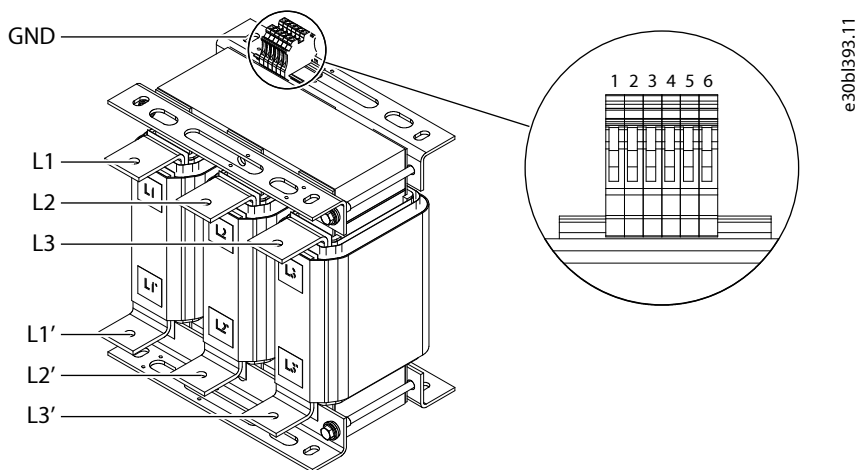


Figure 6: Terminals on the Grid Side Inductor

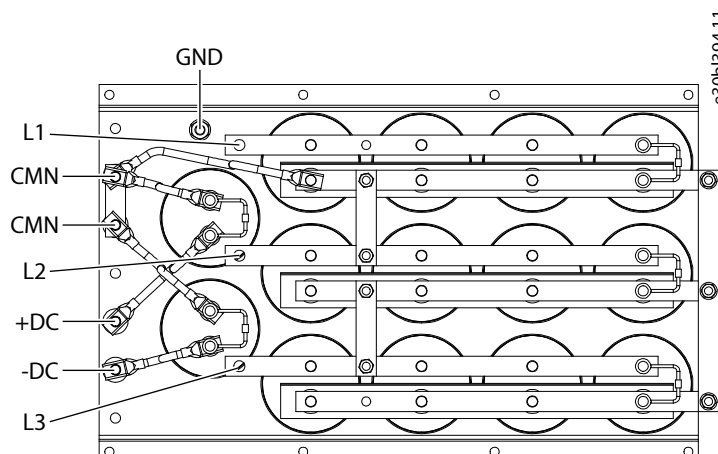
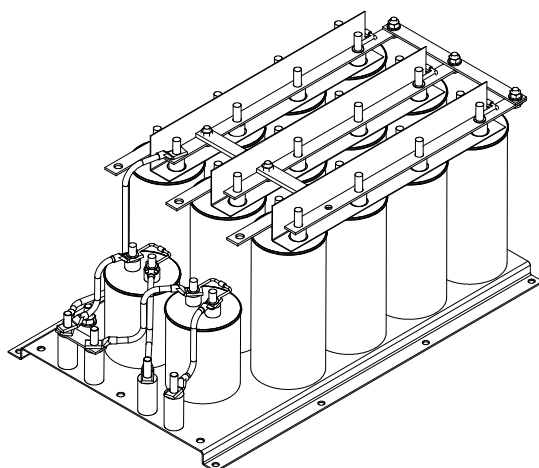


Figure 7: Terminals on the $C_{DM}+C_{FB}$ Capacitor Bank

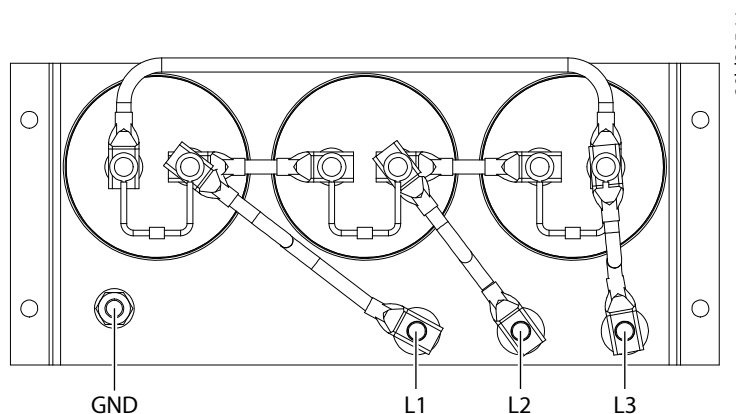
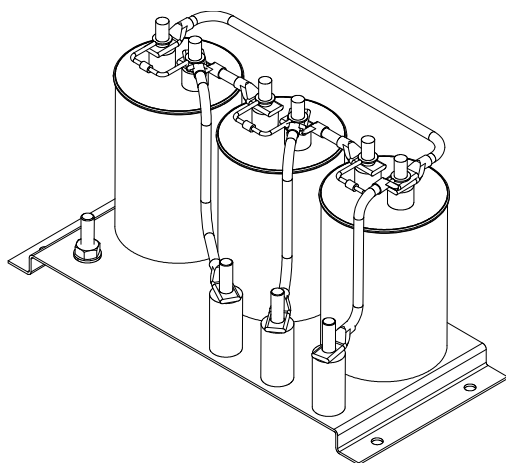


Figure 8: Terminals on the C_{Delta} Capacitor Bank

3.6 Overtemperature Protection

The inductors of the SISO LCL/LC filter have thermal relays and Pt100 temperature sensors. The relays and sensors are installed on the surface of winding L2/V and the DC winding.

- Alarm temperature limit: 110 °C (230 °F)
- Fault temperature limit: 120 °C (248 °F)

1. Install the thermal relay and Pt100 temperature sensor wires to the drive side inductor.

See the terminal locations in [Figure 5](#).

- a. Connect the alarm relay for AC phase windings to terminals 1.1 and 1.2.
 - b. Connect the fault relay for AC phase windings to terminals 2.1 and 2.2.
 - c. Connect the alarm relay for DC windings to terminals 1.3 and 1.4.
 - d. Connect the fault relay for DC windings to terminals 2.3 and 2.4.
 - e. Connect the sensor for AC phase windings to terminals 3.1 and 3.2.
 - f. Connect the sensor for DC windings to terminals 4.1 and 4.2.
2. If the grid side inductor is included in the delivery, install the thermal relay and Pt100 temperature sensor wires to it.

See the terminal locations in [Figure 6](#).

- Connect the alarm relay to terminals 1 and 2.
- Connect the fault relay to terminals 3 and 4.
- Connect the sensor to terminals 5 and 6.

3.7 Fuses

Danfoss products require fuses for protection. To protect the products from short circuits and excessive loads, input line fuses must be used. The SISO filter needs separate fuses for the feedback loop. This guide provides a recommendation for the SISO filter fuses, but the customer is responsible for ensuring the correct fuse protection for the device.

The locations of the fuses are shown in [Figure 9](#). Only the F_{SISO} fuses are addressed in this section. F_{AFE} is marked on the wiring diagram to indicate that when the SISO filter is installed, these fuses must be installed after the feedback loop. Without the SISO filter, the F_{AFE} fuses are installed immediately after the AFE. When preparing the installation, obey the local regulations.

The following type of fuse protection is recommended for F_{SI50}:

- Install 2 fuses in parallel for both capacitors.
- Suitable fuse holders are required.
- Voltage rating: 1000 V DC
- Current rating: 30 A per fuse
- Maximum short-circuit capacity: 100 kA @L/R ≤ 1 ms
- Operating temperature: -30 °C...+70 °C
- The fuses must be current-limiting.

NOTICE

- Make sure that the power cables are compatible with the fuses.
- The power cables must be able to withstand short-circuit currents and ensure sufficient l²t durability.

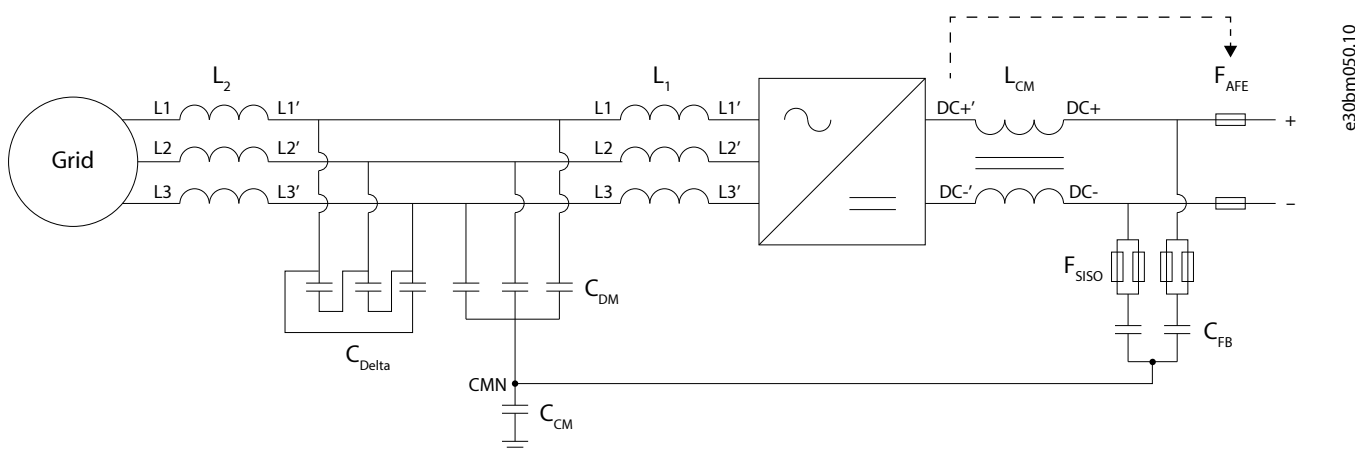


Figure 9: Locations of the Fuses

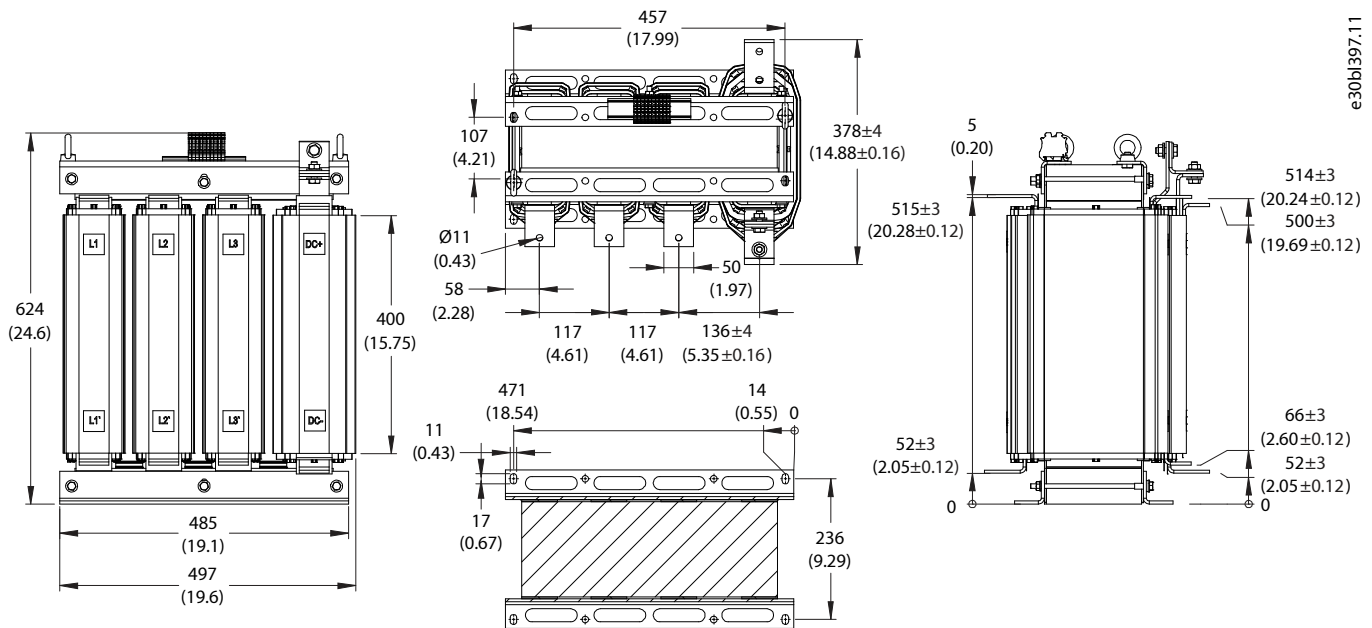
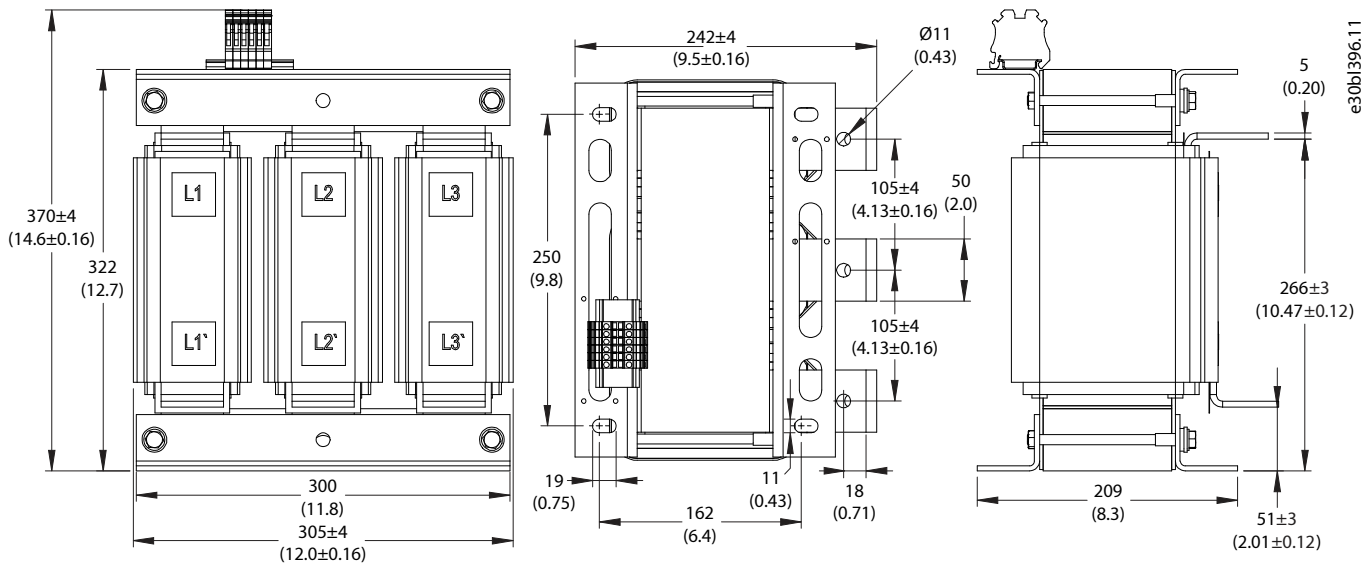
4 Specifications

4.1 Technical Data

Table 3: Specifications

Item	Specification
Nominal ratings	
Current, I_L	525 A rms
Voltage, U_N	500 V AC
Frequency, F_S	3.6 kHz
Frequency range	50/60 Hz
Power losses	LC filter: 1900 W at nominal operating point Grid side inductor: 550 W at nominal current
Mechanical details	
Weight	Drive side inductor: 255.1 kg (562 lb) Grid side inductor: 62.2 kg (137 lb) $C_{DM}+C_{FB}$ capacitor bank: 26.4 kg (58 lb) C_{Delta} capacitor bank: 4.5 kg (10 lb)
Cooling requirement	Forced air cooling, >3 m/s, vertical direction
Ambient temperature	-30...+70 °C (-22...+158 °F) in operation, derating above 40 °C (104 °F)
Storage temperature	-40...+70 °C (-40...+158 °F)
Humidity	<95% RH, no condensation
Insulation class	H 180 °C (EIS180)
Protection level	IP00
Pollution degree	3, IEC60664-1
Installation altitude	< 1000 m (3280 ft) above sea-level without derating
Standards	EN 61558-2-20, IEC 61800-5-1, UL 61800-5-1, REACH, RoHS (2011/65/EU + 2015/863), IEC 62474

4.2 Dimensions



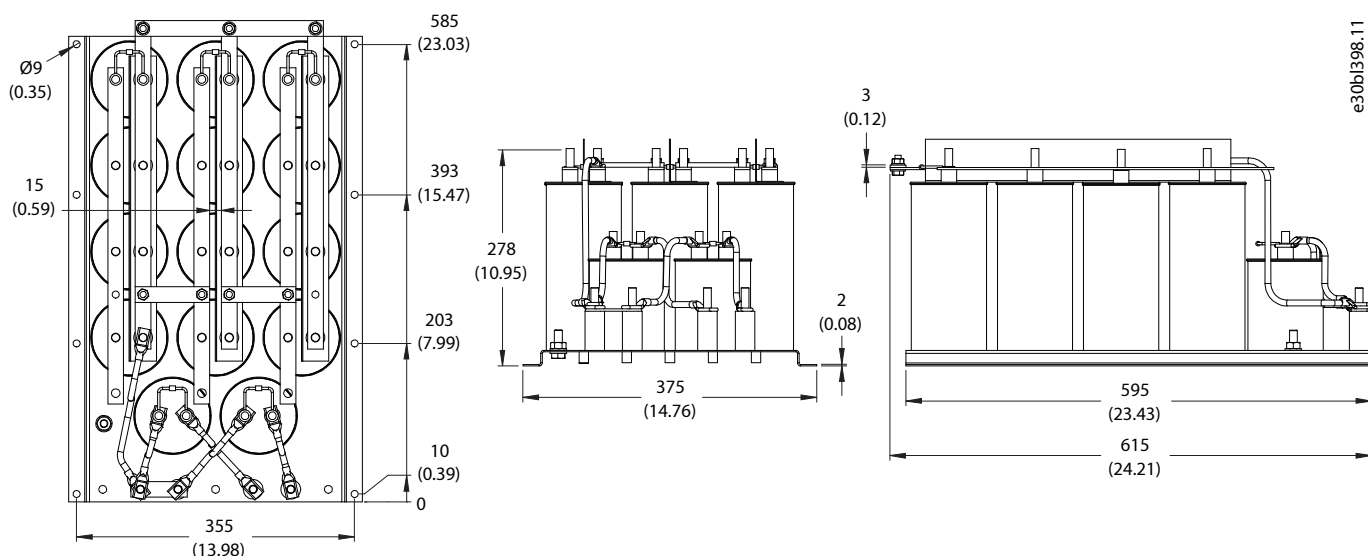


Figure 12: Dimensions of the $C_{DM}+C_{FB}$ Capacitor Bank in mm (in)

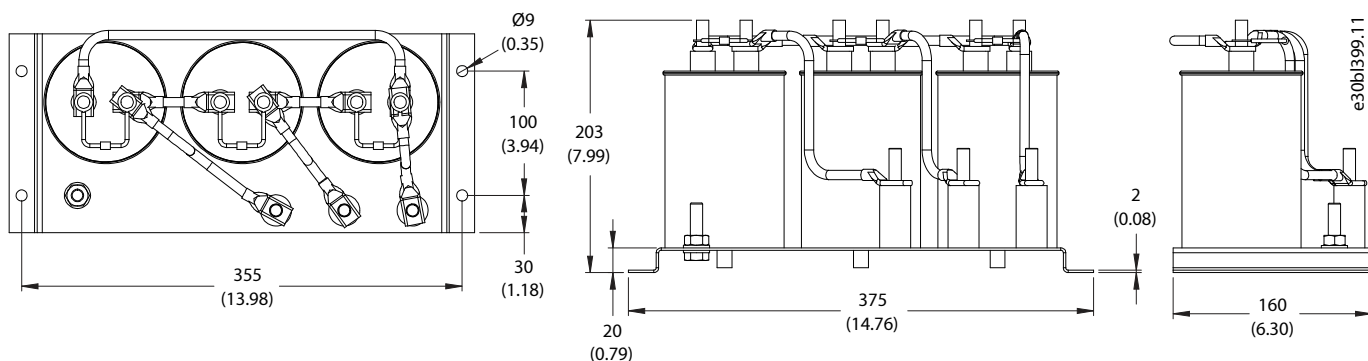


Figure 13: Dimensions of the C_{Delta} Capacitor Bank in mm (in)

5 Maintenance

5.1 Preventive Maintenance Recommendations

Generally, all technical equipment need a minimum level of preventive maintenance. Regular maintenance is recommended to ensure trouble-free operation and long life of the product. It is also recommended, as a good service practice, to record a maintenance log with counter values, date, and time describing the maintenance and service actions.

Danfoss recommends the following inspections and service intervals for the product.

NOTICE

The service schedule for part replacements can vary depending on operating conditions. Under specific conditions, the combination of stressful operation and environmental conditions work together to reduce the lifetime of the components significantly. These conditions can include, for example, extreme temperature, dust, high humidity, hours of use, corrosive environment, and loading.

For operation in stressful conditions, Danfoss offers the DrivePro® Preventive Maintenance service. DrivePro® services extend the lifetime and increase the performance of the product with scheduled maintenance including customized part replacements. DrivePro® services are tailored to your application and operating conditions.

Table 4: Maintenance Schedule

Component	Inspection interval ⁽¹⁾	Service schedule ⁽²⁾	Preventive maintenance actions
Installation			
Visual inspection	1 year	–	Check for the unusual, for example, for signs of overheating, aging, corrosion, and for dusty and damaged components.
Cable routing	1 year	–	Check for parallel routing of power cables and signal wiring. Parallel routing must be avoided. Avoid routing cables through free air without support. Check for aging and wearing of the cable insulation.
Power cabling	1 year	–	Check for loose connections, aging, insulation condition, and proper torque of the connections. Check for proper rating of fuses and continuity check. Observe if there are any signs of operation in a demanding environment. For example, discoloration of the fuse housing can be a sign of condensation or high temperatures.
Control wiring	1 year	–	Check for tightness, damaged or crimped wires or ribbon wires. The connections must be terminated correctly with solid crimped ends. The use of shielded cables and grounded EMC plate, or a twisted pair is recommended.
EMC consideration	1 year	–	Inspect the installation wiring regarding the electromagnetic capability and the separation distance between control wiring and power cables.
Grounding	1 year	–	Check that the ground connections are tight and free of paint or oxidation. Daisy-chain connections are not allowed. Braided straps are recommended if applicable.
Proper clearances	1 year	–	Check that the required external clearances for proper airflow for cooling are followed. For clearances, refer to the local design regulations.
Corrosive environments	1 year	–	Conductive dust and aggressive gases, such as sulphide, chloride, and salt mist, can damage the electrical and mechanical components. Air filters do not remove airborne corrosive chemicals. Act based on findings.
Cooling			
Cleaning	1 year	1 year	Check the cleanliness of the cooling channels, inlets, and outlets.
Cooling fans and fan supplies	1 year	5–10 years	Replace parts according to the recommendations of the manufacturer.
Filter components			
Capacitors	1 year	12–15 years	The expected life time of the capacitor is determined based on load and the temperature of the environment. Replace parts according to the service schedule. For applications with heavy loads or demanding environments, replace the capacitors every 12 years. In typical environment, within specifications of the filter, replace every 15 years. Only trained service personnel are allowed to perform this action.

1) Defined as the time after the commissioning/start-up or the time from the previous inspection.

2) Defined as the time after the commissioning/start-up or the time from the previous service schedule actions.

5.2 Recommended Disposal

When the product reaches the end of its service life, its primary components can be recycled.

Before the materials can be removed, the product must be disassembled. Product parts and materials can be dismantled and separated. Generally, all metals, such as steel, aluminum, copper and its alloys, and precious metals can be recycled as material. Plastics, rubber, and cardboard can be used in energy recovery. Printed circuit boards and large electrolytic capacitors with a diameter of over 2.5 cm (1 in) need further treatment according to IEC 62635 guidelines. To ease recycling, plastic parts are marked with an appropriate identification code.

Contact your local Danfoss office for further information on environmental aspects and recycling instructions for professional recyclers. End-of-life treatment must follow international and local regulations.

All products are designed and manufactured in accordance with Danfoss company guidelines on prohibited and restricted substances. A list of these substances is available at www.danfoss.com.



This symbol on the product indicates that it must not be disposed of as household waste. Do not dispose of equipment containing electrical components together with domestic waste.

It must be handed over to the applicable take-back scheme for the recycling of electrical and electronic equipment.

- Dispose of the product through channels provided for this purpose.
- Comply with all local and currently applicable laws and regulations.

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